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Some Economic Aspects of Ethanol Production

by

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As we enter the decade of the eighties, the outlook for liquid fuels is very uncertain. World oil production is leveling off and most energy analysts agree that output may not increase much more, if at all. Coupled with this unfavorable production prospect is a growing uncertainty of supply. Since the end of World War II, the potential for disruption in oil supplies has never been so great. The unsettled political situation in the Middle East and the Russian invasion of Afghanistan only tends to heighten the feeling of uncertainty with respect to supply availability and crude oil prices. A continually climbing world oil price, with no apparent limit in sight, signals a fundamental change in the outlook for liquid fuels in many countries of the world.

Against this backdrop of events, many countries are turning to ethanol (anhydrous ethyl alcohol) distilled from farm commodities as a source of fuel for automobiles. An alcohol fuel industry has several attractions to policy makers in the United States:

1. Automobile engines can readily burn a gasoline/alcohol mixture containing 10 percent alcohol without any adjustment or significant loss in engine fuel efficiency or performance.
2. Commercial production of alcohol for industrial purposes is already a well established industry and the technology for converting plant materials into alcohol is widely available.
3. Limited supplies of crude oil can be extended by substituting 10 percent alcohol for gasoline in the gasohol mix.
4. The demand for alcohol would open new markets for surplus grain supplies and other plant materials. Idle cropland could be brought into production to produce raw materials for this developing market. For the first time, American farmers would consider producing crops for "fuel" rather than for "food".
5. New productive capacity can come on stream within 6-18 months from the start of construction.

In January 1980, the White House announced major new goals for both 1981 and the mid-eighties. The aim is to produce 500 million gallons of ethanol for fuel in 1981, a figure at least six times greater than the 1979 output. Distilling 500 million gallons of ethanol would require 225 million bushels of corn (assuming 2.22 gallons of ethanol per bushel of corn), the output from 2.25 million acres at current U.S. yields.

Secretary of Agriculture, Bob Bergland, believes that the President's 1981 goal is reachable because a combination of events critically influencing ethanol plant construction decisions that make investment sufficiently profitable to offset anticipated risks.^{2/} These factors include:

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^{2/} Statement by Bob Bergland before the U.S. National Alcohol Fuels Commission, June 19, 1980.

1. Provisions for federal tax incentives for a substantial portion of the amortized life of a plant (through 1992).
2. Continuing increases in the real price of crude oil and gasoline.
3. Clarification of regulatory policies involving the manufacture and use of ethanol for fuel.
4. Recent sharp declines in the cost of capital.

As a rule of thumb, 1 billion gallons of annual ethanol production can be accommodated by an increase in grain supply in excess of all other requirements of either 4 percent in acreage of average yield devoted to corn production (about 4 million acres) or 4 percent in the productivity of currently harvested corn and sorghum grain acreage (from about 100 to 104 bushels per acre yield for corn).

President Carter's goal for the mid-eighties is two billion gallons of ethanol production annually. When mixed with gasoline, this would yield 20 billion gallons of gasohol, or nearly one-fifth of the U.S. 1979 consumption of about 110 billion gallons of automotive fuel. The mid-eighties goal would require 900 million bushels of corn or equivalent.

Government Incentives

The first major boost for the U.S. alcohol fuel program came with the National Energy Act of 1978, which removed the federal gasoline tax of 4¢ on every gallon of gasohol containing alcohol from non-petroleum sources. Effective January 1, 1979, this law exempted a ten-gallon mixture, containing one gallon of ethanol and nine gallons of gasoline, from the federal tax of 4¢ per gallon, thus providing an actual subsidy of 40¢ on each gallon of alcohol used as fuel. As early as 1980, 16 states also exempted gasohol from state gasoline tax. To date, the Arizona Legislature has failed to follow the lead taken by these states.

A second major boost for the U.S. alcohol fuel program was when the White House announced in January 1980 a program for the next decade with specific goals set for 1981 and the mid-eighties (see the discussion above). All told, it is proposed that somewhere between \$8.5 to \$13 billion dollars be committed to encouraging the alcohol fuel industry. Many of the incentives of this multibillion dollar package are already in effect, including the 4¢-a-gallon federal gasoline tax exemption. In order to provide investors in alcohol fuel distilleries a long-term market and profitability for their product, the President proposed that the gasohol tax exemption be made permanent.

A major new component in this program was \$3 billion in proposed new federal loans and in loan guarantees for those investing in alcohol distilleries. The figure includes about \$300 million to assist small scale producers such as individual farmers who wish to produce their own farm fuel supplies.

In addition to the above program, the Department of Energy is already looking at a way to use sweet sorghum to produce ethanol. This crop is attractive because of its high potential alcohol yield per acre (381 gallons).

