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EVIDENCE ON THE ECONOMIC FEASIBILITY
OF SMALL-SCALE FUEL ALCOHOL PRODUCTION*

by

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Abstract: Findings from interdisciplinary research at South Dakota State University with a pilot fuel alcohol plant are presented. That research and other studies indicate that small plants will have difficulty in competing with larger plants and in supplying fuel that is competitive in cost with petroleum-based fuels.

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Evidence on the Economic Feasibility
of Small-scale Fuel Alcohol Production

Interest in producing fuel alcohol from agricultural crops ran high in the late 1970's. As a result of demands for information, U.S. extension and agricultural experiment station personnel conducted several evaluations of the probable economic prospects for large-scale plants capable of producing 200 proof alcohol (e.g., Converse, et al.; Daves; Kendrick and Murray; Litterman, Eidman, and Jensen). Those studies proved highly useful in placing in overall economic perspective the possibility of using biomass for liquid fuel. In addition, some recent policy oriented studies have shed light on the macro-economic implications of potential U.S. expansions in fuel alcohol and associated feed byproduct production (e.g., Meekhof, Gill, and Tyner; Sanderson; Webb).

These studies have helped fill information voids faced by Land Grant and U.S.D.A. economists asked to provide feasibility and public policy information on fuel alcohol production to client groups. However, there has been little solid, research-based information on the economic feasibility of small- or community-scale fuel alcohol plants. Many farm and rural development groups have expressed strong interest in such small-scale plants, with the idea that local investors might own and manage the plants, that the feedstock could be locally produced, and that the fuel and feed byproduct might be utilized locally. Some extension oriented materials (Dobbs; Doering) have been developed to identify key economic considerations for small-scale plants. Also, in late 1980, South Dakota State University (S.D.S.U.) and the University of Nebraska each released economic studies of small-scale plants (Atwood and Fischer; Hutchinson and Dobbs). At that time, however,

the University of Nebraska had no experimental plant of its own on which to base cost estimates and the cost data from S.D.S.U.'s experimental alcohol plant was very preliminary.

This paper is intended to report progress on multi-disciplinary research carried on at S.D.S.U. since 1979, using data from the operation of a small-scale fuel alcohol plant located on the campus. The focus is on economic results to date, since technical findings are being reported elsewhere by microbiology, agricultural engineering, and dairy science members of the research team (Schingoethe, Clark; and Voelker; Stampe and Chisholm; Westby and Gibbons). The study reported herein, jointly funded by the S.D.S.U. Agricultural Experiment Station and a U.S.D.A. competitive grant, should contribute significantly to filling an informational void that has existed on the feasibility of small- or community-scale fuel alcohol plants.

Cost of production findings to date are reported in the following section of the paper. These findings are compared with other (limited) available evidence on small-scale plants and with estimates (from other studies) of costs of producing fuel alcohol from large-scale plants. The next section contains an analysis of the marketing and territorial implications of establishing small-scale plants in grain-livestock farming regions. Preliminary conclusions on economic prospects for small-scale plants using grain feedstock are contained in the final section of the paper.

Costs of Fuel from Small-scale Plants

Costs of fuel alcohol from hypothetical cooperative or commercial fuel alcohol plants patterned after the experimental facility at S.D.S.U. have been estimated for various levels of annual output capacity. At S.D.S.U.,

corn has been used as the principal feedstock and 180 to 190 proof alcohol is normally produced, along with distillers wet grain (DWG). The latter results from centrifuging whole stillage to reduce moisture content of the feed byproduct to about 70%.

Research thus far indicates that costs per gallon of 180-190 proof fuel alcohol--net of feed byproduct credits--may be about \$3.90 for a small plant producing 9,000 to 10,000 gallons per year, about \$2.70 for 49,000 gallons per year, and about \$1.80 for 175,000 gallons per year (costs in 1981 dollars).^{1/} There are clearly some economies of size involved, due in part to greater utilization of various components of the plant as annual output goes up. While some additional capital investments are required to make successive, large increases in annual output with alcohol plants similar to that at S.D.S.U., some components require little or no change up to certain points. For example, the same size of distillation column could be used for annual output up to around 175,000 gallons.

Several other studies shed additional light on probable economies of size associated with fuel alcohol production. These are summarized in Table 1. The data indicate that economies exist in going from "farm-scale" levels of production (around 10,000 gallons per year) to "community-scale" levels (100,000 to 400,000 gallons per year). Besides more intensive utilization of capital equipment when output capacity is expanded, there are also energy, labor, and other operating efficiencies associated with the continuous batch operations that cannot be fully captured in low-volume, discontinuous batch

^{1/} More details of the cost calculations are contained in Hutchinson and Dobbs and in a forthcoming South Dakota State University Agricultural Experiment Station bulletin by Hoffman and Dobbs.

Table 1. Fuel Alcohol Production Costs at Alternative Levels of Annual Output.

