1. INTRODUCTION

For fuels and fuel additives crude oil is worldwide the predominant source for the time being. The events of 1973 and 1978 indicating possible supply shortage and price explosions for gasoline and diesel fuel have stimulated interest and research in the field of alternative fuels. Those based on renewable energy sources seem to offer particular attractiveness, since solar energy is free of cost and the biomass availability is unlimited in comparison with fossil resources such as crude oil, coal or natural gas.

However, except in Brazil (Proalcool) and USA (Gasohol), a market introduction of biomass fuels has not yet occurred to any great extent. The high cost of agricultural fuel products originating principally from the low energy density of biomass has not led to economic competitiveness with conventional or other alternative fuels. Figure 1, with regard to market prices for different fuels or fuel components, shows that biomass products rate at least double the price of gasoline.

Progress in the overall economic situation can be expected primarily from research and development in the fields of plant growing and biomass product processing. Compared with the fuel production costs in excess of conventional fuels, the additional operational costs caused by modified relevant technical concepts in the transport sector are relatively low. In the initial phase, however, high investments, depending on the type of biomass fuel application, may be needed there, too.

Comparing the various technically possible solutions' emphasis will be put particularly on the fact that Western Europe suffers from a surplus of agricultural products for which, at present, no sufficient outlet into the market can be found.

2. FUELS FOR ROAD TRANSPORT

Worldwide present and possible future use and demand of conventional and new fuels are illustrated in Figure 2 and Figure 3. With respect to regional availability biomass fuels, also in the future, will have to compete with other favourable energy sources. Clearly, the best chance for production of energy from biomass has to be attributed to tropical and subtropical areas (cf. Figure 3).

3. BIOMASS FUELS

Favourable production possibilities for fuels from renewable raw materials are shown in Figure 4. Other processing lines such as the hydrolysis of cellulose materials e.g. to methanol, or the use of gaseous fuels from biomass fermentation, or wood gasification, will not be considered here, since their competition levels are still relatively low. However, regional application of biogas e.g. in farm tractors, should generally not be excluded in such cases where biogas will be produced for other reasons anyway. One of the main problems of gaseous fuels arises from the high storage capacity (volume) needed to gain a reasonable mileage for vehicles.
Methanol, as a biomass fuel, will not be regarded here in more detail, since it can be produced much more economically from fossil resources. Incidentally, experience and know-how about methanol application in road vehicles is available worldwide to a higher extent than for any other alternative fuel.

Thus, ethanol and vegetable oils or its derivatives, respectively, are the most interesting biomass fuels. Today, ethanol production relies almost entirely on sugar or starch containing materials. However, for long term and high level substitution aspects, ethanol should be based more on cellulose feedstocks, as they denote a much higher portion of the totally available biomass and as they are not a link in the production line for human food.

4. VEGETABLE OILS

From Figure 53 which shows the suitability of various alternative fuels for Otto and diesel engines, it can be seen that vegetable oils are not appropriate for use in spark ignition engines. This is due to the relevant boiling behaviour shown in Figure 63 for different fuels.

From the fuel data comparison in Figure 73 the high viscosity and the poor behaviour at low temperatures of vegetable oils are recognised, whereas ignition quality and energy content are comparable to the diesel fuel data. Clogging of injector nozzles (Figure 86), contamination of fuel filters, oil thickening and extensive odour of the exhaust gas are further handicaps which can largely depend on the type and saturation degree of the various feedstocks (cf. Figure 5).

These problems can be reduced by blending with diesel fuel or by transesterification of the vegetable oils. The resulting monoesters (methyl and ethyl ester) show a high degree of compatibility with existing motor technology. Figure 86 shows that the viscosity will be decreased significantly. Also cetane numbers are improved (compare Figure 7). But there are problems left to solve for the application of vegetable oil esters (as unit fuels) in unmodified or only slightly modified vehicles: insufficient resistance of some materials, change of fuel composition during storage, dilution and, later, thickening of lubricants with effects on engine durability.

The substitution of diesel fuel by vegetable oils or their derivatives is considered likely to become much more significant for developing countries than for Central Europe due to the fact that, worldwide, a shortage of middle distillates is prognosticated and that there is a lack of relevant infrastructures for goods traffic in many areas. In a first phase probably road transport by diesel engines operating on domestic fuels has to contribute to solve those problems.

5. ETHANOL FUEL AND ENGINE CONCEPTS

Ethanol, from its characteristics, particularly by its high octane and low cetane number (below 10) is, as a unit fuel, an ideal substitute for gasoline. In Figure 93 some fuel data of gasoline, methanol and ethanol are compared. But ethanol can also be applied in diesel engines (cf. Figure 5). In addition to the potential to substitute conventional fuels, ethanol can also bring advantages to factors such as fuel consumption efficiency or environmental protection.

In the following the amount of ethanol fuel content and the resulting extent of necessary engine modifications are selected for concept classification, parameters which are directly linked to the overall possible substitution.