KFB-INFO--96-11

The KFB Program on
Biobased Fuels for Vehicles

KFB
SWEDISH TRANSPORT
& COMMUNICATIONS
RESEARCH BOARD

As constituted today, the transport sector is not sustainable in the long run because it is based almost entirely on non-replenishable natural resources which, when combusted, release emissions that can cause serious harm to human beings, animals and the natural environment. Therefore, in order to achieve a sustainable transport system, it is imperative to achieve a means of propulsion which is based on renewable energy sources in every phase of production and distribution. It will take time to develop and test such a transport system.

The responsibility for developing such a sustainable transport system is an assignment which must be approached as a common cause, involving both the official agencies of society and the business sector and international cooperation.

The KFB program for biobased fuels - engine alcohols and biogas - has been underway since the summer of 1991, and will be concluded at the end of 1997 or early 1998. The objective is to allow various concerned parties, politicians, producers, distributors, vehicle operators, etc., a basis for deciding about possible future investments in biofuels.

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Innehåll

Why Biobased Fuels?

Every kind of combustion produces waste products. Many of them are harmful to our environment and to our health. The combustion engines of cars, buses and trucks produce large quantities of such undesirable substances as carbon monoxide, carbon dioxide, nitric oxides and hydrocarbons. It is true that new and "cleaner" fuels, as well as more energy-efficient engines and the introduction of catalytic converters, have improved the situation appreciably, even though a large part of this environmental gain is negated by increasing transportation, higher speeds, heavier vehicles, and so on. Still, there is at least one major exception to this progress: we have not yet come to terms with the emission of the so-called greenhouse gases, especially carbon dioxide, CO_2. The amount of CO_2 in the atmosphere is constantly increasing, and many researchers believe that in time this can mean large-scale and dramatic climatic anomalies all over the world.

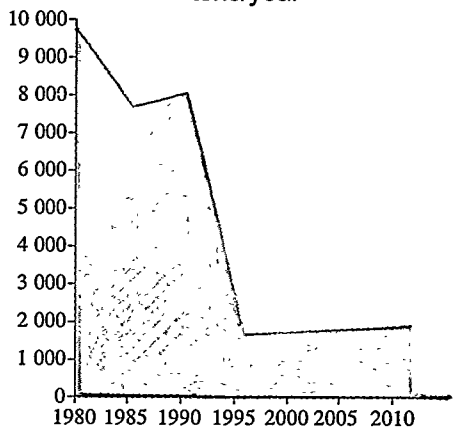
Consequently, the Swedish Government has determined that we must reduce CO_2 emissions. But that will be difficult to achieve as long as our vehicles run on fossil fuels; in that case, there is no other prospect than an increase of CO_2 in the atmosphere.

The solution may be biobased fuels derived from renewable raw materials, such as

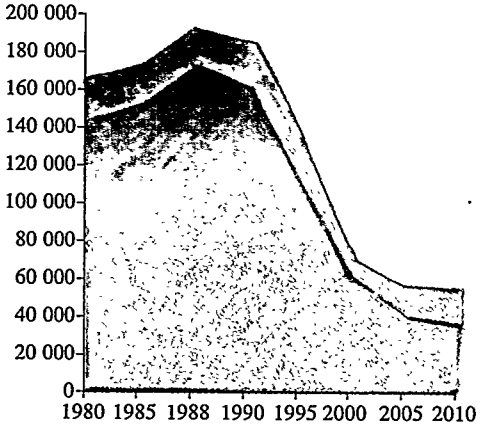
The figures illustrate the emissions of nitric oxides, hydrocarbons, sulphur dioxide and carbon dioxide from road traffic. Emissions of the first three have decreased and are expected to go on decreasing, while the emission of carbon dioxide is increasing and is expected to keep on increasing. The introduction of new alternatives (e.g. biobased fuels and electric/hybrid electric vehicles) may possibly reverse the trend for carbon dioxide as well.

(Source:Swedish National Road Administration Environmental Report 1993.)

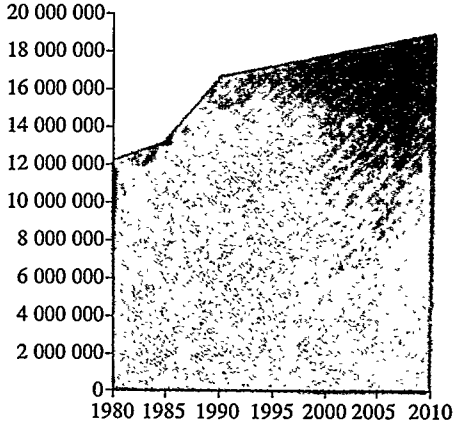
Sulphur dioxide
tons/year



Nitric oxides and Hydrocarbons
tons/year



Carbon dioxide
tons/year



wood products and grains. This would mean that CO_2 is locked into a closed circuit: the same amount of CO_2 that is released from combustion is absorbed by plants for their growth. The total amount of CO_2 does not increase. (Observe, however, that this presumes the use of biobased energy also during the transport, production and distribution of these fuels.)