Cost estimate source	Assumed annual output (185 proof equivalent) ^{1/}	Costs per gallon (1981 dollars; 185 proof equivalent) ^{2/}
	-----gallons-----	-----dollars-----
1. S. Dak. State Univ. ^{3/}	9,300	3.87
2. Univ. of Nebraska ^{4/}	13,000	3.28
3. Univ. of Nebraska ^{4/}	43,200	2.44
4. S. Dak. State Univ. ^{5/}	48,863	2.69
5. U.S. Department of Agriculture ^{6/}	61,600	1.45
6. S. Dak. State Univ. ^{5/}	175,074	1.78
7. U.S. Department of Agriculture ^{6/}	369,700	1.22
8. Solar Energy Research Institute ^{7/}	410,800	1.27
9. U.S. Department of Agriculture ^{6/}	1,081,000	1.25
10. E.S.C.S., U.S.D.A. ^{8/}	10,810,800	1.54
11. E.S.C.S., U.S.D.A. ^{8/}	43,243,300	1.27

^{1/} Some studies presented output in approximately 185 proof terms, while others stated annual output in 190 or 200 proof terms. Adjustments to 185 proof equivalents were made, where necessary, using relative BTU content values.

^{2/} Cost estimates from various studies were adjusted for inflation to 1981 levels by using the Producer Price Index for Processed Foods and Feeds. These are net of byproduct credits.

^{3/} Source: Hutchinson and Dobbs, p. 15.

^{4/} Source: Atwood and Fischer, p. 26.

^{5/} Source: Forthcoming South Dakota State University Agricultural Experiment Station Bulletin by Hoffman and Dobbs.

^{6/} Source: U.S. Department of Agriculture, pp. VIII-11 and VIII-12.

^{7/} Source: Jantzen and McKinnon, p. 7.

^{8/} Source: Meekhof, Gill, and Tyner, p. 15.

operations.

Data presented here are more ambiguous about economies of size as one moves from "community-scale" to medium-scale (e.g., 1 million to 10 million gallons of annual production) and large-scale (more than 10 million gallons) operations. Certain economies have probably been masked by the way in which some of the cost conversions were made and presented in Table 1. For one thing, the original sources stated cost estimates #9, #10, and #11 in 200 proof terms. Conversions to costs in 185 proof terms were strictly on a percentage basis; i.e., it was assumed that 185 proof alcohol in those plants would cost 92.5% as much (per gallon) to produce as would 200 proof alcohol. In reality, going from 185 to 200 proof is a very expensive part of the overall process, and it is currently a relatively more costly process in small than in large alcohol plants.

Secondly, costs published for medium- to large-scale operations (such as for #10 and #11 in Table 1) are generally based upon the assumption that the feed byproduct is dried. The resulting byproduct is a much easier to handle and more marketable commodity than the whole stillage or distillers wet grain products likely to be produced in most small-scale plants. Therefore, the byproduct credits implied in cost estimates shown in Table 1 are more likely to be fully realized in the medium- and large-scale than in the small-scale operations.

For both of the above reasons, cost estimates may be somewhat over-stated for the larger-scale alcohol production operations--relative to the smaller-scale operations. Our focus has been primarily on the smaller-scale operations of less than a quarter of a million gallons annual output, in which it is assumed that approximately 185 or lower proof alcohol is produced. We have avoided a detailed analysis of large- and medium-scale operations.

Sensitivity analyses have been carried out to determine the effects of

assumptions about alcohol yield per bushel of corn, price of corn, and interest rates on alcohol costs per gallon. Costs per gallon in those analyses range from \$1.59 to \$2.30.

Marketing and Territorial Considerations for Small-scale Plants

One of the often-stated arguments supporting the economic feasibility of fuel alcohol plants in midwestern States is the advantage of locations near the major input (corn) and near farming operations which may utilize the fuel alcohol and feed byproduct outputs. However, little work has previously been done to flesh out the precise input supply and product marketing territorial implications of community- or small-scale plants. This section of the paper reports briefly on alcohol plant "case study" findings on: (1) the number of farms required to supply the corn feedstock; (2) the number of farms required to use the fuel alcohol produced annually; and (3) the number of beef farms required to consume the feed byproduct produced each week. Moody County, in eastern South Dakota, has been used as the case territory for operation of the hypothetical alcohol plant, at two different assigned levels of annual capacity. Although some of this analysis is still underway, results to date are summarized in Table 2.

It is clear that the corn acreage required to provide feedstock for the hypothesized plant is quite small for production of either 49,000 or 175,000 gallons of alcohol per year. A few surrounding farms could easily provide the necessary feedstock. Of course, to the extent farmers utilize a portion of the corn they produce for their own livestock feed, the number of farms required as suppliers to the plant would increase.

A critical problem at the present time for small-scale plants is the lack of viable markets for "wet" (non-anhydrous, or less than 200 proof) alcohol.

