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Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

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United Nations Industrial Development Organization

Workshop on Fermentation Alcohol for Use as Fuel
and Chemical Feedstock in Developing Countries

Vienna, Austria, 26 - 30 March 1979

THE COMMON SENSE APPROACH IN DEVELOPING FUEL ALCOHOLS*

by

P. Jawetz**

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** Consultant on Energy Policy, New York, USA

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ABSTRACT

THE COMMON SENSE APPROACH IN DEVELOPING FUEL ALCOHOLS*

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Pincas . awetz**

Fermentation alcohols can be obtained from a very divers series of primary materials. Some of the feedstocks are biomass and waste materials, others can be grown specifically for the purpose of manufacturing alcohol fuels to substitute for imported fossil fuels. Questions arise whether the cultivation of energy crops makes sense in terms of energy yields and overall economics. Specific and particular conditions to a given area allow for a variety of primary materials, and for differing economics. The subject of alcohol fuels becomes diversified and is dependent on a specific climatic and economic environment. Nevertheless, one can draw certain generalities when analizing the practicality of developing fuel alcohols.

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** Consultant on Energy Policy, 425 East 72 Street, New York, N.Y.10021, USA

Our presentation purports at first to clear prevalent misunderstandings when calculating energy balances for the production of alcohol fuels. The need will be shown to develop utility factors to correct for the prevalent misuse of BTU units in energy output / energy input ratios. These factors are calculated when comparing in terms of miles per gallon the use of ethanol-gasoline mixtures and pure gasoline. The introduction of utility factors allows us to show that a positive energy balance results from the use of ethanol-gasoline mixtures. Furthermore, when studying different ways of producing an octane-booster for low-octane regular un-leaded gasoline, one finds that the use of ethanol for that purpose causes large savings in crude that would otherwise be needed when increasing the streams of aromatic or branched aliphatic hydrocarbons from petroleum and natural gas as starting materials.

Having considered the energy balances we shall turn our attention to ways to link farm policy and energy policy. Special attention will be given here to United States farm policies that subsidize so called set-aside and land diversion programs where a percentage of the land is left idle each year and the farmer is paid to decrease his output in order to support the price of the commodity. It will be shown that the present subsidies for non -production on those lands could effectively provide the funds necessary to establish a fuel alcohol industry in the United States and to subsidize the distilleries in order to make alcohol costs competitive with gasoline.

The present U.S. laws prescribe the elimination of the federal excise tax on gasoline (four cents per gallon) for any fuel that contains at least 10% alcohol which is made from any primary material other than crude, natural gas, or coal. This law will allow the importation of alcohol made from vegetation sources overseas, thus allowing for the development of alcohol industries in the Caribbeans and in Central America.

Fermentation alcohols have been obtained from potatoes, corn, sugar cane, cassava, wheat, beets, from agricultural products, from agricultural byproducts and wastes, from sugars, starches, and from the products of the hydrolysis of cellulose. In short whatever can be broken down to sugars can become a primary material for fermentation alcohols. As long as fermentation alcohols were produced for a premium market - for the alcohol beverage market - the price of the product was in a major part determined by such subjective criteria as taste; energy balances in the production of the alcohol were not mentioned and the economics were determined by the classical relations of supply and demand.

Our work shop has been scheduled now, so to say, in a different era. The disequilibrium in the balances of payment of the nations represented in this workshop was caused in a major part by the tremendous outflow of funds from these countries as a result of their need to import petroleum and petroleum products.

Alcohols can be used as a substitute to petroleum products and as such the economical feasibility of the production of power alcohol and of alcohol for feedstocks should be analyzed not just in its own context - but rather in the context of its contribution to that nation's general economy and the potential contribution to the world economy that in the ultimate reflects back to the particular national economy. The question of overall economics of fermentation alcohols becomes intertwined with major aspects of other - to some bureaucrats seeming unrelated - areas. The general contribution of fermentation alcohol to a particular economy has to be studied and underlying this study there is the first question: - do alcohol fuels make sense in terms of energy yields?

In the United States several major oil companies, then followed by the American Petroleum Institute, published papers and testified before U.S. Congress saying that two units of B.T.U. are needed as an energy input to produce one unit of B.T.U. in the form of ethanol. This is used as an argument by the oil industry in the United States against the phasing in of power alcohol. Our first task in this presentation is going therefore to be to neutralize the A.P.I. argument. After proving our thesis that the use of gasoline-ethanol motor-vehicle-fuel mixtures saves petroleum products we will proceed to show how creative joint-farm-and-energy policies can provide a sound basis for improving national policy.