KFB's Assignment

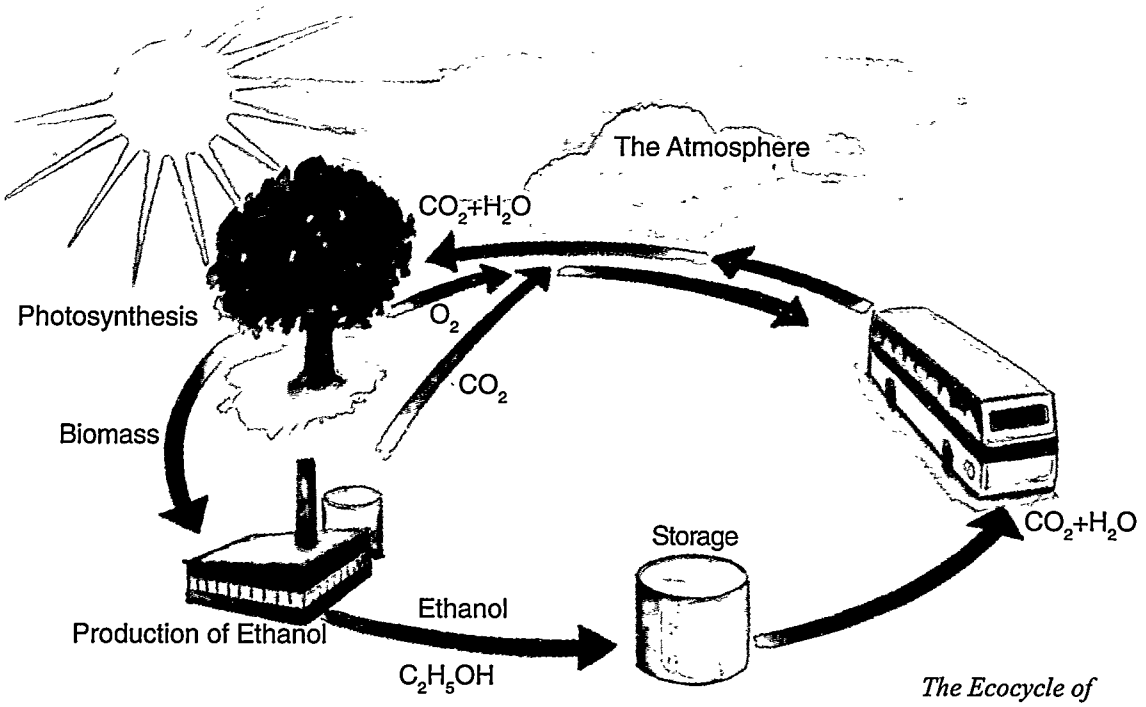
The energy policy proposition (1990/9188) prepared the foundation for the Parliamentary decision to allocate KFB (Swedish Transport and Communications Research Board) SEK 30 million per year for four years to support research and demonstration projects involving the use of engine alcohols. Among other things, the Government's proposal states the following.

The use of alcohol-based motor fuels has advantages from the point of view both of the environment and of national security. It is important to stimulate the development of technology for alternative fuels and to conduct experiments with vehicles in urban areas to gain experience in handling and using alternative fuels.

In December 1992, the executive committee of KFB initiated a program for this activity. The aims of the program are specified as follows:

- to develop, test and assess technology and systems for the use of alcohols as motor fuels,
- to encourage large producers and users to participate actively in development and demonstration projects;
- to increase knowledge about the long-term utility, cost and environmental potential of engine alcohols;
- to determine whether, and to what extent, engine alcohols are ready to be introduced on a large scale.

KFB's program focuses primarily on heavy vehicles because we judge that they represent a major environmental impact. Among the main tasks of KFB is to support the development of smoothly-functioning and environmentally-friendly public transportation. Hence the development of different kinds of buses is an important



The Ecocycle of Ethanol, also applicable to Biogas

ingredient in the program.

Cooperation and co-financing with other authorities, researchers, producers and users of vehicles and fuels are prerequisites for implementing the program. A number of projects were begun with appropriations from other sources prior to the extant biofuel program, but nevertheless provide results that can be employed in its evaluation.

First, absolute alcohol. . . .

From the outset, efforts were directed primarily in the direction of absolute alcohols. The point of departure was the environmental problems in urban areas, where propulsion with absolute alcohol offers the greatest potential for the betterment of both health and the environment.

... then mixed fuels . . .

However, it will take a long time for a technology that requires entirely new engines, for example, to have an effect. Mixed fuels, which can be used in today's engines, are thus interesting during a transition period until engines and vehicles designed for absolute alcohol propulsion have appeared on the market in sufficient quantities. If, in addition, we consider the CO_2 problem, the admixture of alcohol in diesel oil and gasoline is interesting as a solution in and of itself, since it means introducing as much biobased engine alcohol fuel as possible into the propulsion system. The quickest way to achieve this is with low-level admixture in diesel oil and/or gasoline.

