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GASOHOL FROM GRAIN--
THE ECONOMIC ISSUES

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Fuels
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Distillers dried grain
Distillers grains
Esteraldehyde
Fuel supplements
Fusel oil
Gasohol
Grain alcohol
Protein isolate
Wet stillage

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Gasohol from Grain--
The Economic Issues

Executive Summary

Proposals for using fermentation alcohol from grains as a motor fuel supplement raise questions regarding its economic feasibility. These proposals originate from the desire of farm groups to develop an added market for grains and coinçide with the Nation's desire to find alternatives to petroleum fuels. This study is a preliminary economic assessment of introducing a national gasohol program. A national program would require the production of 10 billion gallons of ethanol to mix with 90 billion gallons of gasoline to produce 100 billion gallons of gasohol annually.

Can We Produce Automotive Fuel from Grain?

A bushel of corn produces through fermentation:

* 2.6 gallons of 200 proof (anhydrous) ethanol. This is readily burned in modern automobiles when blended with gasoline at the 10 percent level.

* 17.0 pounds of distillers dried grains, a high protein feed.

Can Alcohol Compete with Gasoline?

To be competitive with gasoline may require--

* A subsidy of 10.4 cents per gallon of gasohol

* A total subsidy of $10.4 billion annually.

Is There a Net Increase in Energy?

Converting corn energy to automobile fuel results in a negative energy balance.

* From 0.5 to 0.8 Btu of ethanol is produced from each Btu of energy invested in growing and processing corn.

Is There Sufficient Grain Producing Capacity for Both Food and Gasohol Needs?

Grain production would have to increase sharply to serve both needs. Some acreage would be taken from soybeans and wheat. Additional land not now farmed would be needed.

What Price Impacts Would be Triggered by a National Gasohol Program?

A 10 billion gallon a year subsidized ethanol market would--

* Sharply increase prices of feed and food grains. Feed grain acreage would expand accordingly.

* The 35 million tons of distillers dried grains produced would depress soybean oil meal prices

-- the soybean crushing industry would be largely supplanted

-- soybeans would be produced mainly for food oil and for export.

* Aggregate livestock production would decline from base estimates
  -- producers will feed relatively cheap distillers dried grains
  -- the more fibrous product will slow down this livestock cycle.
* Net farm income would increase slightly--higher crops receipts.
* Consumer food prices could be expected to increase, reflecting higher livestock prices.
* If the subsidy exempts gasohol from the 4 cent per gallon Federal highway tax then financing of the highway trust fund must come from other sources.

Gasohol from Grain--
The Economic Issues

Proposals for using fermentation alcohol from grains as a motor fuel supplement raise a number of questions regarding economic feasibility and Government policy for energy and food. The technologies for producing alcohol and using it as a fuel are not in question. But there has been no recent experience in producing fermentation alcohol in the quantities required for a significant contribution to U.S. motor fuel supplies. Thus, the economics of a policy to promote such an activity must be evaluated based on engineering estimates.

These proposals to use alcohol originate from the desire of farm groups to develop an added market for surplus grains. Currently, this motivation coincides with the Nation's desire to find alternatives to petroleum fuels. The following are the major questions which must be answered in evaluating these two objectives:

1. Can alcohol from grain, produced with the best known technology, compete with other fuels (particularly gasoline) and become a viable market for grains?
2. Even if incentives are required, how would they compare with the cost of alternative subsidies for supporting grain prices (including credit for any resulting energy contribution)?
3. Is the energy production potential sufficient to warrant the subsidy required compared to the cost of developing other potential energy sources?

4. Is there sufficient grain production capacity to meet food needs and maintain a viable system to produce grain alcohol for fuel?

5. What would be the impact on grain prices, substitute products, livestock industry and consumer food prices from the increased demand for grain for ethanol?

A number of studies have attempted to answer various parts of these questions. Judgments may differ in interpreting some of the results. But, they at least provide information in terms of costs, prices or quantities upon which judgments can be made and compared. This report is based primarily on secondary data from the studies cited in the Appendix.

Can Alcohol Compete with Other Fuels?

Alcohol can be produced from starch from a wide variety of agricultural commodities. This analysis utilizes corn as the feedstock.

A bushel of corn will yield about 2.6 gallons of 200 proof (anhydrous) ethanol. Byproducts of the process are: Distillers grains (the dried residue which is a high protein animal feed), fusel oil, esteraldehyde and carbon dioxide.

