Chapter 1

Principles of Alcohol Production

Two types of alcohol will work equally well for fuel. They are ethanol and methanol. In this e-book, we refer to ethanol when we speak of alcohol, unless we specifically say methanol.

Alcohol content is measured in proof. The proof is twice the percent. Thus 100 proof alcohol is 50% alcohol and 50% water. 200 proof alcohol is 100% alcohol.

Ethanol

Ethanol is also called ethyl alcohol or grain alcohol. All industrial ethanol was produced from grain fermentation until the industry discovered they could make it cheaper from petroleum. This was in pre-OPEC days.

The ethanol industry was geared to producing high-purity industrial alcohol or drinkable alcohol. For this reason, they were locked in to using stainless steel and copper equipment, and also to the process of distillation. Distillation served not only to separate the alcohol from the water, but to separate other impurities from the alcohol - impurities that might make a person sick if he drank it.

That is why the fuel alcohol industry started with technology developed for the liquor and industrial alcohol industry. That was all the technology there was. As more people experiment with making alcohol strictly for fuel, ways will quickly be found to do it cheaper when we get away from the traditional thinking of the old distillers. Ethanol can be made from anything containing starch or sugar. The higher the starch or sugar content, the higher is the alcohol potential of the crop.

Cellulose in stalks, wood or paper can also be used to make ethanol, but the process is expensive with present technology.

Starch is the most important storage form of carbohydrates in the plant kingdom. However, another significant form is inulin. Artichokes, Dahlias and Dandelions all store carbohydrates as inulin. The inulin is made up of fructose molecules instead of glucose, as in starch.

It has been found that most of the carbohydrate is stored in the Jerusalem artichoke stem before the bulb starts to form. If it is stored as fructose, and if it does not change to inulin soon after harvesting, the fructose can be fermented as is. But if it is inulin, we know of no commercial, economical enzymes available to break down inulin. (Bitter almonds do contain inulinase.) The carbohydrate can be broken down with high heat and strong acid, but with a lot of energy input and 20% or more destruction of the sugar.

If the fructose in the stem is useable, the tops can be cut off and the bulb left in the ground to grow again.

Fermentation

Enzymes break down starch into simple sugars, and yeast ferments sugars into ethanol, giving off carbon dioxide gas as a by product. The process has been used since civilization began. Starch is made up of long chains of glucose molecules coiled together. The starch must be broken down into sugars that are only one or two molecules long for the yeast to feed on.

In the process described in this book, the liquefying enzyme breaks the chemical bonds at random inside the chain, producing shorter chains, or dextrins, as they are called.

The saccharifying enzyme works on the end of the chain only. It could take off the glucose molecules one by one from the ends of the starch chains and eventually would convert all the starch to sugar. The liquefying enzyme gives the saccharifying enzyme more ends to work on, however, and speeds up the process considerably.

There are other monosaccharicles (one molecule only) besides glucose, but glucose is the most common.

Disaccharides are two monosaccharicles joined together.
Table sugar (sucrose) is one glucose and one fructose molecule.
Milk sugar, or lactose, is one galactose and one glucose joined together.
Maltose is a disaccharide made up of two glucoses.
Yeast can ferment glucose, maltose, and sucrose rapidly, and galactose and lactose slowly.

Enzymes are proteins that change a chemical entity, or molecule, of one substance into a molecule of something else. The enzyme acts on the substance, but is not used up. The enzyme changes one molecule, then detaches from it and works on another molecule. A few molecules of enzyme will eventually get around to all the molecules of whatever it works on, but the right amount of enzyme will do the job faster.

People have enzymes in their mouths that break down starch. If you hold a piece of soda cracker in your mouth, it will begin to taste sweet. This is exactly the process that takes place in the mash. Enzymes are highly specialized. Each one does only one thing. In this process, one enzyme chops up the long chains of starch into shorter chains. Another enzyme changes the short chains of starch into sugar.

Enzymes, like humans, function within a fairly narrow range of physical conditions. They must have a certain temperature and degree of acidity. They can be rendered useless by chemical poisons, heavy metals, high heat, etc. Each enzyme has a certain set of conditions under which it works best.

When grain sprouts, enzymes change the starch into sugar that the new plant can use for food. Before enzymes were avail-able for purchase, grain was sprouted, or .malted,. then dried, ground, and mixed with the rest of the grain as a source of enzymes.

This method can still be used, but it is quicker to use commercially available enzymes. Starch can be broken down without enzymes with strong acid and high heat. However, the process takes a lot of time and energy, and then the excess acid has to be neutralized with alkali before fermentation can take place. After the starch is changed to sugar by enzymes, yeast changes the sugar to alcohol in the absence of air. The process is called fermentation, and it takes about 21/2 days.

Carbon dioxide gas is produced as the yeast changes sugar to Alcohol. A bushel of grain yields by weight about 1/3 carbon dioxide, 1/3 ethanol, and 1/3 high-protein residue. The carbon dioxide gas can be allowed to escape through an air lock or a one-way vent valve, or it can be collected and used.

The fermented mash contains about 10% alcohol. At this concentration, the alcohol begins to kill the yeast. The batching should be done so that all the sugar and starch in the mash will have been used up by the time this10%alcohol content is reached. It takes 13 pounds of sugar to yield 1 gallon of 190 proof ethanol. The amount of raw material in the mash will be determined by its starch and sugar content. In order to get fuel alcohol, the alcohol content must be increased from 10% to 90 - 95%. At present, the only workable way to do this is to distill it. In the future, other ways may be discovered which take advantage of the different properties of alcohol and water.

Distillation

The temperature of the water-alcohol mixture is raised to above the boiling point of ethanol (173 degrees F at sea level) but below the boiling point of water (212 degrees F). The alcohol changes to vapor and rises in the column, but some of the water vaporizes with it.

In a simple still, like that used by the moon shiner, the distillate is about half water. If this is re-distilled, a higher concentration of alcohol can be obtained, up to about 195 proof. Further separation cannot be obtained by distillation because of a quirk in the chemistry of the mixture. (Water and alcohol form an azeotrope at this point.) The final fraction of water must be removed by other methods, if this is necessary.

Farm alcohol plants can produce 190 to 192 proof alcohol with one pass through a still equipped with a reflux column, which is a device for making the mixture of liquids vaporize, condense, then re-vaporize over and over until the alcohol is nearly free of water.

In summary, the starch is changed to sugar by enzymes. The yeast changes the sugar to alcohol during fermentation, giving off carbon dioxide gas and leaving a high-protein residue in the mash. The mash contains about 10% alcohol after fermentation. It is then distilled to make a fuel alcohol that is 160 to 190 proof, or 80 to 95% alcohol.

After the mash has been distilled, the protein and the water are left. The water can be reused after the protein is separated, or the entire stillage can be flowed over straw or hay and fed to livestock.

Methanol

Methanol, also called methyl alcohol or wood alcohol, works just as well as ethanol for fuel, but the process for making it is completely different. This book does not tell you how to make methanol.

Methanol is a highly poisonous liquid. It will kill you if you drink it, and it can kill you if it soaks into the skin.

Methanol is made by heating wood wastes, stalks, etc., under relatively low heat and high pressure and then purifying the product by fractionating columns. It can be made from material that is not suited to ethanol production, but if grains, for instance were used to make methanol, all the protein would be destroyed. Methanol can also be made from coal. Both ethanol and methanol have their place in farm fuel plants.

Chapter Two

Measurements and Calculations

This chapter is not intended to scare anyone. It is, however, a necessary evil. The tests described below are not hard to do - most are as simple as dipping a strip of paper in liquid and looking at the color.

We suggest you read through it without trying to absorb all of it, then refer to it when the test is called for in the instructions. Temperature affects the test results. The standard temperature is 60 degrees F., but room temperature is close enough. **pH** is a measure of acidity of alkalinity on a scale of 0 to 14. The lower the pH number, the more acid the substance. The higher the pH, the more alkaline the solution. pH is measured by dipping a strip of pH paper into the liquid, then comparing the color with a standard color chart supplied with the paper. **Sugar content** can be read on paper strips similar to pH paper, or tested with tablets available at wine supply shops. In both tests, the color is matched to a standard and the concentration read. .Tes Tape and other strips like .Clinistix. for detecting glucose in urine are available at any drug store. Since it only reads up to 2% glucose, a 1 to 10 dilution should be made of the mash before using the low range paper. A one to ten dilution is made by mixing one drop of mash with 9 drops of water in a dry container and shaking. The strip is dipped, and the sugar concentration reading multiplied by 10 to get the concentration in your mash.

Starch can be detected with iodine. When starch is present, a drop of iodine added to the solution will turn it blue. This test solution should always be discarded after the iodine is added. If no starch is present, the solution will be reddish-brown. This test will show whether or not there are big clumps of starch still present during cooking, and after liquefaction, if all the starch has been changed to sugar. Ordinary tincture of iodine from the drug store works for this test. A sample of the mash should be diluted for the test, and the sample containing iodine should not be returned to the mash.

Alcohol proof is measured with a Proof and Tralle hydrometer, a glass device with a long calibrated stem. The hydrometer floats at different levels in liquid, depending on the liquids specific gravity (weight relative to water). The more alcohol is mixed with the water, the less the specific gravity will be. The alcohol proof is read on the marked stem where it emerges from the liquid.

Alcohol potential is read on a triple scale wine hydrometer that reads specific gravity, sugar content by weight on the Balling or Brix scale, and potential alcohol by volume. To determine alcohol content of fermented mash, a reading must be made on the alcohol scale before fermentation and after fermentation. The second reading is subtracted from the first to give the alcohol content of the fermented mash.

Proof test - Alcohol begins to burn at 100 proof. If a little alcohol in a spoon burns when a lighted match is passed across it, it is at least 100 proof. Caution:

take the sample away from the still before lighting the match. The blue flame is hard to see in a well lighted area.

Most of the equipment mentioned can be purchased at our website or at winemaking supply shops or ordered from a laboratory supply house. Your local hospital, clinic, or any type of laboratory can put you in touch with a laboratory supply company.