That is why KFB's current efforts also involve fuel blends that include alcohol. The challenge is to come up with mixed fuels that can be used in most of today's - and naturally, tomorrow's - vehicles. KFB is therefore conducting tests involving different types of vehicles and fuel mixtures.

In order to achieve a vigorous and meaningful introduction of mixed fuels, it will also be necessary to examine questions touching on both the production of fuels and the composition of fuels, as well as various kinds of political incentives.

... and biogas

Yet another alternative fuel cropped up during the summer of 1993: methane gas derived from biobased raw materials. Experiments involving vehicles and distribution facilities are underway in Linköping, Trollhättan, Uppsala and Stockholm.

A Variety of Approaches

The emphasis here is on field tests of vehicles. Heretofore the efforts have primarily involved heavy vehicles - buses and trucks - but development and testing of private automobiles are also included in the project. This includes both vehicles operating on alcohol (pure alcohol and mixed fuel) and those operating on biogas.

Adaptation and Distribution of Fuels

It has been demonstrated that the composition of fuels has great significance for improving the emissions of both diesel and gasoline engines. A certain amount of development work is being carried out in this area, and estimates will be made of the possibilities for further improvements. However, the KFB appropriation is not intended to be used to develop the actual production of fuels.

Efficient systems for distribution, storage and handling are one prerequisite for the large-scale introduction of biobasedfuels. The techniques that will be used in the demonstration project will be

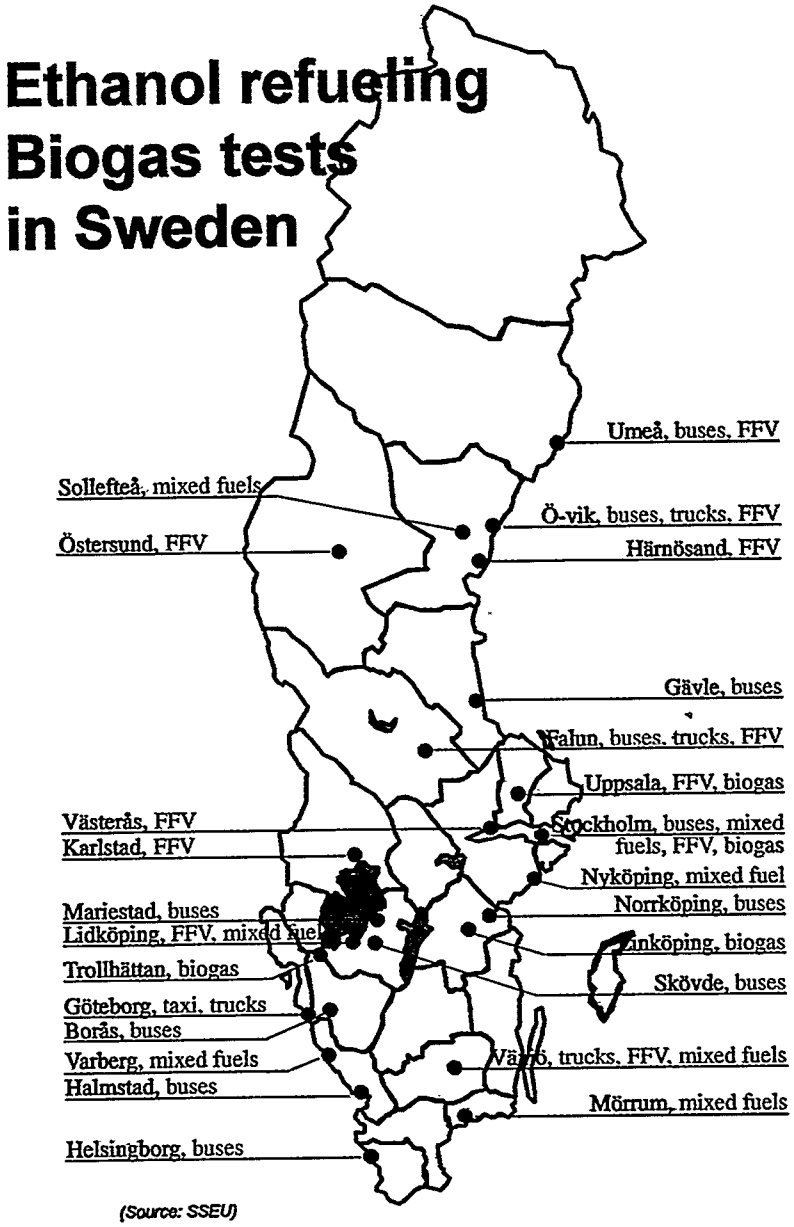
somewhat provisional. KFB will, however, investigate what long-term and large-scale problems exist, and evaluate the need for further development.

Evaluations

Special resources have been earmarked for evaluation, focusing primarily on health, environment, technology and economy. Emissions, and their local, regional and global impact on the environment and on health, will be measured and analyzed. An evaluation will be made of the reliability and developmental potential of alcohol and biogas technology. Economic evaluations will be carried out both for the individual projects and for the overall program. On the program level, too, estimates will be made of the potential for producing and using the various fuels, involving different sources, types of vehicles and traffic applications. The effects of large-scale introduction will also be assessed.