1. <u>The Energy Balance Question</u>:

One could try to analyze the energy output/energy input ratios and to suggest ways where inputs other than petroleum and natural gas could be used, and if those inputs are indigenous and do not increase the dependence on petroleum and natural gas, then these inputs can be eliminated from the calculations.

Instead of going the above route we prefer to start our analysis as a worst case analysis by accepting the American Petroleum Institute allegation that two units of BTU input are needed to produce one BTU of ethanol, or that the energy output/energy input measured in B.T.U., is 0.5.

Our analysis starts with the observation that B.T.U. is a measure of heating value, but <u>not</u> of the effectiveness of fuel in a motor vehicle engine. Ethanol does indeed have only about two thirds the BTU/gallon value of gasoline but when blending a mixture of 10% ethanol and 90% gasoline and using this mixture, the so called gasohol, in a motor vehicle engine, it was shown that the resulting effect is an increase in miles/gallon as compared with a 100% gasoline fuel of the same quality of gasoline that was used in the blend.

According to motor vehicle fleet tests performed in the State of Nebraska the improvement in miles/gallon is 5.3% while a similar test in the State of Illinois showed a 6.1% improvement.

(a) If the ethanol as part of a mixture were only as effective as gasoline in terms of use as a motor vehicle, considering the BTU content of ethanol as 2/3 when compared to the BTU content of gasohol which is 1, it is clear that the effective use of a BTU of ethanol is increased by 50% or in mathematical terms, the proposed energy balance factor of 0.5 has to be multiplied by a utility factor 1.5.

(b) Now let us consider that in effect the gasohol mixture is not only as effective as the original gasoline but it does even increase the usefulness as a motor vehicle fuel by (5.3 + 6.1)/200 or by 5.6 percent. This observation gives us a second utility factor that is approximately 1.56 and we have now 0.5 x 1.5 x 1.56 = 1.17 thus showing that when correcting in a worst case analysis the energy output in BTU / energy input in BTU by the appropriate utility factor one gets a positive value for the gasoline that was saved when replaced with ethanol in the motor engine.

(c) Furthermore, one has to realize that 10% ethanol increases the octane number of the mixture by 2 - 4 points (the exact number has yet to be determined by an objective source - in the meantime I will remark that the U.S. Department of Energy has by now agreed on the basis of measurements made by the Environmental Protection Agency, that there is indeed an increase by two octane points.

The importance of the increased octane value is that after having legislated the start of phasing out leaded gasoline in the U.S., it became clear that the unleaded gasoline is only of a 87 average octane number, whereas the leaded regular is 89 average octane number quality. As a result consumers who have bought new cars built to use unleaded gasoline do switch to leaded regular as the unleaded available does not perform in their car to their satisfaction, spoiling the catalyst in the process, and increasing air pollution levels defeating as a result the regulations according to the Clean Air Act.

If one were to increase octane values of the gasoline via reforming processes that create frictions rich in benzene and toluenes, or via isomerization processes to get branched compounds, one would have to spend an additional 6 percent of crude in these energy intensive processes. Ethanol increases the octane value by the same amount without needing the additional crude. We can thus say that a third utility factor for the saving of crude is 1.6 and the final utility factor becomes 1.5 x 1.56 x 1.6 = 3.75 or that even if it were true that the production of one BTU of ethanol requires an energy input of two BTU's, each BTU of ethanol replaces three and three quarter BTUs of crude or crude products.

2. <u>The Economics Question</u>:

The economics of fermentation alcohol, in today's conditions in the energy and chemical feedstocks areas cannot be based on straight calculations of buying the primary material

at market price with expectation that the product competes in price with petroleum based products. Our argument is that in fact, one has to interwine policies for the production of agriculturally and biomass based energy materials with policies from other sectors of the economy.

Every country may have particular conditions making it possible for a particular primary material under a specific constelation of policy adjustments to allow the production of fermentation alcohols beneficial to that economy. In order to make our point we shall proceed to elucidate the conditions within the U.S. economy while keeping in mind that for other economies a totally different set of creative ideas will have to be applied if one wants to produce rationally beneficial industrial fermentation alcohols.

The United States has an excessive potential for the production of farm crops while lagging in its foreign trade because of the need to import about half of its fuel supplies. The Farm Policy makers have devised a method of support of the farm products by paying the farmers to leave part of their land fallow. In 1978 [illegible] million acres have been put by the farmers under a so called "set-aside" program and in exchange the farmers have been guaranteed minimum prices for their produce and have been given access to other supported programs such as a subsidized grain reserve system and loan programs.

Furthermore, those farmers that have agreed to the voluntary set-aside program are entitled to receive direct cash subsidies if they agree not to plant on an additional percentage of their land. This program is called the land diversion program and in 1978 an additional 5.3 million acres have been left idle under this program.