Enzyme Calculations

The amount of enzyme needed may be calculated on a dry starch basis (DSB) according to the concentration recommended by the manufacturer. One bushel of corn (56 lbs) containing 60% starch would contain 33.6 lbs starch. If the enzyme is needed in the concentration of .1%ofDSB, multiply.001 x 33.6 to get.0336 lbs of enzyme. If the enzyme weighs 10 lbs/gallon, divide .0336 by 10 to get .00336 gallons of enzyme. There are 128 ounces in a gallon. So .00336 x 128 gives .43 ounces, or just less than ½ ounce per bushel of corn.

Enzymes will have different brand names, depending on the manufacturer, and may used at different concentrations and temperatures. The enzyme supplier will furnish recommendations for the amount of enzyme needed and its temperature requirements. See appendix for a list of enzyme suppliers. Some farm alcohol makers use two to three times as much enzyme as recommended by the supplier. Use the tests at the end of each step to see if the desired results have been obtained. If not, the enzyme concentrations may need to be increased. There are other enzymes available to refine the process or for special cases. After you become familiar with the batching, consult your enzyme supplier about any special applications or problems. The following information shows enzyme concentration, sample costs per bushel, and yield of alcohol and byproducts.

Yeast dosage 2 pounds per 1000 gallons of mash.

1 Bushel of grain equals 56 pounds of grain.

1 Bushel of grain equals 2.8 gallons of alcohol

1 Bushel of grain equals 17 pounds of feed stock

Typical enzyme application cost per bushel of grain

	Dosage	Enzyme required	Cost of Application/Bu
Enzyme	(% owg)	Liters/Bu	U.S. Dollars/Bu
Alpha-amylase	0.07	0.018	0.066
Glucoamylase	0.08	0.02	0.072
			0.138

Alpha-amylase for Liquefaction and Glucoamylase for Saccharification

1 Bushel of grain yields 2.8 gallons of Ethanol

Therefore: ($0.138/Bu)/(2.8 gal/Bu) = **$0.049/gal of Ethanol**

Enzyme cost is $0.049 U.S. Dollars/ gal of Ethanol produced

Chapter Three

Step-By-Step Instructions For Making Ethanol

Preparation

A lot of producers use wheat, corn and milo to make ethanol. The process for making ethanol from other crops is the same except for preparation of the raw material. Potatoes, for instance, would have to be sliced or chopped first. If you are using something besides grains, you will have to experiment a little as to how to prepare the feedstock.

If the raw material contains sugar, not starch, the batch does not have to be treated with enzymes. The sugar, as in sugar cane, is ready to be changed to alcohol by the yeast without pretreatment. The batch may need to be cooked briefly to sterilize it before adding the yeast.

Crack wheat, corn, or milo with rollers or a hammer mill grinder. It's best to use rollers because fines in the mash are harder to separate from the liquid. If using corn, it should be screened to separate any whole kernels that escaped cracking. Whole corn kernels are likely to plug up columns.

Making The Mash

Materials Needed - Brewers yeast from the bakery; liquefying and saccaharifying enzymes (See appendix for suppliers); sulfuric acid diluted half and half with water (Caution: Always add the acid to the water, not the other way around); lime; a little sugar; plastic bag; thermometer to read up to 212 degrees F; pH paper; triple scale wine hydrometer that reads sugar content, potential alcohol, and specific gravity.

Batching

Start out using 10 gallons of water per bushel of grain. You will end up with 30 gallons of water per bushel of grain. The tank size varies depending on your application. However, for illustration purposes, we use a 4000 gallon tank.

Into a 4,000 gallon tank equipped with cooling coils and stirrer, put 1,000 gallons of hot water, then 100 bushels of ground grain. Inject live steam and bring to 212 degrees F. Calculate how much liquefying enzyme you need. Measure out the entire amount needed.

Add 1/5 of the liquefying enzyme you have measured out.

Boil the batch 30 minutes with stirring.

Cool to 195 degrees F. Add the rest of the liquefying enzyme measured out, and hold the batch at 195 degrees for one hour, with stirring.

Note: Follow the instructions of your enzyme manufacturer. Take a sample and add a drop of iodine to it. If a blue to purple color forms, the starch has not all been broken down. If the sample containing iodine is colorless or red-brown, all the starch has been broken down. It is possible to break down all the starch in this step so that it gives a negative iodine reaction. Stirring is very important to bring the enzyme in contact with the starch. This is probably the most difficult step in batching.

(If all the starch has not been broken down, the saccharifying enzyme will do it, in time, but you run the risk of not changing all the starch in the batch to sugar.) Cool quickly to 140 degrees F by adding cold water to the batch. Add sulfuric acid, diluted half with water, to bring the pH to 4.2 when tested with pH paper. (If you overshoot with the acid, bring the pH back up with lime.) Add the saccharifying enzyme. Maintain the batch at 140 degrees F for 30 minutes with stirring.

Add cold water until the temperature is about 80 degrees F. Test with the triple scale wine hydrometer. The specific gravity should be about 1.08. Record the potential alcohol reading for later use. if the sugar content is above 20%, add more water. Over 20% sugar will kill the yeast.

Fermentation

Add 2 to 21/2 pounds of brewers yeast for a 3,000 gallon batch. Crumble the yeast up in a little warm water in a plastic bag. Sprinkle in a little sugar and mix the yeast with your hands on the outside of the bag. As soon as the mixture starts to bubble, the yeast is growing and should be mixed in with the batch. (You can grow your own yeast in a super mash)

Maintain the batch at between 80 and 90 degrees F for 21/2 days with agitation. The tank should be covered with a pressure cap or air lock to keep the air out but let the carbon dioxide gas out. The fermentation itself will produce some heat. When the yeast is producing carbon dioxide, it is making alcohol.

You can use an augur pump to mix the batch. Any pump designed for high volume, low pressure, would be ideal.

After 21/2 days, take the potential alcohol reading on the triple scale wine hydrometer again. Subtract this figure from the first figure obtained before fermentation. The difference is the amount of alcohol in the batch now. The mash should contain between 8% and 10% alcohol. If it does not, either something was wrong in the batching, or the fermentation is not complete. If fermentation temperature was below 80 degrees F, the yeast probably needs more time to work. If the temperature was above 90 degrees, the yeast has stopped making alcohol. In that case, the temperature should be brought down, more yeast added, and fermentation continued.

All the sugar should be gone from the batch when fermentation is complete. Dip a glucose test strip in the mash to see if any sugar is still there.

It is important to keep the air out of the batch, change temperatures quickly, and be clean in handling the equipment and the mash. Also, it is possible, but not probable, that your mash may turn .sour. or make vinegar instead of alcohol.

Distillation

The cold mash is put into the boiler. The alcohol vapors are stripped out of the mixture and carried to the top of the column.

The water, since it vaporizes at a higher temperature, is not vaporized and continues to fall to the bottom of the column. The alcohol vapors rise in the column and more water falls out. The vapors exit the top of the column at 170 to 175 degrees F and 190 proof.

Drying The Alcohol

The highest concentration of alcohol obtainable from a still is about 195 proof. The final fraction of water must be removed by other means, if this is deemed necessary. Alcohol with water can be burned in engines as is, but most experts claim all the water has to be removed if it is mixed with gasoline. There are conflicting claims on this.

The alcohol need not be dried if it will be used straight in a vehicle, without mixing it with gasoline, or if it will be injected into the carburetor.

Evidence indicates that when alcohol is burned straight in an engine, the water serves a useful function. It changes to steam in the engine and gives extra power, and is emitted as steam through the muffler. Those using straight alcohol prefer about 160 proof. If the alcohol will be mixed with gasoline, the accepted method is to dry it to about 197 proof. There is no specific recipe for doing this, but there are several possibilities.

The alcohol can be dried by running it over zeolite, aluminum oxide or lime. The chemical takes up the water. After use, the chemical can be dried with heat and used again.

Equipment Needed

Mild steel tanks and equipment can be used for fuel alcohol production. Stainless steel and copper will last longer, but are more expensive. Alcohol swells certain rubbers and plastics. Test materials that will be in contact with the alcohol before use.

Fermentation

Almost any kind of tank can be used for fermentation. The size and number of the fermentation tanks determine how much alcohol you can make in a week. Three fermentation tanks will allow you to distill a batch of alcohol every day.

One fermentation tank containing 1,000 gallons of mash will allow you to produce 100 gallons of alcohol every 3 days, since the alcohol fermented brew contains about 10% alcohol and it takes 2 ½ days to ferment.

Mistakes To Avoid

If the batching is not right, alcohol yield will be lost. Ideally, all the starch should be converted to sugar and all the sugar should be converted to alcohol. If the spent stillage contains sugar, more water should be added to the batch. If the stillage still contains starch, the enzymes should be allowed to work longer, or slightly more should be added.

During batching, after the liquefying enzyme has broken down the starch, the starch can re-form if the batch is allowed to set at below 100 degrees F without continuing the process. The alcohol kills the yeast at above 10% alcohol concentration.

If all the sugar is not used up at this point, it is lost. It takes about an hour and a half for the column temperatures to balance out. For that reason, it is better to run off large batches at one time.

There are six variables that have to be adjusted for maximum output: (1) flow rate of mash coming into the still (2) temperature of incoming mash (3) flow rate of steam injected into the still (4) temperature of steam (5) flow rate of ref lux (condensate returned to top, of column two for higher proof) and (6) temperature of reflux. These six factors have to be balanced with each other.

The columns should be insulated to cut down on heat loss after all the bugs in the plant have been worked out.

Chapter Four

Home Made Gas And Methanol

Kenneth Schmitt, Hawkeye, Iowa, built small plants to make a low-BTU gas and /or methanol. The gas, called producer gas is made from wood waste, straw, cornstalks, or any other organic waste. The gas does not transport well, but can be used in any engine using natural gas that is near the site of production. The gas is a mixture of methane and other gases. The producer gas, Schmitt explains, could be used to provide the heat to cook the mash and make the steam for the distillation columns of an ethanol plant.