❑ Evaluation of the various projects is carried on continually according to a special evaluation plan . Autoemission K-E E Consultant is in charge of emission measurements and prognoses with regard to health and the environment. The plan also embraces technological and economic matters.

❑ An independent evaluation of the biofuel program was conducted in the spring of 1994. It focused on what needed to be done



Biobased fuels are being tested across the whole of Sweden

during the remainder of the program period up to 1997. The judgement of this evaluation was that the program should be more specifically directed towards, and conducted in unison with, the affected industries and consumers of the fuels. A desire was also expressed for a kind of national liaison - a "regulatory agency" - for the long-term use of biofuels in the transport sector.

❑ As a result of that evaluation, KFB has launched a system study to develop economic evaluations and estimates of the potential for producing and using different fuels. This system study is described in greater detail in the next section.

❑ At the request of the National Audit Bureau, the IM Group reviewed the biofuels program during the winter of 1995/96. The following summary is representative of the IM Group's findings:

It is obvious that the 1991 appropriation of SEK 120 million launched many activities in the network. It is also obvious that today, as compared to 1991, we have a significant number of companies/ institutions cooperating in what we might call an engine alcohol network.

. . .

The present (February 1996) state of knowledge makes it possible to state with considerable confidence that absolute ethanol propulsion, at least in the case of heavy vehicles, functions technically well under Swedish conditions and that the environmental benefits are considerable. FFV [Flexible Fuel Vehicles] engines in light vehicles are an established technology. With regard to ethanol-diesel mixed fuel in ordinary heavy vehicles, the question remains whether it is harmless to engines over a period of many years. The stakes involved here are enormous. Generally, however, it can be said that the technical problems, regarding both heavy and light vehicles, are not so complicated but what the auto industry can solve them within a few years, if it makes up its mind to do so.

One of the most important consequences of the program is that know-how regarding ethanol and engines is now widely spread in municipalities throughout Sweden. This undoubtedly implies that there will be little hesitation in getting underway if/when the decision is made to approve tax subsidies for alcohol fuels. At the same time, it is quite possible that the transmissible know-how and the interest generally stimulated by the program represent a political factor that will encourage such a decision.

Information

Great attention has been devoted to information as part of the program. The individual projects are usually documented in the form of KFB reports, but sometimes by project participants as well. Project reports and other printed materials are entered in a list of publications that is constantly updated.

❑ News about the program - and other, "external" material as well - is presented in a newsletter that is published regularly.

❑ KFB's administrative personnel systematically participate in conferences and seminars, both in Sweden and abroad.

❑ The program has also been presented at several exhibitions throughout Sweden, both at more specialized environmental fairs and in connection with transport conferences.

❑ The program area is very international, which is reflected in the information material; many pivotal texts are published in English, and some also in German and French.

Miscellaneous

This includes projects and activities that cannot be directly sorted under the other captions. They involve, for example, regulations and strategic and administrative studies.

Work Currently Underway, in the Planning Stage, or Completed

Comprehensive Studies

The program embraces some 80 projects either ongoing or completed. Some of the larger and foremost of these are described below.

- A status report on fossil and biobased engine alcohols has been compiled by Ecotraffic. It is also available in a briefer, "popular" version (in English as well). The report summarizes developments between 1986-1993 and covers the entire chain from raw materials to use. It also takes up the impact of emissions on health and the environment.
- A similar strategic study in the field of biogas has been produced by Vattenfall Energisystem. This report deals with both the production of biogas and its use as a vehicle fuel; it, too, is available in a condensed version.
- A strategic study of the manufacture, distribution and market for engine alcohols has been carried out by Atrax Energi. The report describes the availability of biomass and how it can best be used, and presents the necessary conditions for introducing ethanol as a fuel and the various consequences that might have from various points of view.
- The employment of biofuels for different purposes is treated in a study conducted by IVL (the Swedish Institute for Water and Air Conservation Research).
- The prerequisites for utilizing biomass in the transport sector are being investigated at the Department of Environmental and Energy Systems at the Lund Institute of Technology. These prerequisites are determined by, among other things, the available biomass resources, the costs involved in utilizing them and in producing transport services, and the possible environmental benefits resulting from the use of biomass.
- Ecotraffic has presented a report on operating experiences with heavy vehicles running on alternative fuels. It covers both Nordic and international experiments.
- A report on engine alcohols and regulations has been produced by the Swedish Foundation for Ethanol Development (SSEU). The report is a compilation of existing regulations for the handling of engine alcohols. It also addresses the differences between methanol and ethanol, and illustrates the need for specifications pertaining to content, risk classification, etc.
- The Institute for Water and Air Conservation Research, IVL, has put together a compilation of energy taxes in the transportation field in different countries. The report describes existing regulations as well as the principles and motive forces for the policies of different countries with regard to taxes and tariffs. The emphasis is on the Swedish taxation system, but the other Nordic countries, the EU, the U.S.A. and Japan are also considered.
- Aspen Utveckling has conducted a project on buses in city traffic, a comparison between bona fide traffic and ordinary bicycles and a study of conversion of motorized bicycles to motorcycles. The objective is to facilitate the transfer of load patterns in real driving conditions to cycles in an engine laboratory.
- The possible injurious effects of engine alcohols on human respiratory passages are being investigated at the Department of Toxicology at the Royal Caroline Institute. Aldehydes and other substances are created during the combustion of engine alcohols, and the aim is to study and rank the tial of these substances to give rise to pathological alterations in respiratory passages.

