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POTENTIAL IMPROVEMENTS IN ALCOHOL PRODUCTION AND USE

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INTRODUCTION

Both methanol and ethanol were widely used as fuels in the latter half of the last century and were often used in the early days of the automobile. With the advent of inexpensive petroleum, alcohol fuels fell into disuse except where their specific advantages dictated use: as a power booster on most World War II and subsequent aircraft; in automotive racing where a 10-20% power boost is obtained due to the high octane; and under the fondue pot and in the flambe where the clean-burning properties of alcohol permit indoor use.

Historically, whenever the cost or availability of gasoline has permitted, alcohol fuels have been introduced as blends with gasoline. Blends were used extensively in Europe before and during World War II, in Cuba in the 1950s and for 20 years in Brazil [1,2]. Worldwide attention has been focused on these clean renewable fuels by two recent international conferences on alcohol fuels [3-5].

In the United States, arguments rage over whether alcohol blends will be satisfactory in cars and whether they can be justified on an economic basis. These arguments often hinge on the resolution of intangible factors such as the leverage value of fuel produced domestically versus imported fuel, the subsidies underpinning present oil production, the energy efficiency of alcohol production, as well as other topics. To avoid these quagmires, this presentation suggests that petroleum prices will rise so rapidly that alcohol must be produced and used at any cost.

In many circles "energy research" has somtimes seemed to be an excuse for inaction. Trying to improve a technology as much as possible before commercialization is natural, yet improving can continue forever and alternate clean fuels are needed today. Fortunately, methanol and ethanol can be produced at costs comparable to the cost of gasoline, and commercialization of alcohol fuels has begun. However, our modern technology is based on research and continuing improvement and research should be started at a high level in parallel to increasing production. Improvements from this research can be incorporated by modifying existing plants or in second generation plants and cars designed for alcohol.

This paper surveys the current areas of research and presents "research bullets" which will possibly make dramatic improvements in production and use. Apologies must be made for not having space to credit the wide variety of sources, many personal, from which these ideas have been drawn. Some ideas can be attributed to specific inventors, others are drawn from recent improvements in related fields, while still others are being formed in discussions in technological circles and are "in the air". The reader is referred to the source references for many of these ideas.

SECTION 2.0

MAJOR IMPROVEMENT AREA

2.1 BIOMASS ENERGY PRODUCTION SYSTEMS FOR FARM AND FOREST

The photoconversion of sunlight to biomass is the only solar technology likely to cover a large fraction of the earth which, in fact, it already does. In the past century of plentiful fossil fuel, the farmer has been in the "specialist" energy production business, producing only that energy required to operate the human engine, called "food". The farmer will now be called upon to optimize his crop and profits around a mixed energy production of food fuel and chemicals such as ammonia. The forest has been thought of as producing only fiber, but in the past it has been used also as a source of fuel and food (browse, wood sugars). Now forest production will have to optimized around the new "total energy" needs.

With this broader biomass energy production assignment, many changes are likely to be seen in farm/forest production, including:

- development of perennial corn and other plants to reduce the energy requirements for fillage and to prevent topsoil loss;
- coppicing (stump sprouting) for production of woody species for energy and fiber production;
- farms becoming net energy producers, making their own fuels and fertilizers from residues with some to spare for the city (See Fig. 1);
- aquaculture in oceans and lakes, large new areas for biomass production;
- ethanol production gives high value use for excess carbohydrates and conserves protein since present crops have a higher carbohydrate/protein ratio than desireable for human and animal consumption; and
- fractionation of plants into protein and carbohydrate in the early growth (vegetative) stage, giving increased yield and quality per acre with multiple plantings. (Presently, starchy plants are grown because starch is easily stored, but other processing methods are now possible and may be preferable.)

The above points outline possible long term changes in our biomass production systems. More immediate expectations are for:

- Acid and enzymatic hydrolysis processes converting the cellulose fraction of plants to sugars (for cattle feed) and thence to alcohols (for automotive feed); and
- improved sugar and grain crops for high sugar/alcohol yields such as sorghum and jerusalem artichoke.