Schmitt's producer gas generator can also power irrigation pumps, and can even be constructed to automatically augur in its own straw or waste as needed to keep the unit running. Schmitt's plant has another option - the gas can be burned to heat wood wastes under high pressures and relatively low temperatures to cause pyrolysis. The pyrolyzed wastes can then be fractionated (separated) and methanol produced. Methanol can be used as a liquid fuel just like ethanol.

At first glance, it might seem that with a methanol plant, there would be no need for an ethanol plant. That is not so. There is no high-protein byproduct left from methanol production. It would be a waste of protein to use grain, for instance, to make methanol. The ideal situation would be to use the wastes not suitable for making ethanol to make producer gas to fire the still, or make methanol if any is left over.

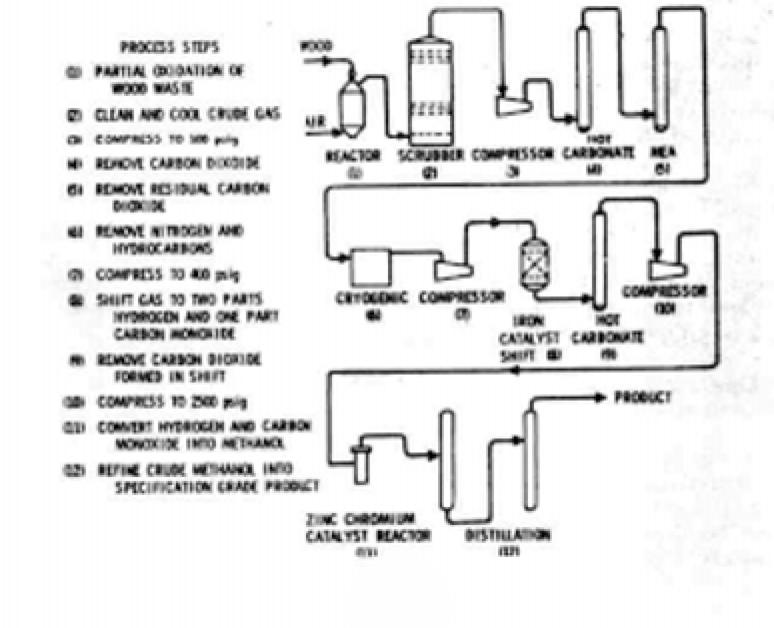
One advantage to methanol is that it is not drinkable, and the Bureau of Alcohol, Tobacco and Firearms do not regulate it. A highly significant fact is that any plant that can produce methanol can also produce ammonia, which is used as fertilizer. If a farmer had a methanol plant, he could produce his own fuel, his own fertilizer, and apply the fertilizer to the land to grow more crops for food and fuel.

Now almost all methanol is made from petroleum gases, mainly natural gas. But one ton of methanol can also be made from one to two tons of coal, 3.5 tons of municipal garbage, or 1.9 tons of wood.

Methane can also be produced by digestion without air or manure, crop wastes, or sewage. The methane can be converted to methanol with Schmitt's plant.

Methanol has less BTU per gallon than ethanol or gasoline. Methanol has 56,560 BTU per gallon, compared with 84,400 BTU per gallon for ethanol and 115,400 BTU per gallon for gasoline. Kenneth Schmitt, a young man who never went to college but had a strong interest in chemistry since he was 12 years old, owned and operated a construction company, which was his main business. He founded Schmitt Energy Systems and went into production of producer gas generators, methanol units, and ethanol plants.

Methanol Synthesis from Wood Waste



Chapter Five

Using Heat From Irrigation Motors

by Elmer Wagner, Belpre, Kansas

Using information available from various sources, the production potential for making alcohol from the waste heat of irrigation motors seems very promising.

In order to find the efficiencies of internal combustion motors, information from the University of Nebraska Tractor Tests was used. These motors would be comparable to irrigation motors. Using the conversion factors, 1 HP equals 2546.4 BTU/hr, diesel fuel has 140,000 BTPU/gal and gasoline has 125,000 BTU/gal.

The test figures were used to calculate the following PTO efficiencies:

J D 7020 26%
J D 4630 28%
Case 1470 32%
Case 2470 28%
Ford 4000 gas 23%

For the purpose of illustration, a Case 1470 Turbo at 75% draw bar load consuming 7.188 gallons of diesel fuel/hour was used. It would use 1,006,320 BTU/hr.

The Popular Science Magazine of July, 1976, gave the following division of heat usage: 1/3 for power, generator, and water pump; 1/3 to heat water (335,440 BTU/hr); and 1/3 as exhaust (338,440 BTU/hr). This is 670,880 BTU/hr wasted, or 16 million BTU per day now wasted.

It takes about 80,000 BTU to process a bushel of corn or wheat into alcohol if the byproduct is dried. 16 million divided by 80,000 is 201 bushels per day, or, times 2.6 gallon alcohol yield per bushel, 552 gallons per day of 190 proof alcohol, or 21.8 gallons per hour.

An irrigation motor runs about 1500 hours a season, or 62.5 days. 1500 hours times 21.8 gallons per hour is 32,700 gallons a season. Divide by 2.6 gallons per bushel and you get 12,577 bushels per season that can be processed from heat now wasted. The value of the 32,700 gallons of alcohol at $1.15 a gallon totals $37,605, and the byproducts are worth about as much as the original wheat. 12,577 bushels at $3 is $37,731. If you have a better figure, use it.

A diesel turbo motor is more power-efficient than the other internal combustion motors such as natural gas, LP or gasoline. The natural gas motor would be the best choice of all to operate the process.

This application relates to irrigation motors being used

about 2months per year, but look beyond this. A farm or community with a bigger motor operating a generator and a water pump could provide electricity, hot and cold water, heating and power fuel, food from irrigated crops, and meat from feed lots. All of this would make it basically self-sufficient for the essentials. There would be no surplus of grain. Straw, wood chips and other cellulose fibers could also be converted to alcohol in the process.

An irrigation system is now wasting the two elements which are the main requirements of a distillation process - heat from the motor and cooling from the water coming from the ground.

Chapter Six

Using The Alcohol

Burning Gasohol

It is generally accepted that up to 15% alcohol can be mixed with gasoline and used without vehicle modification, if the alcohol has been dried so that it contains less than 2% water.

Burning Straight Alcohol

Straight alcohol that is as low as 160 proof can be used in many vehicles with no modification whatever. The carburetor jets can be replaced with larger ones to make the vehicle run better. Users report no trouble starting the car on straight alcohol.

A dual fuel system can be installed consisting of two fuel tanks, and two fuel pumps fixed so that when the engine gets up to about 1,000 RPM, the car switches from gasoline to alcohol. In cars with a 4 barrel carburetor such as the Holley dual feed 4 barrel carburetor with mechanical linkage, 2 barrels can be fixed to run on gasoline and 2 barrels can run on alcohol, or the fuels can be mixed. An electric cutoff could switch the fuels. A 2 to 3 gallon gas tank might be installed for emergencies.

An injection system can be installed on a car for a few hundred dollars. This injects alcohol and water into the carburetor. Any good mechanic, hot rodder or race car enthusiast already knows how to do this. Carburetor injection devices have long been used in Europe.

Dr. William B. Harris and others in the Department of Engineering at Texas A & M University at College Station, Texas, adapted two cars to run on alcohol. Although they use methanol, Dr. Harris said the cars would also run on ethanol. The cars were driven for thousands of trouble-free miles. Dr. Harris estimated the changes cost about $350 in 1979. The car could still run on gasoline, because the gasoline system was not changed. The car started on gasoline, then switched to methanol vapor as soon as the system was warm.

The additions include a standard propane regulator without the high pressure side, a standard propane venturi mounted between the carburetor and air cleaner, a standard electric fuel pump, a standard low pressure fuel tank, and a custom-made heater that fits on the exhaust pipe.

The heater’s job was to vaporize the alcohol in such a way that the vapor pressure was not changed, there was no liquid in the vapor, and the vapor was not superheated. In addition, the heater needs to be compact and easy to install. Texas A & M holds patents on the heater, but to date they have not been able to interest people with the money to buy the patents and manufacture the conversion kits.

The disadvantage to alcohol injection systems that do not vaporize the alcohol are several, according to Dr. Harris. First, it takes 8 times as much heat to vaporize methanol as gasoline.

Therefore, the alcohol enters as a mist or spray that doesn't distribute to the cylinders uniformly and causes uneven burning. It gets on the cylinder walls and washes oil off, causing wear. Also, below 30 degrees F, you have trouble starting because of alcohol's low volatility, Dr. Harris said. The Texas A&M cars got about 60% as much mileage per gallon on methanol containing 10% water as on gasoline.

Dr. Harris estimated that with ethanol they would get 75% of the gasoline miles per gallon. But, he said, the alcohol cars have shown superior carburetion and engine operation, and pollution is cut 20%.

Today, a devise called Flex-Tek from Brazil works really well to convert most fuel-injected engines to ethanol.

Using Alcohol in Diesel Engines

R. P. McWelsh, Virginia farmer, adapted his small Massey Ferguson tractor to run on 100% agri-fuels and demonstrated it in Washington D.C. He said all he did was make minor modifications in the fuel injection system to accommodate the different density fuel. He added nothing to the tractor.

McWelsh used 80% ethanol and 20% vegetable oil. (He preferred sunflower oil.) He says the tractor had more power on alcohol, alcohol, did not miss, pop or crack, and the exhaust fumes were so clean they could be breathed. McWelsh, an American Agriculture farmer, said. If it's mechanical, it can be fixed ... Right out in the field is where the answers are.

Diesel engines can be modified so that 10% to 50% diesel fuel is injected into the cylinders with 192 proof alcohol.