The Crude Oil Windfall Profit Tax Act of 1980, signed into law on April 2, 1980, contains several provisions which will affect persons or firms producing, blending, marketing, or using alcohol fuels. These include:

1. Continuation from 1984 through 1992 of the exemption from the 4¢ per gallon federal excise tax on alcohol-gasoline blends containing at least 10 percent alcohol. The alcohol must be at least 190 proof and produced from sources other than petroleum, natural gas and coal.
2. Refunds for excise taxes paid on gasoline blended with at least 10 percent alcohol.
3. Income tax credits for blenders of alcohol-gasoline blends, and for users of straight alcohol fuel.
4. Continuation through 1985 of the energy investment tax credit for alcohol fuel production equipment.
5. Authority for simplification of Bureau of Alcohol, Tobacco and Firearms regulation of alcohol fuel producers.
6. Tax-exempt status for certain industrial development bonds for financing alcohol fuel production facilities.

For the period October 1, 1980 through December 31, 1992, a person who blends alcohol fuel with gasoline or any other liquid fuel suitable for use in an internal combustion engine may claim an income tax credit. To qualify, the blender must sell the blended fuel for use as a fuel or use it as a fuel himself. For example, a farmer who blends his own alcohol-gasoline fuel would qualify for an income tax credit.

The tax credit amounts to 40¢ per gallon of alcohol of at least 190 proof, and 30¢ per gallon of alcohol of at least 150 proof but less than 190 proof. Alcohol is defined as ethanol and methanol, but does not include alcohol produced from petroleum, natural gas, or coal. The tax credit is reduced by the amount of federal excise tax exemption applicable to the blended fuel. The following table illustrates calculation of the income tax credit according to the alcohol content of the blend:

Gasoline (gallons)	Alcohol (gallons)	Tax Credit #	
		Gross ^{1/}	Net
99	1	\$0.40	.40 ^{a/}
95	5	2.00	2.00 ^{a/}
90	10	4.00	0.00
85	15	6.00	2.00
70	30	12.00	8.00
50	50	20.00	16.00
30	70	28.00	24.00
0	100	40.00	36.00

^{1/} Gross tax credit equals 40¢ times the gallons of alcohol in the blend. The gross tax credit for blends containing 10 percent or more alcohol is reduced by the value of the excise tax exemption (\$4 per 100 gallons of blend) to obtain the net tax credit.

^{a/} Blends that contain less than 10 percent alcohol are not exempt from the 4¢ per gallon federal motor fuels excise taxes; therefore, the gross tax credit is not reduced in these cases. The federal excise tax of 4¢ must be paid on each gallon of this motor fuel.

If alcohol-gasoline blends or straight alcohol fuel are sold to certain purchasers exempt from all federal motor fuel excise taxes, the gross tax credit is not reduced by the value of the excise taxes exemption. Such exempt purchasers are farmers who use fuel for on-farm use, and units of local government.

Any person considering alcohol fuel production, blending, or marketing, and who believes that he may qualify for the tax provisions under this law, should seek professional tax counsel.

The Windfall Profit Tax Act retains through 1982 the 10 percent Energy Investment Tax Credit for "alternative energy property", and creates for the period January 1, 1983 through December 31, 1985, a new eligibility section for "biomass property". Both of these sections apply to equipment that converts biomass into alcohol fuel provided that the equipment producing the alcohol uses a primary source of energy (i.e., more than 50 percent of the fuel energy requirement) other than oil, natural gas, or a product of oil or natural gas. Biomass is defined as any organic substance other than oil, or natural gas. Biomass includes waste, sewage, sludge, grain, wood, oceanic and terrestrial crops, and crop residues. Beginning January 1, 1983, coal may not be used as a feedstock if the 10 percent Energy Investment Tax Credit is claimed.

The Energy Security Act, which is nearing final enactment, will authorize the USDA to insure and guarantee loans for ethanol facilities up to 15 million gallons annual capacity and certain categories of projects (those which use forestry feedstocks or which are sponsored by cooperatives) larger than 15 million gallons annual capacity. This new Biomass Energy Financial Assistance Program will involve the close cooperation of the Department of Energy and the Department of Agriculture. Credit assistance is expected to be available under the act by October 1, 1980. The Secretary of Agriculture has consolidated all USDA financial assistance for commercial biomass energy projects in the Farmers Home Administration. Within the FHA an Office of Renewable Resources has been established to participate in the development and direction of alcohol fuel and other biomass energy financial assistance programs. Processing and servicing of insured loans and loan guarantees will occur primarily through existing personnel of the Farmers Home Administration and through the existing state, district and county offices of the agency.

