ETHANOL - THE NEW (OLD) FUEL OF THE FUTURE

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"Today's innovations are usually just rehashed formulas from years gone by [. . .] If you want a new idea, read an old book" (Marshall 1).

Fossil fuels, such as oil and coal have been an important source of energy that has fueled the Industrial Revolution and has improved the quality of life both in the United States and in the World. However, the consumption of fossil fuels has resulted in a number of problems. The supply of fossil fuels is dwindling, while the demand for fossil fuels is increasing, resulting in price increases. In addition, fossil fuels emit excessive amounts of pollutants when used. Furthermore, many government leaders want to be energy independent and not have to rely on unreliable foreign sources for their energy needs. Therefore, there is an intensive search for alternative fuels for the future. One alternative fuel being considered is ethanol (also known as ethyl alcohol).

Ethanol is prepared by the fermentation of carbohydrates (sugar and starches) in plant products. In this process, sugar, in the presence of yeasts and in the absence of oxygen, is converted to ethanol and carbon dioxide:

$$C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$$

Some plant products, such as sugar cane and sugar beets, contain sugar already and can be relatively easily converted to ethanol. For these products, yeast is added to ferment the sugars to ethanol. Other plant products, such as corn, contain starch that must first be converted to sugar and then converted to ethanol. This is accomplished by (a) grinding the corn or wheat kernels to expose the starch, (b) mixing the ground kernels with water, cooking the mixture, and adding enzymes to the mixture to convert the starch to sugars, (c) adding yeast to ferment the sugars to ethanol, and (d) separating the ethanol from the water by distillation and dehydration. Still other

products, such as trees and grasses, contain cellulose, which can also be converted to sugars but with much more difficulty than converting starches to sugars (Whipnet, "Making Ethanol" 1).

Although ethanol can be used alone as a source of fuel, usually it is mixed with gasoline. These mixtures can vary from as little as 10% ethanol (most of the gasoline sold in the United States) to as much as 85% ethanol (E-85 fuel) (Whipnet "What is Ethanol" 1).

Ethanol is one of the oldest chemical compounds used by humans. There is evidence that even Neolithic peoples used ethanol as a beverage (Whipnet "History of Ethanol" 1). Ethanol is not a new fuel source. For example, 100 years ago, Henry Ford, automotive pioneer and founder of Ford Motor Company, predicted, "ethyl alcohol is the fuel of the future" (Rohter 1). Ford designed his first automobile cars to use either ethanol or gasoline. In World War II, ethanol was widely used to extend gasoline supplies. However, gasoline was so cheap and readily available that interest in ethanol as a fuel decreased, but the oil crisis of the 1970s renewed the interest in ethanol (Luhnow and Samar 1).

There are many agricultural products that can be used for ethanol production, but at present most ethanol production comes from corn or sugar cane. The United States is a big producer of corn and a small producer of sugar cane. Therefore, the United States encourages ethanol production from corn by subsidizing that production and heavily taxing imports of sugar cane ethanol. Unfortunately corn ethanol is not very efficient because the corn starches must be converted to sugars and separation of the ethanol from water is a problem. Whereas one unit of energy expended to produce corn ethanol produces only 1.3 units of energy, one unit of energy expended to produce sugar cane ethanol produces 8.3 units of energy (Rohter 2).

Therefore, most of the world is interested in sugar cane ethanol. Brazil is the leading producer of sugar cane ethanol, with sugar cane ethanol now accounting for about 40% of that

country's fuel. Other countries that grow lots of sugar cane (e.g. South America, Australia, and the Philippines) are stepping up their production of sugar cane ethanol. A massive new sugar cane ethanol plant has recently been constructed in Peru (Whipnet "Sugar Cane Ethanol 1).

An exciting new concept ("cellulosic ethanol") is the production of ethanol from cellulose. This would produce ethanol from agricultural waste products, such as corn cobs, sugar cane stalks, and wheat straw. In his State of the Union Address in January, 2006, President George Bush specifically called for financing "cutting-edge methods of producing ethanol, not just from corn but wood chips and stalks or switch grass" (Rohter 1). Cellulosic ethanol is not yet economically feasible and ExxonMobil estimates that it will not be until 2030 (1). However, a cellulosic ethanol plant was put in operation in Canada in 2004 that demonstrates the technical feasibility of cellulosic ethanol. A big potential advantage of cellulosic ethanol is that it will greatly reduce greenhouse emissions (85%) compared to reformulated gasoline and ordinary ethanol fuels (Whipnet "What is Ethanol" 1).

Ethanol, particularly sugar cane ethanol, is very competitive with hydrocarbon fossil fuels. For example, in January 2006, the production cost (excluding taxes and subsidies) per gallon were about $1.00, $1.50, and $2.00 for sugar cane ethanol, hydrocarbon gasoline, and corn ethanol, respectively (ExxonMobil 1).

However, the costs of various fuels can fluctuate greatly. Consider what happened in Brazil. In the 1970s to reduce dependence on expensive and unreliable foreign energy sources, the Brazilian government encouraged sugar cane ethanol production and consumption by heavily subsidizing the ethanol industry. Brazilian consumers enthusiastically responded to the cheap ethanol prices by buying ethanol burning cars. However, in the late 1980s, the Brazilian government ended its ethanol subsidies and at the same time sugar prices dramatically increased

while oil prices decreased. Brazilian consumers were confronted with having to buy ethanol fuel that was more expensive than hydrocarbon gasoline fuel. Sales of ethanol cars practically disappeared. Now the economics are back in favor of sugar cane ethanol. Brazilians are now prudently buying flexible fuel cars which enable one to burn either ethanol or gasoline (De Castro 1).

Like carbon containing hydrocarbon fossil fuels, carbon containing ethanol fuels generate the pollutant, carbon dioxide. However, ethanol offers an environmental advantage over gasoline because gasoline requires the use of oxygenates, like methyl butyl tertiary ether (MBTE), to reduce photochemical smog. MTBE reduces air pollution, but can result in ground water pollution from spills of gasoline with MTBE. Ethanol does not require the addition of MTBE (Whipnet "What is Ethanol" 1)

Although ethanol offers environmental advantages over fossil fuels in the *consumption* of energy, the *production* of ethanol has some environmental consequences. In their zeal to increase production of corn and sugar cane for ethanol use, many landowners are slashing environmentally sensitive forests and other lands. Increased demand for corn and sugar cane will probably result in increased use by farmers of fertilizers and pesticides which will eventually pollute waterways and animals (Rohter 2).

In addition to the environmental costs of ethanol production, there are social costs. Corn, sugar cane, and other plants used to generate ethanol are also used to feed people, either directly or as feed to livestock. The increased demand for these commodities for ethanol production has driven up the price of the commodities, creating hardship for poor people. For example, in Mexico the mean food of many poor people is the tortilla, an unleavened cake prepared from

corn meal. The increased price of corn has made tortillas too expensive for the Mexican poor (Rohter 2).

Ethanol offers a lot of advantages (as well as a few disadvantages) over fossil fuels and the government should encourage the production and use of ethanol. However, the optimum solution would be to design cars according to old ethanol/gasoline concept of Henry Ford and the new flexible fuel concept. Consumers should have a choice in the fuel they burn in their cars. If there is competition among ethanol, hydrocarbon fossil fuel, biodiesel, and other alternative fuels, there should be lower fuel prices and greater supply stability. Viva competition!

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