• At the same Institute, the Department of Environmental Medicine is conducting a project concerning the evaluation of health risks resulting from vehicles powered by engine alcohols. This work includes calculating the health risks of individual components of alcohol emissions, assessing the significance of oxidation catalyzers from the point of view of health, and comparing the implications for health of emissions from diesel and alcohol powered vehicles. A final report will be presented during late 1996.
• Prior to the conclusion of the biofuels program, KFB will carry out a systems study that will analyze most of the implications of a large-scale introduction of biobased fuels. The following substudies are included:

1. Compilation of emission data and evaluation of emissions levels of vehicles.
2. Production costs for ethanol, methanol and biogas.
3. Vehicle costs.
4. Infrastructure costs.
5. Energy scales.
6. Economic equilibrium studies.
7. Survey of reports on biofuels.
8. Analysis of experiences gained from the introduction of biofuels.
9. Methanol studies: international experiences.
10. Assessment of impact on health.
11. International experiences with biofuel vehicles.

Pure Alcohol

• A fleet test involving ethanol-powered urban buses in Stockholm, operated by Stockholm Transport (SL), was begun in April, 1990. With 32 vehicles participating, this was one of the largest such tests in the world. The aim was to find out whether it is possible to achieve appreciable improvements in emission values for city buses by using ethanol in modified engines. The results showed generally lower emission values (see table), good accessibility for the buses, and that infrastructure problems for ethanol can be solved. This experiment has now been concluded and a final report has been prepared by Tima Projektkonsult. A concise "popular" version has also been published (in English as well).
• One of the world's first fleet tests of ethanol-powered city buses was initiated in the spring of 1985 in Örnsköldsvik (by Örnsköldsviks Buss AB). The original two buses were joined by four more in the fall of 1993, and two more were added during fiscal year 1995/96. A different blend of fuels (a different ignition improver) than SL's has been tried in Örnsköldsvik, where the operating and climate conditions are different from those in Stockholm. This project has very likely contributed to Scania's development of ethanol engines for improved environmental performance.
• A fleet test of ethanol-powered buses is also underway in Skaraborg County under the auspices of Skaraborg County Transport AB. 15 vehicles are involved, 10 of which are rebuilt diesel buses and 5 are new buses built for ethanol operation.

Regulated emissions	"1994" diesel (g/kWh)	Goal, ethanol project	Result acc. to ECE-R49 cycle (g/kWh)	Result acc. to "Braunschweig" cycle (g/km)	Long-term goals
Oxides of Nitrogen, NOx	9	4,5	3,8	6,5	2–3
Carbon Monoxide, CO	5	0,1	0,05	0,16	0,05
Hydrocarbons, HC	1,2	0,2	0,16	0,14	0,1
Particles, "soot"	0,4	0,05	—	0,04	—

Measuring of exhaust emissions in the SL project

Among other things, the objective is underway in Skaraborg County under the auspices of Skaraborg County Transport AB. 15 vehicles are involved, 10 of which are rebuilt diesel buses and 5 are new buses built for ethanol operation. Among other things, the objective is to examine the possibilities of converting heavy diesel vehicles to ethanol auspices of Skaraborg drive to examine the possibilities of converting heavy diesel vehicles to ethanol drive.

• Flexible Fuel Vehicles that can utilize several fuels and blends of different fuels can be significant for developing a market for biofuels. In such FFVs, the blend of fuels is detected by sensors that send signals for the adjustment of various engine parameters. Over 50 FFVs are being tested around Sweden. Most of these vehicles are powered by ethanol (E85). Driving and environmental characteristics are monitored and evaluated. SSEU (the Swedish Foundation for Ethanol Development) is in charge of the project, and the work will be concluded at the turn of the present year (1996/97). The first emissions measurements (spring, 1996) indicated improved environmental characteristics, but not to the same extent as for vehicles exclusively adapted for ethanol drive.