In providing financial assistance, USDA recognizes the need to encourage smaller and intermediate size ethanol production facilities, including on-farm units. A promising approach would be to target financial assistance to cooperatively-owned, "community" sized plants which have excessive anhydrous production capacity which could upgrade farm produced lower-proof alcohol as well as produce anhydrous alcohol directly from locally-grown unprocessed feedstocks.

Projected Cost of Producing Ethanol

The ethanol production process and necessary equipment has been described in another section of the report. For the purpose of budgeting the cost of producing ethanol, three plant sizes were chosen - 60,000, 1,000,000, and 3,000,000 gallons of ethanol annual production capacity.

The projected investment required for each of these plants is tabulated in Table 1. The amount of capital required ranges from \$217,000 for the 60,000 gallon plant to \$4.8 million for the 3 million gallon plant. These figures do not include the cost of land and buildings to house the plant.

Annualized cost are shown in the lower portion of Table 1. The capital was recovered over a 10 year period at 13% interest. Insurance and property tax were figured at 1.5% and 2.0% of the investment cost, respectively.

The projected cost of producing a gallon of ethanol by plant size is shown in Table 2. An ethanol conversion ratio of 2.0 gallons per bushel of corn was assumed for the 60,000 gallon plant. For the larger sized plants the conversion ratio is expected to be as high as 2.3 to 2.4 gallons per bushel of corn. Higher yields should be obtainable for the larger plants because of more sophisticated equipment which will enable a greater degree of process control. Corn is used as the feedstock with a value of \$3.00 per bushel. Present market conditions indicate \$3.50 corn because the market has reflected advances in recent weeks as a result of hot-dry weather conditions prevailing in corn producing areas. In order to make the plants eligible for the 10 percent "Energy Investment Tax Credit", corn stover was chosen as the energy source to heat the boilers. The tax credit is not available if oil, natural gas, or a product of oil or natural gas is used as the energy source.

The variable cost of producing a gallon of ethanol ranges from \$2.06 for the 60,000 gallon plant to \$1.64 for the 3 million gallon plant. It is interesting to note that the cost of feedstock comprises more than 70% of the variable cost. This indicates that the cost of producing a gallon of ethanol will be very sensitive to changes in the cost of the feedstock.

Fixed cost per gallon of ethanol ranges from \$.79 for the 60,000 gallon plant to \$.35 for the 3,000,000 gallon plant.

During the fermentation process, a by-product known as "distillers dried grain" is produced. This product, which is rich in protein, has most value if it is dried before being fed to livestock. The value of this product as feed for animals has been fully discussed in another section of this report. The budgets presented here include the cost of handling and drying this product to about 10% moisture.

Distillers dried grain is normally priced 35% higher than corn, but this relationship has prevailed under relatively low levels of alcohol production. Assuming that grains are used as the feedstock for ethanol production, the price of distillers dried grain deteriorates rapidly at ethanol production levels of more than 1 billion gallons yearly. Consider the results of a study conducted by the Solar Energy Research Institute: ^{1/}

Variable	1983 Baseline	1983 Production (millions gal./yr.)		
		500	1,000	3,000
Corn (\$/bu)	2.47	2.53	2.59	2.74
Soybeans (\$/bu)	7.05	7.07	7.08	7.14
Distillers grain (\$/ton)	132.80	114.50	95.79	21.22
Soybean meal (\$/ton)	200.42	193.74	187.01	160.34

Note that the value of distillers dried grain declines rapidly, 28% and 84% respectively, as the level of ethanol production increases to 1 billion and 3 billion gallons yearly. Potential investors in alcohol fuel producing equipment should keep this price relationship in mind when figuring the value of this by-product.

In the budgets presented here, distillers dried grain credits were computed under market relationships that prevail under low levels of alcohol production. The value of this product was estimated to range from \$.61 to \$.71 per gallon of ethanol produced.

Finally the net cost of producing a gallon of ethanol was estimated as follows:

Plant Capacity	\$/gallon
60,000	2.24
1,000,000	1.48
3,000,000	1.28

The effect of plant size and variations in the price of corn on the cost of producing a gallon of ethanol is presented in Table 3. Production cost can be reduced from 33% to 43% by building larger sized plants. The 60,000 gallon capacity plant is not very economic when compared with the plants of larger capacity. If the price of corn increases from \$3 to \$4 per bushel, the cost of producing a gallon of ethanol would increase about 33%.

^{1/} Solar Energy Research Institute, The Agricultural Sector Impacts of Making Ethanol from Grain, March 1980.

