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Equipment requirements and economic considerations in alcohol fuel manufacture

Bruce E. Dale[1/]

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Quick Facts

- A variety of equipment and supplies is required for alcohol fuel production.
- Stillage use and feedstock costs are critical to the economics of alcohol fuels.
- Anhydrous alcohol probably is required for off-farm markets.
- Equipment warranties may be a problem if alcohol fuel is used.
- Current tax incentives favor alcohol fuels; however, these should not be relied upon.
- This is the fifth in a series of five information sheets on alcohol fuels; other information sheets include the basics of alcohol fuel production, feedstocks for alcohol fuels, use of alcohol fuel by-products, and alcohol distillation.

The production and marketing of alcohol fuel is as complex and difficult as any other production system. This information sheet will cover only a few of the most basic equipment and economic questions that must be answered by individuals interested in producing alcohol fuels.

Facility Resources

Is well water with a capacity of 125 gallons* per day per gallon* per day of alcohol capacity available or, alternatively, is well water at 25 gallons per day per gallon per day of alcohol available plus a cooling pond of a minimum depth of 6 feet* and a surface area of 2,000 square feet per gallon* of alcohol per hour? Is land area available for storage of feedstock, alcohol production and by-products? Are buildings available to house portions of the equipment (depending on the climate)? Are facilities available to store enzymes, yeast, chemicals and boiler fuel? Is insurance coverage certified for the buildings and equipment? Is a hammermill or other grinding equipment available? Are scales or other weighing devices available?

Process Equipment and Specifications

The boiler must be able to supply peak heat requirements for the process and may require air pollution control equipment, a deaerator, feedwater treatment facilities and an automatic feedwater pump. The cooking tank must have a capacity of 15 gallons per bushel* of grain plus 25 percent. In addition, the tank must have a sloped or coned bottom for drainage and must have an agitator, a steam sparger and a heating system. The heat required is

$$= \frac{\text{gallons of mash} \times 8.3 \times 150}{\text{hours to heat}} = \text{Btu/hr}$$

The fermentation tank must have a capacity of 30 gallons per bushel of grain plus 25 percent and must be sealed from the atmosphere and provided with a CO_2 vent. The fermentation system also may require cooking coils, an agitator and a transfer pump. Furthermore, the tank must be sterilizable and should have a sloped or coned bottom with a bottom drain and rounded corners. Instruments required include pH meters or indicators, temperature indicators or controllers, hydrometer (for testing proof), and starch and sugar testers.

Some of the distillation equipment requirements may be as follows: stainless steel or heavy mild steel construction, a heat exchanger or steam sparger to heat the beer, liquid level and temperature indicators and controllers, accessibility for cleaning, a fusel oil removal pump, a condenser with cold water coils, a pressure gauge and a safety valve. If alcohol greater than 190 proof is to be produced, a proven dehydration system must be provided.

A means for adding denaturant acceptable to the Bureau of Alcohol, Tobacco and Firearms (BATF) also must be provided. Alcohol may be stored in mild steel containers equipped with a dessicant-type vent cap. Alcohol metering equipment required by BATF is necessary. Stillage storage capacity equal to the batch size or daily production is required. A refrigeration system may be needed if stillage production does not occur every day and if stillage is fed to high-production animals. A stillage agitator and unloading pump also are needed as is adequate drying equipment if the stillage is to be dried. Safety equipment requirements include fire protection equipment, product security requirements of BATF, federal and state personnel safety regulations and adequate lighting.

Process Performance Specifications

Some of the important performance features of an alcohol fuel process are as follows: How many Btu of fuel are required per gallon* of alcohol produced? How many gallons of alcohol are produced per bushel or per ton* of feedstock? What is the daily (or hourly, or yearly) alcohol production capacity? How are the performance specifications certified (Manufacturer furnishes performance bond, design and

[1/] *Bruce E. Dale, CSU assistant professor, biochemical engineering (6/1/82)*

supervision of construction by registered engineer or other professional, etc.)?

Process Input Requirements

In addition, the quantities, suppliers and costs per gallon of alcohol produced of the following process inputs must be specified: boiler feedwater, liquefying enzyme, saccharifying enzyme, yeast, denaturant required by BATF, acid and base. A weekly schedule detailing the labor requirements to prepare the feedstock, cook, ferment, distill, dispose of by-product, fire the boiler, etc., also should be prepared.