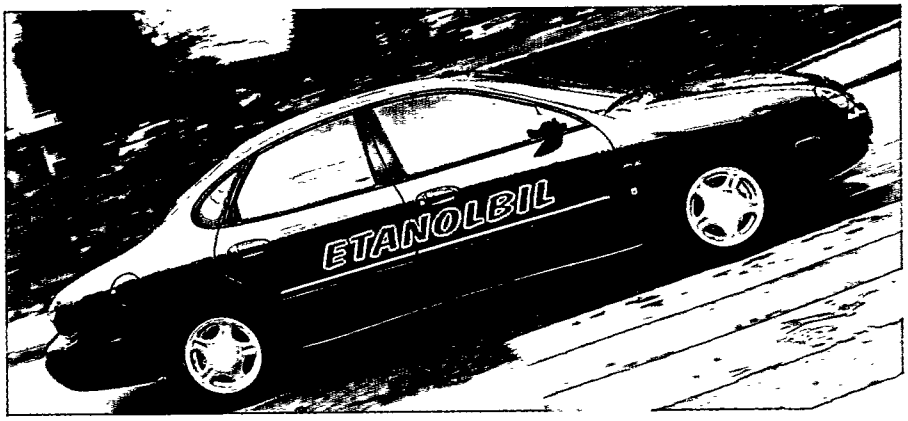
• A study of the introduction of Flexible Fuel Vehicles has been produced by Ecotraffic.

• SSEU is also studying the infrastructure for ethanol fueling of Flexible Fuel Vehicles. This includes accounting for the amount of vehicle wear-and-tear contributed by ethanol.

• SVENOL - ethanol powered trucks in urban traffic. Four vehicles are being tested in Växjö, Örnsköldsvik and Stockholm. The project will provide experiences from this kind of operation, including distribution and waste treatment. The SVENOL project (and others) have made it possible to test a number of the engine concepts and systems solutions generated by other parts of the program. For example, the engine now being used was developed by Volvo and the Chalmers Institute of Technology with the support of KFB's biofuel program.

• A project now concluded at the Department of Human Work Sciences at the Luleå Institute of Technology dealt with noise and exhaust emissions from ethanolengines in heavy vehicles. The aim was to reduce the discharge of unburned fuel and other unwanted emissions, and to map the effect on noise pollution that may be involved in a changeover from diesel to ethanol. The project also included further development of the engine (Scania DSC11) used in the SL fleet test mentioned above.

• The Department of Thermal and Fluid Dynamics at Chalmers Institute of Technology has concluded a study of the development of an alcohol engine for heavy vehicles. The work involved a Volvo engine (TA 73) for ethanol and



FFV (Flexible Fuel Vehicles) run just as well on pure ethanol (E85) as they do on gasoline and blends of the two. Nearly 100 FFV's are involved in a study supported by KFB.

SSEU and Aspen Petroleum are running fleet tests of vehicles operating on a blend of biobased ethanol, diesel oil and emulsifiers. No modifications have been performed on the engines. This makes it possible to vastly increase the amount of environmentally friendly fuel in today's vehicle fleets. (Photo courtesy of the Forest Owners' Association, Norrskog)

Beraid ignition improver. These engines are now being used in the SVENOL project (see above). Three different kinds of catalyzers were also tested.

• A "concept study" of alcohol engines for buses at AVL Gesellschaft für Verbrennungskraftmaschinen in Austria has been completed.

• Development of catalyzers is a project currently underway at the Department of Chemical Engineering at the Royal Institute of Technology (KTH) in Stockholm in association with the Luleå Institute of Technology. The work concerns vehicles operating in urban areas. A final report will appear in the fall of 1996.

• KTH is currently developing new "catalyzer concepts", i.e. new materials, combinations of materials and constructions of catalyzers intended for heavy vehicles operating on biofuels. In this project, KTH is cooperating with Svenska Emissionsteknik and Johnson Matthey plc. This work is based on well-grounded results from a NUTEK (Swedish National Board for Industrial and Technological Development) project.

• The Department of Human Work Sciences at the Luleå Institute of Technology is characterizing the release of regulated and unregulated emissions from five different catalyzers. In the first stage, three catalyzers developed by catalyzer manufacturers are being studied, and in the second phase, two catalyzers developed at KTH. The purpose is to find out whether these newly developed catalyzers do a better job of measuring up to the demands that should be placed on catalyzers for heavy vehicles running on ethanol.

• Luleå University is investigating the prerequisites for using EGR (recirculation of exhausts) in ethanol powered diesel engines. The aim of the project is to reduce the nitric oxide emissions of ethanol powered diesel engines while maintaining or improving the emissions values of other gas components. This project is expected to result in the development of optimized monitoring parameters for EGR systems.

• Ecotraffic is conducting a study of dimethylites - DMEs - as fuels for diesel engines. This work includes studying production and handling techniques as well as the suitability of DMEs as vehicle fuels.

• A completed project on ignition properties of ethanol fuels (Berol Nobel) was concerned with a numeric model for ignition of ethanol spray with ignition improvers.

• The Department of Analytical Chemistry/ Arrhenius Laboratory at Stockholm University is undertaking a comparison of two different ignition improvers. The aim is to investigate whether emissions from the two kinds of systems differ with regard to

impact on the environment and health. Both chemical and biological characteristics are included.