Special Engines

Richard Blaser, Argentina, spent 8 years working on engines to burn alcohol. He said he could easily retrofit existing engines. Blaser adapted one engine to burn 100% alcohol, 100% gasoline, or anything in between by increasing the compression ratio and reshaping the pistons.

Blaser pointed out that it is highly unfair to test alcohol against gasoline in an engine designed for gasoline. He said gasoline is not nearly as manageable as alcohol because one batch varies greatly from another batch.

Blaser's engine ran on 120 proof alcohol produced by Dr. Middaugh's still at the Appropriate Community Technology Fair in Washington D.C.

Blaser said since the Model A Ford was designed for either alcohol or gasoline, but for some shadowy events in history, alcohol might be the primary fuel today and we might be looking at gasoline as an alternate fuel.

Alcohol Vehicles Available Today

Today in the year 2005 there are cars and sports utility vehicles available to buy which were designed to use alcohol fuel with no gasoline. The Department of Energy maintains a website to let the consumer search for these vehicles by model and also maintains a site showing the consumer where alternate fuels can be purchased.

Chapter Seven

Possibilities For The Future

New Developments

Several improvements are possible to make farm alcohol plants more efficient. Without going into much technical detail, we will touch on some of them.

It is possible that membranes can be used in several places in the alcohol production process. Membranes could separate salts out of the stillage when molasses is used as the feedstock. (Molasses stillage is too salty to feed to livestock without treatment.)

Membranes could be used to take the alcohol out of the fermenting brew as it was produced, thereby avoiding the alcohol buildup which kills the yeast. A continuous flow fermentation system could then be used, with raw materials being constantly fed in instead of letting one batch set for 21/2 days. Membranes might be used to take off the last bit of water to make anhydrous ethanol, which can be used as an industrial alcohol or mixed with gasoline.

Protein can be removed before the mash is sent through the distillation columns. There is no need to subject the protein to the heat of the still. It can be separated at the beginning of distillation and used immediately.

Enzymes that work faster or at a higher temperature may be isolated. This would cut down on the time needed for cooking and holding before fermentation begins.

Yeast strains that tolerate a higher alcohol concentration can probably be used. These are already being used in wine making. It is already known that cellulose can be broken down into starch and sugar to make alcohol. Improvements in the process could make it more economical.

A way to take the last bit of water out of the alcohol to make it anhydrous may be found that is not able to be patented and can be used on the farm. Some techniques include flowing the alcohol across solid aluminum oxide crystals. The chemical takes up the water, and then can be heated to drive the water off again. The aluminum oxide is re-used.

Improved engines designed especially for alcohol may become popular if there is enough demand.

Solar energy may be used to power the still. Heat of irrigation engine exhausts may be used in the alcohol making process.

New markets may open up for the distillers dried grain solids.

It makes good livestock, pet, and human food.

Better ways may be found to use the carbon dioxide gas produced in fermentation. Hot water that occurs naturally in some areas might be used to cut down on energy costs for distillation. A combination of wind power, solar heat, and geothermal heated water might be used.

New crops for alcohol production may be grown. For instance, it has been found that Jerusalem artichokes have a lot of potential, because the sugar is deposited in the stems before the bulb begins to form. The tops can be chopped off, the sugar harvested, and the bulbs left in the ground to regenerate. Cassava, a starchy root, can be grown on marginal land.

Experiments are being done burning coal and alcohol. Results indicate that high-sulfur coal can be used, and the sulfur that is released can go into fertilizers.

Some are planning to use a vacuum pump to create a partial vacuum in the distillation columns. This could take less energy since the alcohol vaporizes at a lower temperature under vacuum.

Farmers Must Help Themselves

Fuel alcohol production on the farm is in the dark ages as far as technology is concerned. America's farmers stand on the threshold of the greatest new market for their products in years, and there are few to break through the first barriers. There will be no government leadership in this movement, nor a lot of encouragement, either financial or verbal. The energy crunch has a stranglehold on the country, but there are far too many enemies of farm alcohol in high places to expect any help for it. The consumer is told that making alcohol from grain would cause a food shortage. The farmer is told that grain prices are low because of burdensome surpluses.

Many researchers are working on renewable sources of energy. In general, they face the same kind of discouraging attitude the farmer does. But many are attacking bits and pieces of the problem, and if the work goes on and communication continues, there may, indeed, be an alcohol plant every 10 miles across America.

It is up to the farmers if they want to push into this new market. With the agricultural economy in the shape it is in today, farm alcohol may be the only thing that saves the family farm system. We need to point out again to consumers that the price paid to farmers has absolutely no relation to the price the consumer pays in the grocery store, and that world hunger is not due to a shortage of food but due to people not having money to buy food.

Chapter Eight

Regulations

State Regulations

Alcohol is controlled by different state agencies. State laws as well as federal will have to be complied with. The main regulations controlling alcohol fuel are federal.

Federal

There are no Bureau of Alcohol, Tobacco and Firearms regulations on the manufacture, sale or use of methanol, since it is not drinkable.

Production and sale of ethanol is regulated by the ATF of the Department of the Treasury. Liquor tax brings in billions of dollars a year to the federal coffers. Most regulations are designed to make sure that everyone who drinks alcohol pays the high tax on it.

There is no cost for the permit to make fuel alcohol. However, once a medium or large alcohol fuel plant begins operations they must pay a Special Occupational Tax due each July 1st which is explained on ATF F 5630.5. This tax stamp is normally $1000 per year but taxpayers whose gross receipts are less than $500,000 per year may qualify for a reduced rate of $500. No Special Tax Stamp is required for the small Alcohol Fuel Plants.

BATF regulations were revised in 1980 to allow for simpler qualification for those who want to produce alcohol strictly for fuel use.

Those regulations are now codified in 27 CFR Part 19 which are available on ATF's website at www.atf.treas.gov and clicking on Regulations. The applicable Section of Part 19 is Subpart Y, beginning with paragraph 19.901 through 19.1008. The law cited is 26 U.S.C. 5181.

The Special Occupational Tax Return, ATF F 5630.5 that is to be filed annually by medium and large plants should be sent along with a check to:

Bureau of Alcohol, Tobacco and Firearms
P. O. Box 371962
Pittsburgh, PA 15250-7962

How to Apply for a Permit

Application for an Alcohol Fuel Producer permit should be submitted on ATF F 5110.74 and directed to the address below:

Alcohol, Tobacco and Firearms
National Revenue Center
Room 8002 Federal Office Building
550 Main Street
Cincinnati, OH 45202

They are also available at www.atf.gov .

Alcohol Denaturants

The Bureau of Alcohol, Tobacco and Firearms require that ethanol be denatured, or rendered unfit for human consumption.

The fact that the alcohol you make in your fuel-grade still is not drinkable anyway does not eliminate these requirements.

Approved denaturants are 2 gallons or more per 100 gallons of alcohol of any of the following: unleaded gasoline, kerosene, deodorized kerosene, rubber hydrocarbon solvent, methyl isobutyl ketone, mixed isomers of nitropropane, heptane, or any combination of the above, or 1/8 ounce of denatonium benzoate N. F. (Bitrex) and 2 gallons of isopropyl alcohol.

The BATF may change the list of required denaturants from time to time. Current lists are available free from the ATF Distribution Center, 7943 Angus Court, Springfield, Virginia 22153.

Labeling Containers

BATF requires that each container of fuel alcohol containing 55 gallons or less that will be moved from the plant premises be marked as follows:

WARNING
FUEL ALCOHOL
MAY BE HARMFUL OR FATAL IF
SWALLOWED

Chapter 9

Comparison of Raw Materials for Alcohol

Produce	Gallons Alcohol	Protein Yield	% Pro Dry	Lbs CO2
Wheat	2.6/bu	20.7/bu	36	16-17
Grain sorghum	2.6/bu	16.8/bu	29-30	16-17
Corn	2.8/bu	18 lb/bu	29-30	16-17
Average Starch Grains	2.5/bu	17.5/bu	27.5	16-17
Potatoes (75% Moist)	1.4/cwt	14.8/cwt	10	12-14
Sugar Beets	20.3/ton	264/ton	20	120-140
Molasses (50% sugar)	.4/gal		20	.2-.3
68/ton 400-440				

Alcohol Yields of Various Crops

Crop Yield of 200 proof alcohol (gallons)

Corn	2.8/bu
Milo	4.4/cwt
Spring Wheat	2.65/bu
Winter wheat	2.65/bu
Cane Molasses	75/ton
Beet molasses	75/ton
Barley	2.1/bu
Cull potatoes	1.5/cwt
Sweet sorghum	10.5/ton

Percent Sugar and Starch in Grains

Grain	%Sugar	%Starch
Barley	2.5	64.6
Corn	1.8	72.0
Grain sorghum	1.4	70.2
Oats	1.6	44.5
Rye	4.5	64.0
Wheat		63.8

Sample Costs for Ethanol Production

	Corn per Bushel		Milo per cwt	
	$2.00	**$3.00**	**$3.00**	**$5.00**
Grain costs (1)	67.5	101.2	57.8	96.3
By-Product Credit (2)	-43.7	-43.7	-45.7	-45.7
Net Grain Cost	23.8	57.5	12.1	50.6
Conversion Cost (3)	30.0	30.0	31.0	31.0
Interest on Loan (4)	9.8	9.8	9.8	9.8
Ethanol Cost	63.6	97.3	52.9	91.4
Depreciation (5)	11.5	11.5	11.5	11.5
Taxes (50%)	7.0	7.0	7.0	7.0
20% Return (6)	7.0	7.0	7.0	7.0
Ethanol Value	89.1	122.8	78.4	116.9

Notes:
1. Assumes 75% marketable grain plus 25% distressed grain at 50% of the marketable grain price.
2. $120 per ton from corn and $116 per ton from milo based on protein content.
3. Based on coal as the fuel source.
4. Based on a $19,500,000 loan at 10% for a plant to produce 20,000,000 gallons per year of 200 proof ethanol.
5. Depreciation is 10% per year.
6. Return is 20% on $7,000,000 of private capital invested.