Table 1. Projected Investment in Ethanol Plants of Selected Capacities and Annualized Costs^{1/}

Item	Plant Capacity (gallons per year)		
	60,000	1,000,000	3,000,000
Raw material preparation, conversion and fermentation	\$ 25,900	\$ 650,000	\$1,368,000
Distillation and dehydration	26,900	350,000	1,136,000
Evaporators	83,100	287,000	716,000
Stillage and ethanol storage (30 days) ^{2/}	19,600	98,000	200,000
Electrical, instrumentation, pumps and laboratory equipment	-	155,000	400,000
Pumps and mechanical equipment	10,800	-	-
Erection and start-up	14,600	125,000	190,000
Sub-total	180,900	1,665,000	4,010,000
20% contingency	36,180	333,000	802,000
Total capital investment	217,080	1,998,000	4,812,000
Capital recovery (10 years @ 13% interest)	40,006	368,213	886,800
Insurance (1.5% of investment)	3,256	29,970	72,180
Property tax (2% of investment)	4,342	39,960	96,240
Total annual fixed cost	47,604	438,143	1,055,220

^{1/} November, 1979 dollars

^{2/} Thirty day storage capacities are:

60,000 gallon plant . . . 6,000 gallons
 1,000,000 gallon plant . . . 90,900 gallons
 3,000,000 gallon plant . . . 272,700 gallons

Table 2. Projected Cost of Producing a Gallon of Ethanol by Plant Size

Item	Plant Capacity (gallons per year)		
	60,000	1,000,000	3,000,000
Gallons of ethanol per bushel of corn	2.0	2.3	2.4
Pounds of distillers dried grain yield per gallon of ethanol	8.4	9.8	9.8
Corn @ \$3.00 per bushel	\$1.50	\$1.31	\$1.25
Chemicals, solvents, acid, yeast, etc.	.07	.03	.02
Grain milling and processing	.04	.05	.04
Electricity @ 4.5¢ per KWH	.05	.04	.04
Process water and cooling water	.01	.01	.01
Corn stover for boiler @ \$20 per ton ^{1/}	.13	.09	.08
Labor @ \$5 per hour	.10	.11	.10
Labor overhead ^{2/}	.03	.03	.03
Maintenance	.04	.03	.03
Miscellaneous	.09	.05	.04
Total variable cost per gallon	2.06	1.75	1.64
Fixed cost per gallon	.79	.44	.35
Less distillers dry grain credit ^{3/}	(.61)	(.71)	(.71)
Net cost per gallon	2.24	1.48	1.28

^{1/} Requirements estimated as follows:

60,000 gallon capacity . . . 400 tons
 1,000,000 gallon capacity . . . 4,667 tons
 3,000,000 gallon capacity . . . 12,000 tons

^{2/} Includes FICA match, industrial insurance, unemployment insurance and fringe benefits.

^{3/} 28% protein and 10% moisture. DDG is priced at \$145 per ton (corn price per ton x 135%)

Table 3. The Effect of Corn Price and Plant Size on the Cost of Producing a Gallon of Ethanol

Price of Corn, \$/bu	Plant Capacity (gallons per Year)		
	60,000	1,000,000	3,000,000
\$2.50	\$2.09	\$1.38	\$1.19
2.75	2.17	1.43	1.24
3.00	2.24	1.48	1.28
3.25	2.32	1.53	1.33
3.50	2.39	1.58	1.37
3.75	2.47	1.63	1.42
4.00	2.54	1.68	1.46
4.25	2.62	1.72	1.51

Ethanol Production

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Summary

- Fuel grade ethanol can be produced from sugar or starch crops by fermentation and distillation.
- Since distillation cannot remove all water from alcohol, most on-farm stills produce 190 proof ethanol or less.
- Production plants require multiple fermentation tanks in order to have a continuous supply of fermented mash for distillation.
- The "Fuel from Farms" publication listed as a reference at the end of this article describes a small ethanol plant and lists the equipment required.
- The heat required for ethanol production may be supplied by biomass, wood, coal, solar, LP gas, natural gas or geothermal sources.
- Safety is of great importance in the planning and operation of an ethanol plant. National Fire Protection Association codes will furnish most of the information needed regarding safe practices in wiring, lighting, insulation, etc.
- USDA Farmers Home Administration offices have instructions on processing FmHA loans for plants that give details on performance guarantees that should appear in construction contracts.

The discussions today are concerned with fuel for and from farms. American agriculture is dependent upon foreign crude oil supplies at the present time. Our agricultural production could be seriously curtailed if crude oil supplies were cut off. Alcohol is a liquid fuel that can serve as a substitute for at least some of the petroleum based fuels we use. The Biomass Energy and Alcohol Fuels Act passed in June of this year as a part of the Energy Security Act was intended to promote production of fuel with present technology and with newly developing technologies. The Department of Agriculture was authorized to guarantee 600 million dollars in loans over the next two years. The Department of Energy was authorized to operate another 600 million dollars in biomass programs, including fuel alcohol projects.