(a) <u>The U.S. farm program</u>: In order to join the basic set-aside of croplands, program farmers have to let fallow 10% of their

usual acreages in feed grains (corn, barley and grain sorghum) or 20% of their usual wheat acreage. The farmers benefit then from a guaranteed minimum target price, from a farmer-owned grain-reserve system and from loans. In 1978 8.4 million acres of wheat, 3.3 million acres of corn, 1.1 million acres of grain sorghum and 0.6 million acres of barley were left idle under the basic set-asode program.

Farmers that have agreed to the basic set aside program can then choose to increase the non producing lands beyond the minimum requirements and receive direct payments (subsidies) for the additional acreage. The subsidy limits are an additional 20% for wheat land and 10% for feed grains. Cotton was added to this program with a 10% upper limit. Under this program in 1978 were registered 2.8 million acres of corn, 1.4 million acres of wheat, 0.4 million acres of grain sorghum, 0.2 million acres of barley and 0.5 million acres of cotton. The farmers received then 50 cents per bushel of wheat produced on the remaining 60% of their wheat land, 20 cents per bushel of corn produced on the remaining 80% of their corn land or 4 cents per bushel of sorghum and 2 cents per bushel of barley and 5 cents per lb. of cotton produced on the remaining 90% of their cotton land.

(b) <u>The potential for ethanol production</u>: Let us assume for a moment that we could have planted corn on all 5.3 million acres under the diversion program. At 100 bushels per acre and 2.6 gallons of anhydrous ethanol per bushel of corn, we could have produced over 32 million barrels of alcohol. Over 115 million barrels could have been produced if the basic set-aside acreage would have been included and when pulling into production additional lands the potential for production of alcohol from agricultural commodities, grown specifically for this purpose, on land not in use under present food crop production conditions, could have reached in the U.S. up to 200 million barrels a year.

(c) The availability of subsidy funds: The yields used for the calculation of the subsidy under the diversion program are the historically recognized yields for that farmers land as calculated from an average of the last three years of production. Our calculations gave us for national averages $145.28 per acre of corn, $65.3 per acre of wheat, $42.24 per acre of barley, $53.95 per acre of sorghum and $96.5 per acre of cotton.

If one had planted corn and used the payment for non production in order to create a subsidy for the distiller one could have made available at least $0.62 to subsidize a gallon of ethanol. Calculating the subsidy as a weighted average of the different agricultural crops, as the other crops receive less subsidy than corn, under the diversion program, the average subsidy drops to a potential $0.44/gallon of ethanol. Let us note here that these calculations use only the diversion payments while additional subsidies remained untouched under the set-aside program.

(d) The cost of ethanol: According to Mr. Lipinsky, Battelle's Columbus Laboratories, the costs in dollars per gallon of ethanol produced from grain is as follows:

the primary ingredient (corn at $2.50/bushel)	$ 0.89
conversion cost	$ 0.44
annualized capital charge	$ 0.20
by product credit (mainly for cattle feed)	$(0.36)
net cost per gallon	$ 1.17

when substracting $0.62 as a new distiller's subsidy, one gets ethanol produced at 55 cents a gallon and this is quite close to the cost of a gallon of gasoline at the refinery.

Furthermore, remembering that ethanol in a 10% ethanol - 90% gasoline mixture increases by 2-4 octane numbers the value of low octane regular unleaded gasoline, and makes it into

a higher value premium unleaded gasoline, which could easily command the remaining differential of 2-3 cents per gallon of fuel (that is 20-30 cents per gallon of ethanol). Also the cost of corn here used in this calculation is the guaranteed minimum target price which is well above the market price. In effect, the opening up of a new market for the commodity should allow for additional income to the farmer and a decrease in the subsidy program so that the cost of a bushel of corn when intended for the production of ethanol should be closer to $2.25/bushel and the cost of a gallon of ethanol would than be reduced by 9 cents.

(e) Other U.S. policy considerations: The present U.S. laws prescribe the elimination of the federal excise tax on gasoline (four cents per gallon) for any fuel that contains at least 10% alcohol which is made from any primary material other than crude, natural gas or coal. This law, as it is worded, should be of special interest to potential alcohol exploiters as it allows the importation of alcohol made from vegetation sources overseas, thus allowing for the development of alcohol industries that will diffine the U.S. dependency on foreign sources of energy.

Conslusion:

We have shown here that the present subsidies for non production of U.S. farm lands could effectively provide the funds necessary to establish a fuel alcohol industry in the United States and to subsidize the distilleries in order to make alcohol costs competitive with gasoline. Also, the U.S. thirst for energy sources may eventually help outside economies establish alcohol export industries.

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