There are three components to the cost of producing grain alcohol:

1. The cost of the grain as a feedstock--variable with the supply produced and the demand for all uses including export.
2. The process cost--capital costs, process heat, labor, etc.
3. Credit for the sale of byproducts--primarily distillers grains for feed, valued relative to their volume and the competitive cost of other feeds.

The largest component of cost is the grain used as feedstock or raw material for fermentation. Corn is generally used for purposes of analysis. It is high in starch content, causes no process problems, is the most abundant grain and is lower priced than wheat. The cost of corn (corn price) could vary from year to year even beyond the range of recent prices if a large alcohol demand were developed. A range of from $1.00 to $3.50 per bushel is adequate for illustration purposes.

Process or conversion costs have been estimated by Scheller (Neb.), Miller (USDA-ARS), Battelle and others. These studies indicate that costs for salaries and wages, energy inputs and general administration would fall in the range of 31 cents to 44 cents per gallon of ethanol produced. There is some variation in the handling of capital costs depending on prices for equipment and whether a plant is debt or equity financed. The range used by Battelle (the only recent study showing method of calculation) is from 21 cents to 32 cents per gallon.

Because the principal product is ethanol, the value of byproducts is typically shown as a credit to the cost of producing the alcohol. The major byproduct is distillers grains, the nonstarch portions of the grain including largely cellulosic and protein materials. It is produced from wet stillage by extracting most of the water. As a feed, it is high in protein (22 percent total digestible protein), vitamins and minerals with a feeding value for cattle of about 135 percent of that of corn.

In most studies, the value of the distillers grains has been held constant at about $100 per ton. This is not realistic. With small supplies, its feed value would be expected to move up and down with the value of corn which is also used primarily as feed. Using the feed value of 135 percent of the value of corn, the value of distillers grain per gallon of alcohol produced could vary with the corn price as follows:

Corn Price	Distillers Grain Value	
	Per Ton	Per Gallon of Alcohol
$.bu.	$	$
1.00	48.21	.16
1.50	72.32	.24
2.00	96.42	.33
2.50	120.54	.41
3.00	144.64	.49
3.50	168.75	.57

Recent production of distillers dried grains has averaged around 400,000 tons per year. With a national gasohol program some 35 million tons would be produced annually. To consume this greatly expanded volume in competition with soybean oil meal would require discounting its price sharply below the relative feeding values in the table above. The price level might drop to as low as $50 per ton irrespective of the price of corn.

Some researchers indicate that an edible protein isolate similar to that extracted from soybean oil meal may be extracted from the distillers grain. This high protein powder could then be used to fortify and extend food products. In removing protein isolate from the distillers grain, the protein fraction is lowered but the remaining protein is modified so that a greater proportion is digestible. Hence, weight gain in animals is about the same with the modified distillers grains. Not enough of the protein isolate has been manufactured and marketed to determine costs of extraction or returns for the product.

Some studies include byproduct credits for fusel oil, esteraldehyde and carbon dioxide. These are not included in this summary because of the uncertainty of whether they would be realized. In most alcohol plants, the credits for fusel oil and esteraldehyde if realized would amount to only about a half cent per gallon of alcohol and are not significant. For fuel purposes, fusel oil and esteraldehyde need not be removed. Most studies dismiss the likelihood of there being an available market for the carbon dioxide.

The Nebraska studies also impute an added value to alcohol in fuel for raising the octane rating of low lead gasoline. But results of fuel tests by the Department of Energy and other researchers have not substantiated this. There is a positive effect from the alcohol on the combustion of gasohol, but this apparently just about overcomes the fact that gasohol contains fewer Btu per gallon than gasoline.

Based on the above information, the cost of producing ethanol at various corn and byproduct prices is shown in Table 1. Ethanol is not competitive with gasoline (at the current wholesale price of 38 cents per gallon) under any combination of costs and prices shown in Table 1.

With corn at $2.00 per bushel the lowest indicated cost of alcohol is 96 cents or 58 cents higher than the cost of gasoline. Gasohol, a blend of 90 percent gasoline and 10 percent alcohol, costs 67.8 cents a gallon or 5.8 cents higher than gasoline.

Item	Gasoline	Gasohol
	Dollars Per Gallon	
Gasoline @ .38	.380	.342
Ethanol @ .96	---	.096
Product Price	.380	.438
Transportation	.030	.030
Station markup	.090	.090
State tax 1/	.080	.080
Federal tax	.040	.040
Pump price of product	.620	.678

1/ Currently, 35 States tax gasoline at the 8 cent rate or higher.