Summary of ERDA Emissions

and Fuel Consumption Tests at 75 degrees F
All figures in grams per mile

Emissions	**Gasohol**	**No-Lead**
Carbon monoxide	20.7	30.6
Hydrocarbons	2.3	2.3
Nitrogen oxides	2.3	2.3
Subtotal	25.3	35.2
Carbon dioxide	705.3	711.1
Total	730.6	746.3
Fuel Consumption		
Urban, mi/gal	10.9	11.0
Hwy mi/gal	15.6	16.1
Combined mi/gal	12.7	12.8

Typical Analysis of Distillers Dried Grain Solids

Component	%
Moisture	9.0
Protein	28.0
Crude Fat	11.0
Crude Fiber	8.0
Ash	4.0
Pentosans	15.0
Lignin	5.5
Dextrose (Glucose)	2.3
Dextrin	3.4
Lactic Acid	1.8
Acetic and Succinic Acids.	1.0
Glycerin	2.3
Hemicellulose	1.5
Pectin	3.0
Riboflavin (gamma/gram)	9.0
Thiamin (gamma/gram)	6.3
Pantothenic Acid (gamma/gram)	10.1
Niacin (gamma/gram)	63.4

Water, Protein, and Carbohydrate Content of Selected Farm Products

Crop	%Water	% Protein	Carbohydrate
Apples,raw	84.4	.2	14.5
Apricots, raw	85.3	1.0	12.8
Artichokes, (French)	85.5	2.9	10.6
Artichokes, jerus.	79.8	2.3	16.7
Asparagus, raw	91.7	2.5	5.0
Beans, lima, dry	10.3	20.4	64.0
Beans, white	10.9	22.3	61.3
Beans, red	10.4	22.5	61.9
Beans, pinto	8.3	22.9	63.7
Beets, red	87.3	1.6	9.9
Beet greens	90.9	2.2	4.6
Blackberries	84.5	1.2	12.9
Blueberries	83.2	.7	15.3
Boysenberries	86.8	1.2	11.4
Broccoli	89.1	3.6	5.9
Brussels sprouts	85.2	4.9	8.3
Buckwheat	11.0	11.7	72.9
Cabbage	92.4	1.3	5.4
Carrots	8.2	1.1	9.7
Cauliflower	91.0	2.7	5.2
Celery	94.1	.9	3.9
Cherries, sour	83.7	1.2	14.3
Cherries, sweet	80.4	1.3	17.4
Collards	85.3	4.8	7.5
Corn, field	13.8	8.9	72.2
Corn, sweet	72.7	3.5	22.1
Cowpeas	10.5	22.8	61.7
Cowpeas, undried	66.8	9.0	21.8
Crabapples	81.1	.4	17.8
Cranberries	87.9	.4	10.8
Cucumbers	95.1	.9	3.4
Dandelion greens	85.6	2.7	9.2
Dates	22.5	2.2	72.9
Dock, sheep sorrel	90.9	2.1	5.6
Figs	77.5	1.2	20.3
Garlic cloves	61.3	6.2	30.8
Grapefruit pulp	88.4	.5	10.6
Grapes, American	81.6	1.3	15.7
Lambsquarters	84.3	4.2	7.3
Lemons, whole	87.4	1.2	10.7
Lentils	11.1	24.7	60.1
Milk, cow	87.4	3.5	4.9
Milk, goat	87.5	3.2	4.6
Millet	11.8	9.9	72.9
Muskmelons	91.2	.7	7.5

Crop	**%Water**	**% Protein**	**Carbohydrate**
Mustard greens	09.5	3.0	5.6
Okra	88.9	2.4	7.6
Onions, dry	89.1	1.5	8.7
Oranges	86.0	1.0	12.2
Parsnips	79.1	1.7	17.5
Peaches	89.1	.6	9.7
Peanuts	5.6	26.0	18.6
Pears	83.2	.7	15.3
Peas, edible pod	83.3	3.4	12.0
Peas, split	9.3	1.0	62.7
Peppers, hot chili	74.3	3.7	18.1
Peppers, sweet	93.4	1.2	4.8
Persimmons	78.6	.7	19.7
Plums, Damson	81.1	.5	17.8
Poke shoots	91.6	2.6	3.1
Popcorn	9.8	11.9	72.1
Potatoes, raw	19.8	2.1	17.1
Pumpkin	91.6	1.0	6.5
Quinces	83.8	.4	15.3
Radishes	94.5	1.0	3.6
Raspberries	84.2	1.2	13.6
Rhubarb	94.8	.6	3.7
Rice, brown	12.0	7.5	77.4
Rice, white	12.0	6.7	80.4
Rutabagas	87.0	1.1	11.0
Rye	11.0	12.1	73.4
Salsify	77.6	2.9	18.0
Soybeans, dry	10.0	34.1	33.5
Spinach	90.7	3.2	4.3
Squash, summer	94.0	1.1	4.2
Squash, winter	85.1	1.4	12.4
Strawberries	89.9	.7	8.4
Sweet potatoes	70.6	1.7	26.3
Tomatoes	93.5	1.1	4.7
Turnips	91.5	1.0	6.6
Turnip greens	90.3	3.0	5.0
Watermelon	92.6	.5	6.4
Wheat, HRS	13.0	14.0	69.1
Wheat, HRW	12.5	12.3	71.7
Wheat, SRW	14.0	10.2	72.1
Wheat, white	11.5	9.4	75.4
Wheat, durum	13.0	12.7	70.1
Whey	93.1	.9	5.1
Yams	73.5	2.1	23.2

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Alltech, Inc
3031 Catnip Hill Pike
Nicholasville, KY 40356
Telephone 606-885-9613
Fax 606-887-3228
Http://www.alltech.com

Genencor Enzymes Division
PO Box 4859, Elkhart, IN 46514
Phone 219-266-2400, Customer Service 800-847-5311

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Website: www.ethanoltech.com

Genencor International Inc.
Phone: (585) 256-5208
Website: www.genencor.com

Lesaffre Yeast Corporation
Phone: (877) 677-7000
Website: www.lesaffreyeastcorp.com

Novozymes North America Inc.
Phone: (919) 494-3000
Website: www.novozymes.com

Vogelbusch USA Inc.
Phone: (713) 461-7374
Website: www.vogelbusch.com

How to Apply for a Permit from BATF

Application for an Alcohol Fuel Producer permit should be submitted on ATF 5110.74 and directed to the address below:

Alcohol, Tobacco and Firearms National Revenue Center
Room 8002 Federal Office Building
550 Main Street
Cincinnati, OH 45202

The BATF defines three sizes of plants:

Small - Produces and receives not more than 10,000 proof gallons of alcohol per year.

Medium - Produces and receives more than 10,000 but not more than 500,000 proof gallons of alcohol per year.

Large - Produces and receives more than 500,000 proof gallons of alcohol per year.

Small plant are not required to file a bond. Medium and Large plants are required to post bonds, generally obtainable from insurance companies.

Warning - If your plant premises are in a or eligible for inclusion in the National Register of Historic Places and you plan to make any changes to construction or us of those premises, you need to contact your State Historic Preservation Offices and follow their guidelines.

There is no cost for the permit to make fuel alcohol. However, once a medium or large alcohol fuel plant begins operations they must pay a Special Occupational Tax (due each July 1^{st}) which is explained on ATF F 5630.5. This tax stamp is normally $1000 per year but taxpayers whose gross receipts are less than $500,000 per year may qualify for a reduced rate of $500. No Special Tax Stamp is required for the small. Alcohol Fuel Plants.

BATF regulations were revised in 1980 to allow for simpler qualification for those who want to produce alcohol strictly for fuel use. Those regulations are now codified in 27 CFR Part 19 which are available on ATF's website at www.atf.treas.gov and clicking on .Regulations.. The applicable Section of Part 19 is Subpart Y, beginning with paragraph 19.901 through 19.1008. The law cited is 26 U.S.C. 5181. The Special Occupational Tax Return, ATF F 5630.5 that is to be filed annually by medium and large plants should be sent along with a check to:

Bureau of Alcohol, Tobacco and Firearms

P. O. Box 371962

Pittsburgh, PA 15250-7962

Useful Measurements

1 barrel equals 42 gallons
1 gallon of ethanol weighs 6.6 pounds
1 gallon of water weighs 8.3 pounds
1 U.S. liquid gallon = 4 quarts = 231 cubic inches = 3.78 liters
2 pints = 1 quart
4 quarts = 1 gallon
8 gallons = 1 bushel
128 ounces = 1 gallon
1 liter = 1.057 U.S. liquid quarts
1 fluid ounce = 30 milliliters
1 inch = 2.54 centimeters
1 pound = 453.6 grams
1 gram = 0.035 ounce
1 ounce = 28.349 grams
1 kilogram = 2.2 pounds
1 BTU x 252 equals calories
Celsius temperature x 9/5 plus 32 equals degrees Fahrenheit.
Fahrenheit temperature minus 32 x 5/9 equals degrees Celsius.
1 lb of starch yields 0.568 lbs of ethanol
1 lb sugar yields 0.511 lbs ethanol

A rule of thumb is that a 12 inch diameter column will produce 25 gallons per hour. If you double the column diameter, you increase the output by 4. If you halve the column diameter, you get only 1/4 the output.

Miscellaneous Sources

Purdue University - West Lafayette, Indiana. Has done much research on alcohol fuel.

Mother Earth News - P. 0. Box 70, Hendersonville, North Carolina 28739.
A magazine that regularly carries how-to articles on solar stills, alcohol powered cars, and other alternate energy information.

Your Local Extension Agent - Can steer you to sources of alcohol information in your state, and has access to land grant college studies on alcohol.

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Report - University of Nebraska, Agricultural Experiment Station, Dept. of Agricultural Economics (115): 58 p.; Dec 1980.
Bibliography p. 37-43.
Language: English
Descriptors: Synthetics; Fuel; Production; Costs; On-farm
Abstract: Extract: This study is intended to identify and present the various costs of producing alcohol in on-farm plants with currently available technology. The study is further designed to provide a method whereby these costs can be quantified for specific plants. This information should be of value to those considering the construction of a small-scale alcohol plant, as well as for persons involved in related public policy and financial decisions.