The fleet test involving pure alcohol has shown that there is a great potential for achieving improved environmental characteristics. Generally speaking, it can be said that there are many environmental advantages in using ethanol drive as compared with diesel drive, particularly with regard to carbon dioxide, nitric oxides, particles and certain toxic hydrocarbons (particle-bound PAH, Polycyclic Aromatic Hydrocarbons).

Mixed Fuels

The biofuel program encompasses demonstration experiments involving some 20 diesel vehicles operating on mixed fuels.

• SSEU and Aspen Petroleum are conducting the project "Mixed-fuel Diesel — Emulsifier — Ethanol". The initial stage comprised the development of different fuel mixtures and a limited number of fleet tests with vehicles in daily use with varying kinds of driving. The project has now entered a second stage involving about 25 vehicles running on different blends of fuels. SSEU is the project leader for some 20 vehicles, and Aspen is in charge of the others. This project also includes studies of fuel characteristics and the need for and design of fueling facilities, as well as other infrastructure matters.

• Aspen Petroleum is in charge of efforts to formulate, test and evaluate a mixed fuel for diesel engines - "Diesohol". Aspen has been testing similar fuels for a number of years, but with somewhat varying formulas. The aim of this project is to come up with a satisfactory diesel fuel providing good environmental and operating characteristics.

• The Department of Heat and Power Engineering at the Lund Institute of Technology as carried out a study of the literature on blending ethanol in diesel oil.

• A similar study concerning the blending of alcohol in gasoline has been made by the Department of Human Work Sciences at the Luleå Institute of Technology.

• Aspen Petroleum has conducted tests of the vehicular fuel "Aspen Taxi" in gasoline engines. The fuel is a blend of bioethanol and alkylated gasoline, and is being used in some 80 vehicles.

Mixed fuels can be used in existing vehicle fleets. Hence there is a great potential for using biofuels while simultaneously achieving environmental improvements, e.g. lower emissions of particles and carbon dioxide. The experiences gained heretofore suggest that an admixture of up to 15% ethanol in diesel oil is possible without the need for conversion of existing engines. Ease of operation is as a rule not affected. The experiments also indicate environmental improvements.

Biogas

• The final report of "The Nordic Gas Bus Project" has been presented. The aim of the project was to remove the obstacles - social, industrial and legislative - impeding the introduction of natural gas and biogas propulsion for buses and other heavy vehicles in the Nordic countries.

• VBB-VIAK is making a compilation of international experiences with biogas vehicles. The aim is to identify the projects involving biogas operated vehicles around the world, bring together the available experiences and create possibilities for cooperation. Important questions being illuminated by VBB-VIAK include the motive forces behind such projects, the numbers of biogas vehicles, evaluations of the futureprospects for biogas vehicle technology, operating experiences, handling and refueling facilities for gas, and exhaust emissions test.

• The Swedish Hydroelectric Power Authority has presented a status report on biogas. The report addresses questions about the production of sludge digestion gas, the additional refinement into a usableavailable in a condensed version.

• A test of biogas-powered buses in Linköping (Linköpings Biogas AB) was begun in January 1991. Six buses using converted diesel engines (Scania DS 1126) engine fuel and various principles for refueling. Individual chapters are devoted to gas engines and to economic considerations in connection with the introduction of biogas. The report is also were involved. The project also included testing and evaluating the infrastructure required for refining biogas. The project presented a final report in early 1995, but it has now been extended because of the expansion of production facilities and the vehicle fleet. It is estimated that ca. 30 gas buses will be operating by the summer of 1997.
• Another biogas project is underway in Trollhättan. The project is being run by the municipal board for technical administration; the goal is to increase the production of biogas from existing digesters and to use the gas as fuel in the city's fleet of vehicles. The project will involve ca. 20 vehicles.
• Stockholm Vatten AB intends to test a total of 20 biogas vehicles. The project was begun in the summer of 1996. The gas is produced at an existing digester facility in western Stockholm.
• Uppsala is operating cars, buses and a garbage truck on biogas. The experiment was launched in the summer of 1996, and involves a total of 13 vehicles.
• The Swedish Gas Association is leading a study to specify the quality of biogas used for vehicle fuel. The composition of biogas varies from one source to another, and sometimes even within one and the same source. If biogas is to be used as a vehicle fuel, this variation poses difficulties for manufacturers of vehicles and other equipment, as well as for purchasers and users.

Pivotal Areas of Challenge

Technology

Further efforts are needed in the development of engines and peripherals. In principle, the same cleaning technology (catalyzers) can be used for light vehicles (automobiles) with sparkplug (gasoline) engines regardless of whether they run on biofuels or gasoline. The introduction of Flexible Fuel Vehicles also shows that it is technically feasible to mass produce vehicles that can permit a wide range of fuel formulas.