Table 1.--Cost Per Gallon for Producing Ethanol from Corn

Item	Corn Price Per Bushel					
	$1.00	$1.50	$2.00	$2.50	$3.00	$3.50
Grain Cost	.38	.57	.77	.96	1.15	1.35
Conversion Cost 1/ ...	.31	.31	.31	.31	.31	.31
Byproduct Value 2/ ...	-.16	-.24	-.33	-.41	-.49	-.57
Capital Charge 3/						
--Low	.21	.21	.21	.21	.21	.21
--High	(.32)	(.32)	(.32)	(.32)	(.32)	(.32)
Cost Per Gallon						
--Low	.74	.85	.96	1.07	1.18	1.30
--High (a)	(.85)	(.96)	(1.07)	(1.18)	(1.29)	(1.41)
--High (b)	(.98)	(1.09)	(1.20)	(1.31)	(1.42)	(1.54)

Note: Low = lowest range of both conversion and capital cost.
High (a) = low range conversion cost, high capital cost.
High (b) = high range of both conversion of capital cost.

1/ Different studies show conversion costs ranging from 31 cents to 44 cents. Expert opinion indicates 31 cents is theoretically possible and could be achieved in large commercial facilities.

2/ Value of byproduct distillers grain feed calculated at 135 percent of corn price. This assumption would not hold with a national gasohol program.

3/ Low capital cost assumes debt financing. High includes profit margin sufficient to attract equity financing.

Other Costs--A significant but not quantifiable cost of producing ethanol is the added expense of abiding by U.S. Treasury regulations concerning alcohol production, distribution and use.

The cost of permits and construction plats; building the security required including fences, locks, seals, valves and piping; bonding for potential tax liability; and the plethora of bookkeeping forms to record all inputs used and all outputs produced add appreciably to the cost of producing ethanol.

A task force of Treasury officials is now being formed to consider ways of reducing the extent of regulation that would cover ethanol production for gasohol.

The most common size of ethanol distillation plant being considered appears to be one with a capacity of 20 million gallons annually. This size plant is said to achieve most of the economies of scale. Each such plant is estimated to cost between $25 and $33 million. To produce enough ethanol for a national gasohol program would require some 500 such plants. The investment necessary could be $15 to $17 billion.

No estimates have been prepared for the added cost burden of maintaining separate distribution facilities--tanks, lines, pumps--for a fuel that must be kept nearly free from water. The recent experience with introducing lead-free gasoline into the retail distribution system appears to be a reasonably close parallel. Battelle estimated that separate lead-free facilities for service stations, bulk plants and terminals would require an annual capital investment of $470 million and an annualized cost of $134 million.

Another significant but intangible cost is the undependable nature of the grain supply. Grain crops are subject to the capriciousness of weather and the individual decisions of hundreds of thousands of farmers. Does a farmer plant corn? If so, does he contract with the distillery? At what price can he negotiate? If a short crop occurs will he deliver to the distillery or sell the product on the open market? How can one differentiate distillery from market corn and protect the investment in the distillery?

This is quite a different supply situation than confronts the petroleum industry with respect to gasoline.

What Incentives Would be Required to Make Gasohol Competitive?

The difference in cost between gasoline and gasohol can be used to determine the probable magnitude of the incentives which would be required to either make alcohol fuel a viable market for corn or induce the use of alcohol as a gasoline substitute. In terms of incentives per bushel of corn, the amount would be 58 cents per gallon of alcohol times 2.6 gallons per bushel or $1.51 per bushel based on corn at $2.00 per bushel and distillers grains at its feed value of 135 percent of corn.

With a national gasohol program about 10 billion gallons of alcohol would be needed. This would take about 3.85 billion bushels of corn. If the above price relationships held, incentives of $1.51 per bushel to make gasohol competitive with gasoline would total some $5.8 billion annually.

Preliminary assessment of the impact of a gasohol program operated on a national basis indicates the above feed-price relationship does not hold. With the interaction of supplies of distillers grains and soybean oil meal, the price of distillers grains could drop to as low as $50 per ton and the price of corn could rise to $2.75 per bushel. This reduces the byproduct credit in Table 1 to 16 cents per gallon of ethanol. The total cost of producing a gallon of ethanol with $2.75 corn is about $1.42 or 10.4 cents per gallon of gasohol. On 10 billion gallons of ethanol the direct public subsidy would be $10.4 billion annually.