NAL Call. No.:aT223.V4A4
Dehydration of ethanol.
Robertson, G.H.; Pavlath, A.E.
Washington, D.C.? : The Department; 1985 Dec03.
United States Department of Agriculture patents (4,556,460): 1 p. ill; 1985 Dec03. Copies ofUSDApatents are available for a fee from the Commissioner of Patents and Trademarks, U.S. Patents and Trademarks Office, Washington, D.C. 20231. Includes references.
Language: English
Descriptors: U.S.A.; Ethanol; Dehydration; Patents; Small businesses; Usda; Fuel moisture content
Abstract: A process and apparatus for dewatering an ethanolwater solution is disclosed wherein a carrier gas is used to vaporize the solution and transport the vapors to a sorbent where water is sorbed in preference to ethanol. The invention is

particularly suited for small-scale production of fuel-grade
ethanol for blending with gasoline.

NAL Call. No.:TP360.E544
Design, construction, operation, and costs of a
modern small-scale fuel alcohol plant (Corn as feedstock, biomass
fuels).
Leeper, S.A.; Dawley, L.J.; Wolfram, J.H.; Berglund, G.R.;
Richardson, J.G. Chicago : The Institute, c1982; 1982.
Energy from biomass and wastes VI : symposium, January 25-29,
1982, Lake Buena Vista, Florida / symposium chairman D.L.
Klass ; sponsored by the Institute of Gas Technology. p. 871-886. ill;
1982. Includes references.
Language: English

NAL Call. No.: 65.9 SO83
The development of a micro distillery for fuel alcohol in
Brazil. Hulett, D.J.L.
Mount Edgecombe, The Association; 1981.
Proceedings ... annual congress - South African Sugar
Technologists. Association (55th): p. 64-66. ill; 1981.

NAL Call. No.:SB249.N6
Economic factors affecting agriculture in the
southeast in the 80s. Sullivan, G.D.
Memphis, Tenn. : National Cotton Council and The Cotton
Foundation; 1981 Jan04.
Proceedings - Beltwide Cotton Production Research Conferences.
P. 189-191; 1981 Jan04. 1981 Proceedings Beltwide Cotton Production
Research Conferences in New Orleans, Louisiana, Jan. 4-8,
1981.
Language: English
Descriptors: U.S.A.; Energy; Costs; Irrigation; Drought;
Pollution; Farm structure; Interest rates; Ethanol
Abstract: Extract: Demand for food products will expand rapidly,
with vigorous growth in effective demand in foreign markets.
Southeastern producers have the advantage of a strategic location
to share in the growth in export markets for agricultural
products. The growth in demand will raise prices sufficiently to
offset cost increases for major enterprises, so that farmers will
continue to bring marginal land into production and hold down
their expansion of grazing livestock enterprises. On balance,
total agricultural output will expand but shifts in competitive
positions will cause traditional enterprises to diminish in
importance. The structure of southeastern agriculture will
continue to change rapidly in the decade ahead. I believe that

commercial agriculture of the 1980.s will differ remarkably from its predecessor of a short two decades ago.

NAL Call. No.:HD1750.W4
Economic prospects for small-scale fuel alcohol production. Dobbs, T.L.; Hoffman, R.; Lundeen, A.
Lincoln, Neb. : Western Agricultural Economics Association; 1984 Jul. Western journal of agricultural economics v. 9 (1): p. 177-185; 1984 Jul. Includes 25 references.
Language: English
Descriptors: South Dakota; Alcohols; Fuels; Energy; Cost analysis

NALCall. No.: HD1761.A1M5 no.86-12
The economics of ethanol production and its impact on the Minnesota farm economy.
Fruin, Jerry E.; Halbach, Daniel W.
University of Minnesota, Dept. of Agricultural and Applied Economics St. Paul, Minn. : Dept. of Agricultural and Applied Economics, University of Minnesota,; 1986.
40 p. : ill. ; 28 cm. (Staff paper P, no. 86-12). Title from cover. March, 1986. Bibliography: p. 40.
Language: English; English
Descriptors: Alcohol as fuel; Economic aspects; Minnesota

NAL Call. No.:S27.A3
The economics of producing fuel alcohol in farm size plants. Fischer, L.K.
Alcohol Fuel Workshop, (1980, Kansas State University,. Manhattan, Kansas, Kansas State University; May 13, 1980. Publication - Great Plains Agricultural Council (94): p. 103-117; May 13, 1980. 14 ref.
Language: English
Descriptors: Synthetics; Fuel; Production; Economic analysis

NAL Call. No.: FICHE S-25
The economics of producing fuel alcohol in farm size plants. Fischer, L.K.
Michigan State University Energy for Agriculture Series ENR (MCA/BIO 67): p. 103-117; May 1980. Source: Kansas State Univ.,
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ref.
Descriptors: Organic; Alcohol; Ethanol; Economics; 033

NAL Call. No.:S27.A3
The economics of producing fuel alcohol in farm size plants (USA). Fischer, L.K.
Alcohol Fuel Workshop, (1980, Kansas State University,. Manhattan, Kan., Kansas State University; 1980.
Publication - Great Plains Agricultural Council (94): p. 103-117; 1980. 14 ref.
Descriptors: USA

NAL Call. No.:HD1407.C6
The economics of small scale alcohol production.
Casler, G.L.
Ithaca, N.Y., The Station; Feb 1981.
Cornell agricultural economics staff paper - New York State Cornell Agricultural Experiment Station, Ithaca (81-5): 8 p.; Feb 1981.
Descriptors: Synthetics; Fuel; Production; Costs; On-farm

NAL Call. No.:HD1775.N8E35
Economics of small scale on-farm alcohol distilleries.
Nichols, T.E. Jr; Jackson, J.D. Jr
Raleigh, N.C., The Service; Jan 1981.
Economics information report -N. Carolina State Univ., Dept. of Economics and Business, N. Carolina Agricultural Extension Service (64): 46 p.; Jan 1981. 6 ref.
Descriptors: Synthetics; Fuel; Production; On-farm; Costs; Values; Planning; Break-even analysis
Abstract: Extract: This report documents the costs of producing ethanol from five small on-farm distilleries and compares the production costs with the value of ethanol when used as a motor fuel. Important factors useful in planning a farm distillery are discussed and production costs for five model distilleries, producing 190 proof ethanol and ranging in output from 840 gpy (gallons per year) to 201,600 gpy, are derived using a base set of input prices with a breakeven analysis used to evaluate the profitability of each distillery.

NAL Call. No.:QR53.B56
The effect of micro-aerobic conditions on continuous ethanol production by Saccharomyces cerevisiae.
Hoppe, G.K.; Hansford, G.S.
Kew, Eng. : Science and Technology Letters; 1984 Oct.

Biotechnology letters v. 6 (10): p. 681-686. ill; 1984 Oct.
Includes references.
Language: English
Descriptors: Saccharomyces cerevisiae; Ethanol; Production; Fermentation; Aerobiosis

NAL Call. No.:S494.5.E5A39
Effects of an alcohol fuels program on farm economics.
Dovring, F.
Boulder, Colo. : Pub. by Westview Press for American Assn. for the Advancement of Science, 1982; 1982.
Agriculture as a producer and consumer of energy / edited by William Lockeretz. p. 41-60; 1982. 3 p. ref.
Language: English

NAL Call. No.: FICHE S-72
Energy analysis for small-scale ethanol distillation (Corn, Zea mays, biomass fuel, South Dakota).
Stampe, S.; Chisholm, T.; Westby, C.
St. Joseph, Mich. : The Society; 1982.
Paper - American Society of Agricultural Engineers (Microfiche collection) (fiche no. 82-1049): 1 microfiche : ill; 1982. Paper presented at the 1982 Summer Meeting of the American Society of Agricultural Engineers. Available for purchase from: The American Society of Agricultural Engineers, Order Dept., 2950 Niles Road, St. Joseph, Michigan 49085. Telephone the Order Dept. at (616) 429-0300 for information and prices. Includes references.
Language: English
Descriptors: South Dakota

NAL Call. No.:TJ163.5.A37E5
Energy consumption of a farm-scale ethanol distillation system. Stampe, S.; Alcock, R.; Westby, C.; Chisholm, T.
Amsterdam : Elsevier Scientific; Dec 1983.
Energy in agriculture v. 2 (4): p. 355-368. ill; Dec 1983.
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Language: English

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Energy farms: are they for real? (Alcohol, methane).
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Energy from Missouri farms (emphasis on ethanol).
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Descriptors: Missouri; Organic; Alcohol; Ethanol; Energy Crops; Animal; 033

NAL Call. No.: FICHE S-72
Energy recovery and utilization on a Texas farm (Alcohol from biomass). Raley, D.K.; Malish, D.A.
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Paper - American Society of Agricultural Engineers (Microfiche collection) (fiche no. 84-3042): 1 microfiche : ill; 1984. Paper presented at the 1984 Summer Meeting of the American Society ofAgricultural Engineers. Available for purchase from: The American Society of Agricultural Engineers, Order Dept., 2950 Niles Road, St. Joseph, Michigan 49085. Telephone the Order Dept. at (616) 429-0300 for information and prices. Includes references.
Language: English
Descriptors: Texas

NAL Call. No.: No Call No. (ENR)
Ethanol: Farm and fuel issues.
Energy in agriculture collection - Michigan State University, Department of Agricultural Engineering United States National Alcohol Fuels Commission: 137 p. ill., maps; Aug 1980. Source: Schnittker Associates. Includes bibliography.
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Descriptors: Organic; Alcohol; Ethanol; Energy Crops; Corn; Policy; 033

NAL Call. No.:S17.N4
Ethanol from farm crops (Corn, sugarbeet, cellulosic residues, economics, New Zealand).
Spriggs, T.W.
Wellington, Editorial Services; May 1980.
NewZealand agricultural science v. 14 (2): p. 76-83;May1980. 17 ref.
Descriptors: New Zealand

NAL Call. No.:916937(AGE)
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Language: English
Descriptors: Ethanol; Grains; Fuel; Cost analysis; Economic evaluation; By-products; Feed
Abstract: Extract:Weevaluate the economics of three operating plants producing ethanol from grain in and around Illinois with rated capacities of 625 to 1,500 thousand gal./yr. We first present anecdotal results on capital costs, operating difficulties, and success in marketing the ethanol and the feed by-product. All three plants are viable because, among other things, their indirect costs are low due to acquisition of used tanks. We then analyze the sensitivity of production costs to changes in costs of inputs, and, assuming uncertainties in inputs, the total uncertainty in production cost. Besides the cost of grain and fuel, the most important factor in cost is the .duty cycle., the fraction of total capacity actually realized.