The feedstock cost (price of grain divided by the expected yield) also must be estimated over the life of the alcohol plant. Alternate feedstock use also should be considered. Process electrical requirements of motors greater than about one horsepower should be estimated. Some electricity consumers include the grinder, conveyors, pumps, agitators, air compressors, lights, etc. One kwh per horsepower hour of operation can be assumed and the electrical rate used to compute the electrical cost per gallon of alcohol produced. Purchased water for processing and cooling also should be estimated. Waste or low-cost sources of process heat should be sought.

Product and By-product Utilization

On-farm use of the alcohol fuel in automobiles, trucks, gasoline and diesel tractors and stationary engines must be estimated. For each on-farm alcohol fuel consumer, the gallon-per-year requirements should be known as should the alcohol proof needed and whether engine modifications will be necessary. Although available data are contradictory, it probably can be assumed that 1 gallon of alcohol will replace about 1 gallon* of gasoline or diesel fuel. If some alcohol is to be sold off the farm, the intended consumer's proof requirements and yearly consumption should be firmly established in advance.

By-product stillage also deserves careful attention. The form of the stillage (wet or dried) must be determined as must the quantity per day available. If wet stillage is fed, will the animal water intake exceed about 1 gallon per 2 pounds* of solid feed? A mature cow can consume the stillage from about 1 gallon of ethanol production in one day. For feeder calves and hogs, the rate is one animal per 0.7 and 0.4 gallons of alcohol per day, respectively. The rate for poultry is one animal per 0.05 gallons of alcohol per day. If all stillage is not consumed on the farm, other consumers must be firmly established and their feed requirements determined. The value (per gallon wet or per pound dry) of the stillage also must be estimated per gallon of alcohol produced. Finally, markets and prices for the CO_2 product should be explored.

Summary of Operating Costs and Revenues

Once these data are available, it will be possible to summarize the total costs per gallon of alcohol produced. Such a summary for typical costs is provided in Figure 1. Obviously, there are no correct answers for operating costs except that the cost per gallon of alcohol should be less than its value (including such intangibles as degree of self-sufficiency) to the farmer or producer.

Some Basic Considerations

Proper use of stillage in animal feeding is critical to the economic success of an alcohol fuel plant. The alcohol production cost also is sharply dependent on the feedstock cost: If corn goes to $4 a bushel, the feedstock cost will be $1.60 per gallon. This is a critical point because it could mean an idle alcohol plant.

Anhydrous alcohol probably is required to assure an off-farm market. This increases the production cost by 2 to 5 cents per gallon, but a 15 cents-per-gallon difference in the selling price of anhydrous makes it attractive. Alcohol plant operation is fairly complicated. Warranties may be a problem if alcohol is used in farm machinery. Tax exemptions are important to the economics of alcohol fuel; however, these laws and exemptions can change at any time and probably should not be relied upon. Alcohol can be considered as an octane booster for unleaded gasoline and should be marketed off-farm as such.

**To convert to metrics, use the following conversions: 1 gallon = 3.8 liters; 1 foot = 30 centimeters; 1 square foot = .09 square meter; 1 bushel = .04 cubic meter; 1 ton = 907 kilograms; 1 pound = .45 kilogram.*

Figure 1: Dollars per gallon of alcohol.*

Direct costs			
Feedstock (corn grain, $2.50 per bushel)		$1.00	
Less credit for stillage	0.30		
Less credit for CO_2	0.01	0.31	
Net feedstock cost			0.69
Labor			0.08
Fuel			0.15
Electricity			0.05
Water (purchased)			?
Supplies (yeasts, enzymes, denaturant)			0.15
Other (storage, etc.)			0.02
Total direct costs			1.15
Indirect costs			
Maintenance			0.02
Supervision			0.02
Taxes (property)			0.03
Insurance			0.06
Depreciation			
Total investment $1.60 per annual gallon 20 years			0.08
Total indirect costs			0.21
Total costs — direct plus indirect			$1.36

**These are composite estimates only; detailed analyses are required for specific cases.*