The proposed exemption for gasohol of the 4 cents per gallon Federal highway tax on gasoline would fall 6.4 cents per gallon short of making this fuel competitive with gasoline.

Some States are considering exempting gasohol from all or part of their State gasoline tax alone or in concert with the 4 cents per gallon proposed Federal tax exemption.

Is There a Net Increase in Energy?

The utilization of grain to produce a petroleum substitute such as ethanol requires energy. How much energy relative to that produced in the process has been in question. There is no one accepted way of measuring the energy input-output ratio. The following two examples serve to illustrate the problem but do not resolve the dilemma.

Method A--To produce a bushel of corn in 1974 required 107,400 Btu of energy. The bushel of corn if burned directly yields approximately 375,000 Btu. When one bushel of corn is fermented by yeast the chief products are:

Ethanol	2.6 gals.	If burned yield	218,000 Btu
Distillers grains	17.00 lbs.	" " "	130,000 Btu
Carbon dioxide	16.35 lbs.	Not burnable	
			348,000 Btu

Therefore, the products give slightly less energy than is in the raw corn.
Note: Distillers grains are usually fed, not burned.

Energy is required in the conversion of corn into ethanol and the by-products. Some 312,000-340,000 Btu of energy for steam and 27,000-54,000 Btu of energy for manufacture of electricity are required per bushel of corn in an ethanol plant. Therefore, the energy expended in plant conversion is from 339,000 to 394,000 Btu per bushel. Adding the energy to produce the grain brings the total Btu input to from 446,000 to 501,400 Btu per bushel. This suggests that from 0.69 to 0.78 Btu of energy (ethanol and distillers dried grains) is produced from each Btu of energy invested in growing and processing corn for a gasoline substitute.

Method B--To produce a bushel of corn in 1974 required 107,400 Btu of energy inputs. However, in the fermentation process only the starch fraction of the corn is converted to alcohol. The rest of the grain remains as a high protein feed, distillers grains, which has a beef feeding value equivalent to 0.41 bushels of corn. Thus, only 59 percent of the energy used to produce a bushel of corn--63,377 Btu--should be charged as an input to alcohol production. Using the same Btu of conversion as in Method A the total Btu input ranges from 402,366 to 457,366 Btu per bushel. This suggests that from 0.48 to 0.54 Btu of energy is produced from each Btu of energy invested in growing and processing corn for 2.6 gallons of ethanol.

As shown neither method results in a positive energy balance. However, some researchers contend that energy in the stover (stalks and leaves) can make this a positive fossil fuel energy balance. But, as yet no commercial process utilizes stover as its energy source. Most use coal, oil, or natural gas.

The net energy produced could be increased substantially if it proved feasible to use the cornstalks and cobs for process fuel. But the bulk handling problem is still too costly and there are fears of mining the soil if all the stover is removed.

The major short-term energy concern is the dependence of crop production on oil and natural gas. While a bushel of corn yields a net fuel energy of 111,000 Btu (Method A) or 155,000 Btu (Method B) over the production energy input, the same bushel of corn if exported at $2 would purchase 800,000 Btu of imported oil at $14 per barrel.

In comparison with other potential energy sources, alcohol from grain appears expensive. Alcohols can be produced from many different organic materials and by several processes. A recent report issued by ERDA showed some of the following energy costs:

Product	Source	Cost Per Million Btu
Methanol	Tree crops	$ 5.20
Methanol	Coal (in situ process)	2.68
Ethanol	Corn ($1/bu)	8.99
	Corn ($2/bu)	12.50
Gasoline	Petroleum	2.77

The industrial alcohol market is frequently mentioned as an alternative to the motor fuel market for grain alcohol. The estimated costs of producing ethanol from corn are competitive with current prices for synthetic alcohols. But, this is not a large market and it is dominated by large firms with substantial excess capacity. The synthetic alcohol is a joint product of petroleum refining, and the present producers would have little difficulty in absorbing the costs of competition in keeping new producers out of the alcohol market. This does not appear to be a viable market for alcohol from grain.

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Future Cost of Ethanol Production--It has been suggested that should the price of gasoline double, ethanol would become economically competitive as a liquid fuel without any subsidy. For this hypothesis to remain valid, the real price of gasoline would have to double while the costs of producing ethanol remain constant. However, it takes energy to produce corn, including a sizable component of gasoline. Relative prices of other energy forms (diesel fuel, coal, natural gas, etc.) are unlikely to remain constant while gasoline prices double.