Table 2. Input Supply Acreage and Marketing Territory for Hypothetical Fuel Alcohol Plant in Eastern South Dakota.

Plant size	To provide the corn feedstock		To utilize the fuel alcohol		To utilize distillers wet grain byproduct with beef	
	No. of ^{1/} farms	No. of acres	No. of farms ^{2/}	No. of ^{3/} sq. miles	No. of ^{4/} farms	No. of ^{5/} sq. miles
#1. Approx. 49,000 gals of 185 proof alcohol annually	1.5	215	47	31	9	20
#2. Approx. 175,000 gals of 185 proof alcohol annually	5.5	771	168	112	32	72

1/ Farms in case county averaged 141 acres of corn and 83 bu./acre.

2/ Farms in case county used an average of 2,140 gallons of gasoline and 2,082 gallons of diesel fuel in 1978. It is here assumed that some farmers would replace 25% of their annual gasoline usage and 10% of their diesel fuel usage with alcohol. There are 1.5 farms/sq. mile.

3/ This assumes that the farms nearest the alcohol plant utilize the alcohol fuel.

4/ Farms fattening beef in case county average 81 head on feed. There are about four beef fattening farms for every 9 square miles.

5/ This assumes that the beef fattening farms nearest the alcohol plant rely on DWG from the plant.

The wet alcohol cannot be mixed with gasoline to form gasohol. Although engineering tests have demonstrated possibilities for conversion of gasoline and diesel equipment to run at least partially on wet alcohol, there remain many inconveniences, unknowns about engine wear, and questions of economy. We have assumed in calculations for Table 2 that these problems might be sufficiently resolved in the near future for the farms nearest the alcohol plant to replace 10% of their annual diesel fuel usage and 25% of their annual gasoline usage with 185 proof alcohol. In that case, it would require 47 and 168 farms--scattered over 31 and 112 sq. miles--to utilize the fuel product of the 49,000-gallon and 175,000-gallon plant sizes, respectively.^{2/}

Disposal of the DWG byproduct may be less of a problem, though not every beef or dairy operator will wish (or be set up) to handle this high-moisture byproduct. Ideally, the kind of small-scale plant referred to in this paper would be immediately adjacent to and integrated with a very large beef feedlot or dairy operation which could continuously utilize all of the plant byproduct. If this is not possible, a cooperative or commercial marketing operation will be required in which farmers in the surrounding area either pick up the high protein feed at the plant or have it delivered to them. As indicated in Table 2, this could require a marketing or distribution territory for the 175,000-gallon plant of over 70 sq. miles when delivering DWG to beef fattening farms. This would be the situation in the "case study" county if the farmers closest to the plant decided to use DWG in lieu of soybean meal or other protein supplements.

^{2/} Alcohol required for displacement of conventional fuel was calculated on the basis of SDSU agricultural engineering experiments. At present, other fuel alcohol utilization assumptions are also being analyzed.

Cost of fuel and feed delivery could be significant for a small-scale plant if it is not adjacent to a large feedlot or dairy operation. Under one particular set of assumptions--for a 175,000-gallon plant in which fuel and feed delivery trucks are purchased--delivery costs were estimated to be approximately 9¢/gal. of alcohol; this consists of about 2¢/gal. for fuel delivery and over 7¢/gal. of alcohol for feed byproduct delivery.

Tentative Conclusions on Economic Prospects for Small-scale Alcohol Plants

This paper contains a highly condensed version of results to date of research carried on since 1979 at South Dakota State University on the economics of small-scale fuel alcohol plants. Data from research at S.D.S.U. and elsewhere support the argument that there are economies of size associated with fuel alcohol production. Diseconomies of small-scale plants may in some cases be offset by lower transportation costs for both the corn feedstock and the fuel and high-protein feed products. However, our research shows that the product delivery costs are not necessarily negligible for small-scale plants, particularly if existing, under-utilized farmer or cooperatively owned equipment and labor are not available for feed byproduct delivery.

It appears desirable for so-called community-scale plants to be as large as available technology, capital, and management (including marketing) capacity permit. In the case of a plant utilizing a distillation unit like that at S.D.S.U., production of about 175,000 gallons of alcohol per year should be the goal. With larger distillation units and greater fermentation capacity, community-scale plants might well be striving for an annual output of 500,000 or 1,000,000 gallons. However, the larger the plant, the more critical it becomes--from a fuel marketing standpoint--to achieve production of anhydrous alcohol.

Near-term prospects for economical, non-subsidized small-scale fuel alcohol production based upon corn feedstock do not appear especially bright. Although small-scale plants may prove feasible in some instances, it is likely that such plants will have a very difficult time in the immediate future--both in competing with large-scale feed-food-fuel complexes and in economically producing anhydrous alcohol for the gasohol market. A good deal more research and development will be required to bring down processing costs in small-scale plants. Even then, profitability may require continuation of "low" corn prices, substantial government subsidies, much higher prices on petroleum-based fuels, or feedstocks other than grain.

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