NAL Call. No.: aTJ810.S6 1983
Ethanol research on the Missouri Integrated Energy Farm System (Hydrolysis of corn, biomass fuel).
Garcia, A. III; Fischer, J.R.; Iannotti, E.L.
Washington, D.C. : The Department, 1983?; 1983.
3rd annual Solar and Biomass Workshop, April 26-28, 1983, Holiday
Inn, Atlanta Airport/North Atlanta, Georgia / co-sponsors United States Department of Agriculture ... (et al.).. p. 86-89; 1983.
Language: English
Descriptors: Missouri

NAL Call. No.: No Call No. (ENR)
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Hinz, W.W.
Arizona, University, United States, Dept. of Agriculture.
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Descriptors: Organic; Alcohol; Ethanol; Safety; Energy Source; 033

NAL Call. No.:TP374.C6C6
Ethanol.increasing farm income.
Vaughn, E.
Washington, D.C. : Corn Refiners Association, Inc; 1988.
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Language: English
Descriptors: Fuel crops; Maize; Ethanol; Trends

NAL Call. No.:HD1401.A56
Ethanol.s role: an economic assessment.
Kane, S.; Reilly, J.; LeBlanc, M.; Hrubovcak, J.
New York, N.Y. : John Wiley; 1989 Sep.
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Language: English
Descriptors: U.S.A.; Ethanol; Grain; Prices; Petroleum; Production costs; Subsidies; Energy shortages; Market competition; Environmental protection; Farm income

NAL Call. No.: TEXAS A&M
MASECR79034NTI Farm alcohol fuel plant.
Zeithamer, A.E.
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Language: English

NALCall. No.:TEXASA&MTP358.A28
Farm alcohol fuel plant.
Hall, M.D.; Andrew, F.
West Lafayette, Ind. : Agricultural Engineering Dept., Purdue University, 1981; 1981.
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Language: English

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Farm alcohol/methane production model (Biomass fuel).
Broder, J.D.; Waddell, E.L. Jr

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Holiday Inn, Atlanta Airport/North Atlanta, Georgia / co-sponsors
United States Department of Agriculture ... (et al.).. p. 199-201; 1983.
Language: English

NAL Call. No.:TP358.F37
Farm and forest produced alcohol : the key to liquid
fuel independence : a compendium of papers submitted to the
Subcommittee on Energy of the Joint Economic Committee, Congress
of the United States. United States, Congress, Joint Economic
Committee, Subcommittee on Energy. Washington U.S. Govt. Print.
Off; 1980. v, 76 p. : ill. ; 24 cm. At head of title: 96th Congress, 2d
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references.
Language: ENGLISH
Descriptors: Alcohol as fuel; Economic aspects; United States;
Addresses, essays, lectures; Liquid fuels; Addresses, essays,
lectures; Biomass energy; United States; Addresses, essays,
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Language: ENGLISH
Descriptors: Organic; Alcohol; Fermentation; Corn; Wastes; 033
52 NAL Call. No.: 23 N472
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Quick, G.R.
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ill; Feb 1982.
Language: English
Descriptors: Australia
53 NAL Call. No.: 58.8 P87
Farm fuel production.ethanol.
Sydney, Pacific Publications (Aust.).; Jan 1982.
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Language: English

NAL Call. No.: No Call No. (ENR)
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Department of Agricultural Engineering. various pagings. ill., maps; Mar 6, 1979. Source: Oklahoma State University; Oklahoma Dept. of Energy; Oklahoma Wheat Commission. Includes bibliography.
Language: ENGLISH
Descriptors: General; Solar; Organic; Biomass; Alcohol; 016

NAL Call. No.: Document available from source. Farm production of alcohol fuels.
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Language: English
Descriptors: Agricultural engineering; Fuel production; Ethanol
Abstract: This publication is a question and answer sheet about using by-products for fuel on the farm.

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Language: English
Descriptors: Agronomy; Grain crops; Utilization; Energy; Agriculture; Ethanol fuel; Agricultural engineering; Fuel produciton; Equipment
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Language: English
Descriptors: Ethanol; Funds; Usda; Industry; Investment policy; Program development

NAL Call. No.: 6 SU12
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Mowitz, D.
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Successful farming v. 86 (10): p. 22-23. ill; 1988 Aug.
Language: English
Descriptors: Biomass; Energy resources; Fuel resources; Ethanol; Production potential; Marketing; Agricultural production; Maize; Plant production; Product development; Product markets

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Farm-produced alcohol and methane model.
Broder, J.D.; Waddell, E.L.
St. Joseph, Mich. : The Society; 1983.
Paper - American Society of Agricultural Engineers (Microfiche collection) (fiche no. 83-3565): 1 microfiche : ill; 1983. Paper presented at the 1983 Winter Meeting of the American Society of Agricultural Engineers. Available for purchase from: The American Society of Agricultural Engineers, Order Dept., 2950 Niles Road, St. Joseph, Michigan 49085. Telephone the Order Dept. at (616) 429-0300 for information and prices. Includes references.
Language: English

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Language: English
Descriptors: Cellulose; Glucose; Conversion; Fuels;
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Language: English

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Language: English

Descriptors: South afRica; Saccharum; Fuel crops; Ethanol; Distilling

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Descriptors: California; Starch crops; Sugar crops; Biomass determination; Ethanol; Fuel resources; Distilling industry; Models

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Fermentation guide for common grains : a step-by-step procedure for small-scale ethanol production : a product of the Solar Energy Information Data Bank, Solar Energy Research Institute., 1st ed.
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Descriptors: Alcohol as fuel; Fermentation

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Descriptors: Alcohol as fuel; Biomass energy; Energy crops

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Descriptors: Synthetics; Fuel; Production; Grain; Energy; Prices; Feed grains
Abstract: Extract: This paper calculates energy and economic balance for three sizes of ethanol-for-grain plants: (1) Singlefarm size (10,000 gallons a year), (2) Farm-consortium size (250,000 gallons a year), and (3) Industrial size gasohol plant (2.5 million gallons a year).

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Descriptors: Organic; Alcohol; Ethanol; Safety; 033

NAL Call. No.:TJ163.2.E42
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Malcolm, D.G.; Paul, S.E.
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Descriptors: Agricultural wastes; Biotechnology; Processing; Feeds; Fuels; Production; Ethanol

NAL Call. No.: A281.9 AG8A
Fuel ethanol and agriculture: an economic assessment.
Gavett, E.E.; Grinnell, G.E.; Smith, N.L.
Washington, D.C. : The Department; 1986 Aug.
Agricultural economic report - United States Dept. of Agriculture (562): 54 p.; 1986 Aug. Includes 37 references.
Language: English
Descriptors: Ethanol; Economic analysis; Farm income; Legislation; Costs; Cost benefit analysis
Abstract: Increased fuel ethanol production from renewable

resources like grain through 1995 would raise net farm income benefiting mainly corn and livestock producers. Production of additional byproduct feeds would depress prices of soybeans. Large ethanol subsidies, which are required to sustain the industry, would offset any savings in agricultural commodity programs. Increased ethanol production would also raise consumer expenditures for food. Any benefits of higher income to farmers would be more than offset by increased Government costs and consumer food expenditures.
Direct cash payments to corn growers
would be more economical than attempting to boost farm income through ethanol subsidies.

NAL Call. No.: 381 J8224
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Language: English

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Language: ENGLISH

NAL Call. No.: No Call No.: (ENR)
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Williams, J.E.
Arizona, University, United States, Dept. of Agriculture.
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Descriptors: Organic; Alcohol; General; 033

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Language: English
Descriptors: Alcohol fuel industry; United States; Gasohol industry; United States; Alcohol as fuel; Energy conservation; United States; Biomass energy; United States

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Descriptors: Michigan; Distillation; Corn; 033

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Language: English

Descriptors: Sunflowers; Fuel; Oils; Models; Cash flow; Energy; Costs; On-farm

Abstract: Extract: Small scale on-farm production of sunflower oil as a diesel fuel substitute and grain alcohol as a gasoline substitute are both technically feasible. This research compares the technical feasibilities of these two technologies, estimates the cost of producing these fuels at three different scales and examines the impact of the available subsidies for ethanol production on the economic ranking of these technologies. The ethanol plants are based on technologies modeled in previous studies. The sunflower oil plants were designed as a part of this thesis on the basis of available oil presses and relatively simple oil refining equipment. As modeled in this study, sunflower oil is screened, filtered, de-gummed, neutralized, transesterified, washed and dried in order to produce transesterified, refined sunflower oil (TRSO).