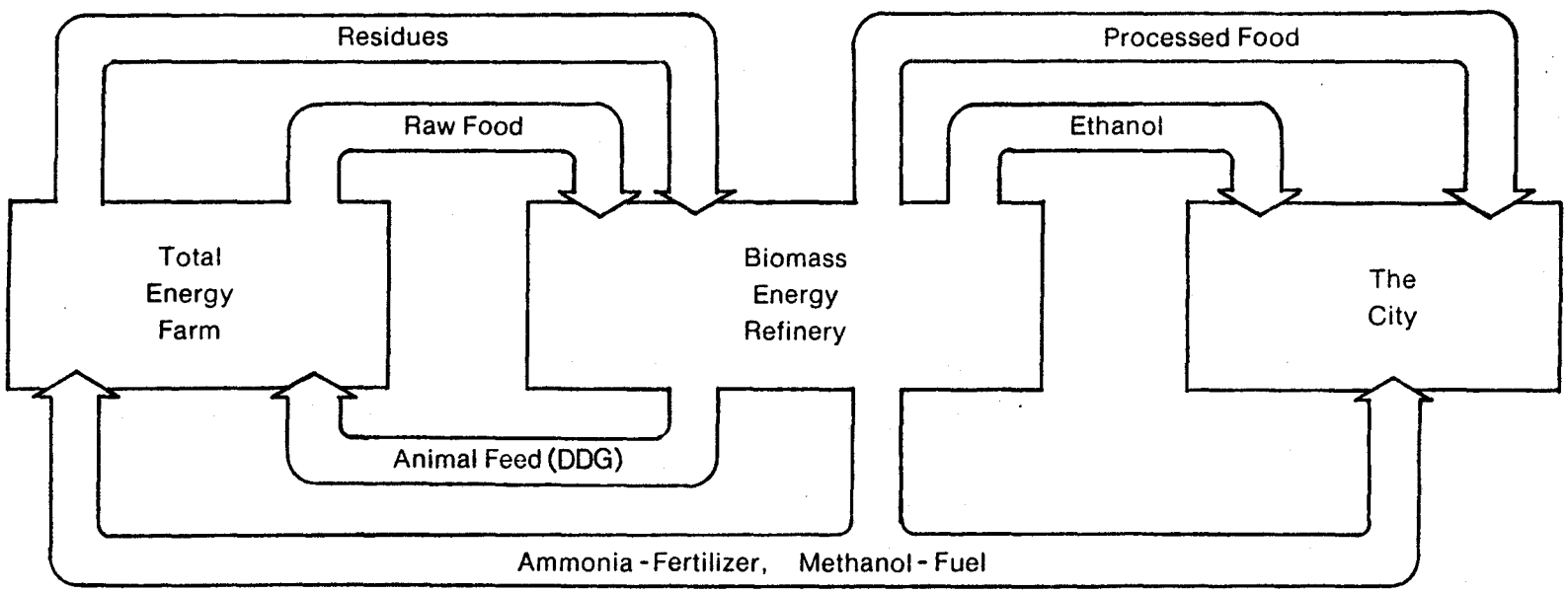

Figure 1. The Total Energy Farm

2.2 ETHANOL PRODUCTION

In the fermentation and purification of alcohol these developments may soon be seen:

- high alcohol tolerance yeast strains to reduce separation costs;
- thermophilic yeast strains to greatly reduce fermentation times;
- biological production of other alcohols and chemicals;
- new uses for the 12 gallons of "stillage" (slops) produced for each gallon of alcohol made;
- continuous fermentation/distillation;
- vacuum fermentation;
- improved methods for "breaking" the azeotrope, including codistillation with gasoline; and
- other separation methods including freezing, absorption, and membranes to lower separation energy and costs.

2.3 METHANOL PRODUCTION

At present the thermal/catalytic production of methanol is considerable less expensive than the biological production of ethanol and may remain so. Furthermore, the same technology that produces methanol can product ammonia, a "fuel for biomass." The following improvements in methanol production could occur:

- package methanol/ammonia plants of farm cooperative size to operate from farm and forest residues;
- new catalysts to permit methanol production at lower pressure and temperature;
- homogeneous methanol reactors in liquid media;
- direct production of methanol from methane and biogas; and
- biological methanol production from unusual substrates.

2.4 AUTOMOTIVE USE

Investigations and developments should include:

- engines optimized for alcohols, which will attain higher efficiency than gasoline engines by utilizing the lean, clean burning, and high octane properties of alcohols. Clearly 20-40% and possibly 60% higher thermal efficiencies are possible;
- vapor engines using waste heat to boil alcohol fuels giving cleaner combustion and increased efficiency (5% for methanol, 1% for ethanol);

- engines operating from hydrogen-carbon monoxide mixtures produced by decomposing alcohol catalytically with waste heat and recovering 13% waste heat for methanol and 15% for ethanol;
- "smart" carburetors, adjusting the mixture to the load for optimal efficiency; and
- optimal water content in alcohol fuels giving minimum emissions, optimal octane, and reducing the energy of distillation.

These advances will be required for cars burning alcohol instead of gasoline. More immediately, the following need to be determined for blends:

- economic gasoline feedstocks and additives for optimal utilization of alcohol fuels in blends; and
- "smart" gas tanks using separated gasoline/alcohol-water layers for optimal fuel use at all conditions (starting, acceleration, cruise, idle).

Investigations necessary for diesel and turbine use are:

- optimal methods for diesel use of alcohol, including dual fuel, emulsification, and blends for minimizing emissions; and
- higher alcohols (such as butyl) which can be obtained by fermentation for jet fuel and diesel use.

SECTION 3.0

SUMMARY

Alcohol production using current technology is believed to be technically and economically feasible today. Moreover, it is necessary for the orderly transition of our society from fossil fuel to renewable energy sources, from our present "exploitive energy production" which comsumes energy "capital" to a "stewardship" role in which people live on the "interest" of land used wisely.

It is hoped that this list of possible improvements in total energy production from biomass and alcohol fuels will stimulate for a concurrent investigation of second generation ideas for improving biomass and alcohol production.


SERI

SECTION 4.0
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While alcohol fuels are in many ways practical and economical substitutes or additives for gasoline, they are still in their infancy as compared to the 50 years of intensive development enjoyed by petroleum fuels. Construction of alcohol fuel plants can begin immediately based on the technology available today. Simultaneously, the investigation of potential improvements in the production and use of alcohol fuels should be expanded. This paper surveys a number of areas in which improvements in either efficiency or economy of production are being studied. Also examined are areas in which alcohol use efficiency will be improved.

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