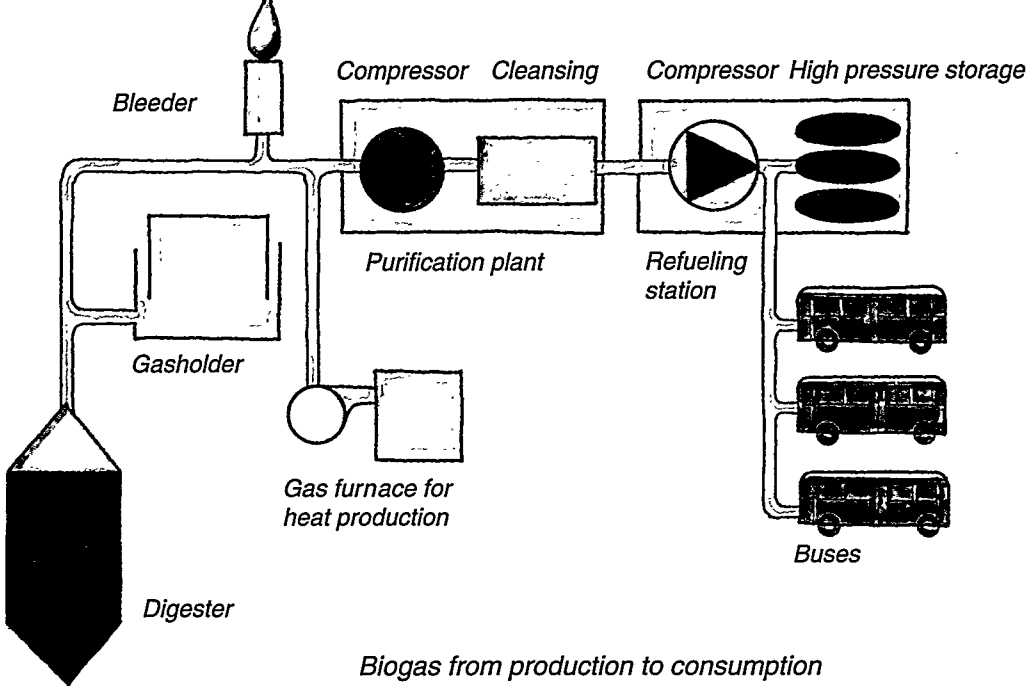
With the cleaner diesel fuel that has been introduced on the market, it has become possible to use catalyzers even on heavy vehicles. Many diesel powered buses in Sweden today are using catalyzers. Burning ethanol makes it still easier to use catalyzers, since ethanol drive is almost entirely free from the soot particles that are produced by combustion in diesel engines and that upset the function of catalyzers.

More extensive development work is required for using biofuels in heavy vehicles (diesels) than in gasoline vehicles. That is one of the reasons why KFB's program is primarily directed at heavy vehicles. The long-term potentials - both environmental and technological - for these engines when operating on biofuels and employing new catalyzer concepts are indeed enormous - greater than for conventional diesel operation because, among other things, development work on biofuels has existed for a much shorter time.

To cope with Swedish winter conditions, more development will be required in the area of cold starting systems.

Environment and Health

The transition from diesel to biofuels has the potential to produce cleaner vehicles. Going over to alcohol improves an engine's degree of energy efficiency. This means the



Biogas from production to consumption

reduction of various kinds of emissions. According to a life cycle analysis conducted by Ecotraffic, it is possible to reduce the emission of climate gases on the order of 65-80% as compared to diesel oil and gasoline. Whether this environmental potential will actually be fully realized depends on a number of factors, however; the choice of technology, for example, can play a decisive role.

Economy

Many vehicles have left the prototype stage, but they will be more expensive than conventional vehicles because production runs are still limited. Greater demand on the market, and hence larger production runs, will gradually bring down the cost of vehicles.

The same thing applies to fuels. Reports from the U.S.A. indicate major reductions in the costs of both ethanol and methanol in the future. Since both of these can be transported around the world just like fossil fuels, and can replace other raw materials, it is necessary to examine the development of the international market for biofuels. This is being done within the framework of the systems study.

Many users, however, are worried about the rise in ethanol prices following Sweden's entry in the EU. Price stabilization is regarded as one prerequisite for encouraging users to make long-term investments in the new technologies.

Today's fuel prices, taxes and tariffs taken together mean that using biofuels involves excess costs for vehicle operators, regarding both vehicles and fuels. In the short run, at least, it will be more expensive to produce domestic biofuels than to import gasoline and diesel oil. But the price picture today does not reflect the true environmental costs. Socioeconomically correct pricing requires that the costs be somehow established for all environmental effects and included in the price of fuel. This is not being done today, and that is why solutions that are unfriendly to the environment have the advantage. Hence government intervention of various kinds is needed if the introduction of biofuels if to be made possible.Modified principles of taxation based on environmental concerns requires knowledge about the connections among a number of different systems. The intention is to present a number of these connections more clearly in KFB's systems study.

Those desiring further information about KFB's biofuels program can receive a free subscription to the newsletter "Ren Trafik" (Clean Traffic - sorry, only in Swedish). This also includes a list of publications and other information about KFB's two vehicle programs: "Biobased Fuels" and "Electric and Hybrid Electric Vehicles".
Information about the biofuels program is also available on KFB's home page: http://www.kfb.se

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