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Language: English

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NAL Call. No.: FICHE S-72

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NAL Call. No.:TP360.E532
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Language: English; English
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Language: ENGLISH
Descriptors: Organic; Alcohol; Economics; Distillation; Ethanol;

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Descriptors: Maize meal; Cooking; Steam; Ethanol; Production; Maize starch

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Descriptors: Organic; Ethanol; Renewable Energy; 033

NAL Call. No.:916937(AGE)
Small-scale ethanol production: economics and issues.
Braden, J.B.
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Descriptors: Energy; Synthetics; Fuel; Production; Costs; Prices; Economic feasibility

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The small-scale ethanol production enterprise: arrangement and economics. Leiner, F.T.; Braden, J.B.
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Language: English

Descriptors: Petroleum; Models; Prices
Abstract: Extract: The purpose of this paper is to examine, within an economic framework, the optimal arrangement of small-scale ethanol production. The first is on-farm production. Most observers believe that on-farm production will not be undertaken widely due to technical disadvantages, low product yields, and significant demands on the time of farm operators. The second option is a small specialized production unit which though not actually part of a farm operation, has direct ties to the local economy for its inputs and outputs. Local grain feedstocks would be used. Protein-rich by-products could be fed to livestock in a feedlot associated with the plant or on nearby farms. Finally, the alcohol produced might be used locally. It is this small specialized production unit which serves as the basis for our analysis.

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A small-scale ethanol production facility design and performance (Production of fuels from biomass).
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Paper - American Society of Agricultural Engineers (Microfiche collection) (fiche no. 81-3567): 1 microfiche : ill; 1981. Paper presented at the 1981 Winter Meeting of the American Society of Agricultural Engineers. Available for purchase from:
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St. Joseph, Michigan 49085. Telephone the Order Dept. at (616) 429-0300 for information and prices. Includes references.
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Descriptors: Alcohol as fuel; Synthetic fuels; United States

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Language: English

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Substituting diesaveg fuel for diesel fuel.
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Language: English
Descriptors: Diesel oil; Vegetable oils; On farm consumption; Mechanical methods; Ethanol; Economic analysis; Energy resources; Energy cost of activities

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Systems analysis of economics of on-farm energy production. Atwood, J.A.; Schulte, D.D.; Helmers, G.A.
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Language: English
Descriptors: Linear programming; Systems analysis; Economics; Farms; Methane production; Ethanol

NAL Call. No.:QR151.S542
Thermophilic microbes in ethanol production.
Slapack, Gary E.,; Russell, Inge,_1947-; Stewart, Graham G.,
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Descriptors: Fermentation; Bacteria, Thermophilic; Microorganisms, Thermophilic; Alcohol; Synthesis; Cellulose; Metabolism; Biomass energy

NAL Call. No.:aHD1401.A2U52
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Language: English
Descriptors: U.S.A.; Ethanol; Fuels; Farm income; Economic depression; Tax incentives

NAL Call. No.: 166.2 N47
Will alcohol fuels offer new opportunity for farmers.
Lee, B.W.; Prevan, S.D.
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Descriptors: Synthetics; Fuel; Production; Costs; Plant; Size

Glossary Of Terms

Acidity - The measure of how much acid a solution contains.

Air Lock - A device for keeping the air out of a fermenting brew. Can be made by attaching a tube to the top of the fermentation vessel and immersing the other end of the tube in a container of water. The carbon dioxide gas bubbles out through the water, but air cannot enter the fermentation container. A one-way vent valve may be used for the same purpose.

Alkalinity - The measure of alkali in a solution. The word .base. is a chemical term meaning alkali.

Alcohol - The family name of a group of organic compounds. Includes methanol, ethanol, isopropyl alcohol and others. In this book, the word .alcohol. generally refers to ethanol.

Anaerobic - Without air. All fermentation is anaerobic.

Anhydrous - Literally, without water. Anhydrous alcohol refers to 197 proof or above.

Azeotrope - The chemical term for two liquids that, at a certain concentration, boil at the same temperature. Alcohol and water cannot be separated more than 194.4 proof because at this concentration, alcohol and water form an azeotrope and vaporize together.

Beer - The fermented mash, which contains about 10% alcohol.

BTU - British Thermal Unit. The quantity of heat needed to raise one pound of water one degree Fahrenheit.

Boiling Point - The temperature at which a liquid boils. The boiling point varies with the liquid and with the altitude. The greater the altitude, the lower the boiling point.

C - Abbreviation for Celsius temperature.

Calibrated - Marked so that each mark signifies a certain percent, proof, temperature or other measurement. For example, a thermometer is calibrated in degrees F.

Calorie - The amount of heat required to raise one gram of water one degree Celsius.

Carbohydrate - A chemical term describing compounds made up of carbon, hydrogen, and oxygen. Includes all starches and sugars.

Carbon Dioxide - A gas produced as a by-product of fermentation. Chemical formula is C02. Harmless. Can be compressed and used as a refrigerant, used in silos to exclude air and prevent spoilage, or vented to a greenhouse to help plant growth.

Cassava - A starchy root crop used for tapioca. Can be grown on marginal croplands along the southern coast of the US.

Cellulose - A complex carbohydrate that gives plants their rigid structure.

Celsius - A temperature scale commonly used in the sciences. Water freezes at 0 degrees C and boils at 100 degrees C at sea level.

Centigrade - The same as Celsius but now outdated.

Columns -As used in this book, the apparatus for separating water from alcohol through distillation.

Compound - A chemical term denoting a combination of two or more distinct elements.

Condenser - A cooling apparatus designed to change a vapor to a liquid by lowering the temperature.

DDGS - Distillers Dried Grain Solids. The residue left after fermentation and distilling DDGS from corn contains about 28% protein.

Denaturant - As used in this book, a liquid that makes ethanol unfit for drinking.

Dextrose- The same as glucose. The terms are interchangeable.

Distillate - The end product of distillation. For fuel, ethanol.

Distillation - The process of separating two liquids by changing one to a vapor with heat and driving the vapor off the other liquid. The separated vapor is then condensed into another container.

Distillers Grain - The high-protein residue left over after fermentation. See DDGS.

DSB - Abbreviation for dry starch basis.

Energy Crops - Crops grown for their energy potential, as for alcohol production.

Enzymes - Proteins which act as catalysts to change one chemical compound to another chemical compound. Each chemical reaction requires a different enzyme. The enzymes are not used up, but can be destroyed by high heat, acidity, heavy metals and other chemical poisons.

Ethanol - The same as ethyl alcohol or grain alcohol. Will produce intoxication and can be burned as fuel.

F - Abbreviation for Fahrenheit temperature.

Fahrenheit - A temperature scale. Water freezes at 32 degrees F and boils at 212 degrees F at sea level.

Feedstock - The raw material for fermentation, in this book.

Fermentation - The process where yeast changes sugar to alcohol in the absence of air.

Fines - The fine particles that result from grinding or cracking solids.

Flash Point - The temperature at which a combustible liquid will ignite when a f lame is introduced. Anhydrous ethanol will f lash at 51 degrees F. 90 proof ethanol will flash at 78 degrees F.

Gasohol - A blend of 10% anhydrous alcohol with 90% unleaded gasoline.

Glucose - A simple sugar that can be fermented to make ethanol.

Hydrometer - A long stemmed glass tube with a weighted bottom. It floats at different levels depending on the relative weight (specific gravity) of the liquid. The specific gravity or other information is read where the calibrated stem emerges from the liquid.

Methanol - The same as methyl alcohol or wood alcohol.

Highly poisonous to drink or get on skin. Can be used as fuel.

Methane - A gas that can be produced from the decomposition of organic materials or from the incomplete combustion of wood.

Membrane - As used in this book, a thin layer of a substance that separates liquids by allowing one to pass through, but not the other.

Molecule - The chemical term for the smallest particle of matter that is the same chemically as the whole mass.

Malting - The process of sprouting grains to produce enzymes which break down starch into sugar.

Mash - The mixture prepared for fermentation.

Non-Renewable Energy - Energy produced from sources that cannot be regenerated in a reasonable length of time. Oil, coal, and nuclear energy are non-renewable energy sources.

Polysaccharides - 30 or more molecules of sugar joined together.

Proof –A measure of alcohol content. Proof is twice the percentage of alcohol. Thus, 200 proof is 100% alcohol.

Proof Test - Passing a lighted match over the alcohol to see if it ignites. Alcohol will burn at 100 proof or above. It has reached .proof when it will first burn. Use test with caution.

pH - A measure of acidity or alkalinity on a scale of 0 to 14. The more acid the solution, the lower the pH number. The more alkaline, the higher the pH. Neutral is pH 7.

Pot Still - The type of simple still used by moon-shiners. These have no reflux columns.

Producer Gas - A low BTU gas containing methane and other gases, produced by incomplete combustion of organic matter.

Pyrolysis- Bring about chemical change by heating.

Rectifying Column - In a two column still, the second column.

Reflux - To return the liquid or vapor to a previous point in the process to be processed again. Part of the alcohol is refluxed through the distillation column.

Renewable Energy - Energy produced from renewable resources, such as the crops grown on America's farms.

Saccharify - To change to sugar.

Sight Gauge - A glass tube parallel to the bottom 2. of the column used to gauge the level of liquid in the column.

Sight Window - The glassed-in portion of the reflux columns that allows visual inspection of the process.

Specific Gravity - The ratio of the weight of any volume of a sub stance to the same volume of water which is taken as a standard. Water has a specific gravity of 1.000. Different percentages of alcohol and water will have a specific gravity of less than 1.000, depending on the concentration of alcohol.

Starch - A carbohydrate made up of long, tightly coiled chains of glucose molecules.

Starch Test - When iodine is added to a solution, it turns blue if starch is present. If no starch is present, the solution remains colorless or turns red-brown, depending on how much iodine is added.

Stillage - The water and high-protein residue left over from distillation.

Temperature Scale –A scale used for temperature designations. The Fahrenheit scale is used in this book. Another common scale is the Celsius scale, formerly called Centigrade.

Vaporize - To change from a liquid or a solid to a vapor, as in heating water to steam.

Vaporization Temperature of Ethanol - 172.9 degrees F. at sea level.

Vaporization Temperature of Water - 212 degrees F. at sea level. Less at higher elevations.

Volatile Liquid - A liquid that is easy to vaporize.

Wood Alcohol - The same as methanol or methyl alcohol. See methanol.

Yeast - A micro organism that is capable of changing sugar to alcohol by fermentation.