Iowa accounts for about one-fifth of U.S. corn acreage, and can serve as a good illustration as to how energy cost increases impact on farmers' costs of production. Energy costs represent about 7 percent of total corn production costs. At 90 bushels per acre energy costs approximate $0.16 per bushel. Assume that gasoline prices do rise to $1.25 per gallon, prices of other energy forms increase at the same rate, while all non-energy input costs remain constant. For corn grown in Iowa, costs would rise 8.5 percent, or almost 20 cents per bushel. If farmers are to receive fair prices for their product, corresponding real increases in long run corn prices would be indicated. This then translates ultimately into increased costs of production for ethanol, raising the target price at which it would be competitive.

The assumption that all non-energy input costs will remain constant in real terms (effects of inflation factored out of all costs) is not likely to hold true in reality. For example, prices paid by farmers for energy have risen 102 percent since 1967, with 4 years of rapid energy price increases since the embargo. Farm wage rates have jumped 126 percent, with costs of building materials up 137 percent. The composite index of prices paid by farmers is up 104 percent, while prices received have risen only 76 percent. There is little evidence to suggest that energy costs will outstrip costs of other inputs, implying much sharper total impacts on costs of producing corn, and therefore ethanol.

Steam costs are a major component of the total ethanol price. Because all energy costs tend to be interrelated, whether the source is coal, oil, gas, or nuclear power the price of steam and the price of wholesale gasoline will probably increase at much the same rate.

Therefore, the cost picture for converting corn into ethanol is not expected to improve significantly without a major technological breakthrough.

Is There Sufficient Grain Production Capacity for Both Food and Gasohol Needs?

Grain production would have to increase substantially to satisfy both food and energy needs. Additional acreage could be pulled into grain production to produce gasohol but this would result in such dramatic changes in crop mix and apply such sharp pressure to land rents that the impact on other crops cannot easily be estimated. Much of the needed land would be diverted from the production of soybeans because of the competition between distillers dried grain and soybean meal.

What Price Impacts Would be Triggered by a National Gasohol Program?

A national gasohol program could not be implemented immediately. Assume a time frame of 5 years for installation and operation of some 500 distilleries. Further assuming 2 billion gallons of alcohol are produced the first year and then 2 billion gallons additionally each subsequent year through 1982 the following represents a preliminary assessment of likely directions of impacts by 1982.

The price of feed and food grains would increase with the new demand for ethanol for gasohol. Feed grain acreage would increase sharply to produce the grain for the ethanol market. Much of this land would be transferred out of soybeans.

The volume of distillers dried grains to be consumed would be enough to depress soybean oil meal prices to the extent that the domestic soybean crushing industry would be largely supplanted by the gasohol byproduct, distillers dried grains. Soybeans would be produced basically for food oil and for export.

Aggregate livestock production would decline from the current base estimates. This occurs because of the shift to distillers grains. The higher fiber content of this feed will require a longer digestion phase. But the much cheaper relative price of this feed should make it sufficiently attractive so as to be substituted for soybean oil meal into hog and poultry rations as well as beef. If livestock producers accept this low cost feed and modify their feeding schedules accordingly, this would slow down the livestock cycle and result in higher total costs to livestock producers.

Farmers are exempt from the 4 cents per gallon Federal tax for nonhighway business purposes. A public subsidy exempting gasohol from this tax implies that farmers will pay 4 cents more per gallon of gasohol used. The current Federal tax refund is $115 million. It would appear that farmers fuel costs would increase by this amount under a national gasohol program.

Farm Income

Crop receipts would be up somewhat, but would be partially offset by the higher variable costs of corn relative to soybeans. This would result in a slight net increase in farm income.

Consumer Food Prices

Consumer food prices could be expected to move up reflecting the higher prices incurred as producers hold livestock for longer periods due to the slower growth cycle.

Gasohol Program Costs

A preliminary assessment of the costs of operating a national gasohol program include some $10.4 billion annually in direct subsidy to bring gasohol competitive with gasoline.

If the subsidy results in the exemption of gasohol from the 4 cent per gallon Federal highway tax on gasoline, then additional subsidy must be provided to highway trust funds for maintenance of roads. This could amount to over $3 billion annually.

In addition, consumers would experience higher food prices primarily with meat products. Dramatic regional shifts in livestock production would occur as producers relocate adjacent to distilleries for a low-cost feed source. Such a program would render obsolete the investment in the domestic soybean crushing industry. It would also stress the capital market to produce the $15 billion investment capital for the needed distilleries.

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