Rapport 5/2001

Motor-alcohols from wood resources in heavy duty vehicles

A Nordic project on market-penetration through stakeholder group networks

Final report from European Commission ALTENER-project XVII/4.1030/Z/98-089

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WNRI Report

Title: Motor-alcohols from wood resources in heavy duty vehicles. A Nordic project on market-penetration through stakeholder group networks	Report number: 5/2001 Date: February 2001 Grading: Open
Project title: Motor-alcohols from wood resources in heavy duty vehicles. A Nordic project on market-penetration through stakeholder group networks	**Number of pages** 113
Researchers Otto Andersen, Hans Einar Lundli, Eivind Brendehaug, Kyrre Groven, Kari Mäkelä and Bengt Sävbark	**Project responsible**: Karl G. Høyer
Financed by: European Commission DG XVII	**Subject heading** Renewable energy, barriers, ethanol, methanol, heavy duty vehicles

Summary

This report presents the results from a project on motor-alcohols from wood resources in heavy duty vehicles. It has been a project on market penetration through stakeholder group networks. The networks have included large engine- and fuel producers important for the market penetration of motor alcohols in the Nordic countries. The activities of the stakeholder group networks have identified the most important barriers to increased use of wood-based motor alcohols. The network have also agreed upon common strategies for resolving the barriers.

The members of the motor-alcohol stakeholder group network established in the project is presented. The functioning of the networks during the project period is also presented. Analyses of Nordic policies on renewable fuels reveals that Sweden has the most active strategies for biological motor-fuels, while Norway and Finland have no such strategies. The lack of national support for bio-alcohol is an important barrier to the use of this fuel in these countries.

The report further present the main barriers in the production chains, distribution chains and when using bio-alcohols as motor-fuels. Main barriers include high production costs, higher distribution costs compared to fossil fuels. Use of additives which could effect health and environment are also identified as barriers. The field experiments on the use of motor-alcohols in the Nordic countries are summarised and evaluated.

Other publications from the project

Hans-Einar Lundli: *Motor-alcohols from wood resources in heavy duty vehicles. Analysis of barriers and stakeholder groups.* VF-Rapport 10/2000.Vestlandsforsking, Sogndal

ISBN: 82-428-0198-3 ISSN: 0803-4354	Price: NOK 200,-, SEK 200,- FIM 140,-

Preface

This report presents the results of a pilot action project under the European Commission DG XVII ALTENER –programme. The final report is edited and partly written by researcher Otto Andersen, who also has been the main person responsible for co-ordinating the project. The report is however mainly based on work carried out by Hans Einar Lundli, who also had the co-ordinating responsibility for part of the project. Also contributions from several other researchers at Western Norway Research Institute and from the two partners VTT Building and Transport and Ecotraffic R&D AB are included in the report. The chapters on 1)Finnish policies on renewable fuels and 2)Experiences with the use of motor-alcohols in Finland are based on written contributions by Kari Mäkelä at VTT. Mäkelä also made an important contribution regarding the identification of possible Finnish members in the Nordic stakeholder group network on motor-alcohols. Similarly, the chapter on possible Swedish members in the Nordic stakeholder group network is based on a written contribution from Bengt Sävbark in Ecotraffic.

Karl Georg Høyer has headed the project.

Sogndal, February, 2001

Karl G. Høyer

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Summary

The project *Motor-alcohols from wood resources in heavy duty vehicles. A Nordic project on market-penetration through stakeholder group networks* was carried out with financing from the ALTENER-programme in the European Commission DGXVII.

Use of biological motor-alcohols could reduce the emissions of greenhouse gases from the transport sector. In addition it could contribute to a reduction in the emissions of several compounds harmful for the local and regional environment. In the Nordic countries Norway, Sweden and Finland there are large wood resources that can form the basis for production of both methanol and ethanol.

In all three countries several studies have substantiated that available wood resources are large enough to achieve a substantial substitution of fossil fuel use in the whole transport sector. The main aims of the project has been to gain knowledge about key barriers against a broader deployment of wood-based motor alcohols and to explore the conditions for resolvement of such barriers and a market-penetration of these alcohols through stakeholder group networks.

An important difference in the motor-fuel policies of the three Nordic countries is identified: The Swedish authorities have for many years been concerned with motor-alcohol issues. This has not been the case in Norway and Finland. Motor-alcohols are not on the political agenda in these two countries.

The feedstock costs and the alcohol production costs are important barriers making it difficult to obtain a market penetration for wood-based motor-alcohols. There is today a lack of experience with wood-based feedstock for motor-alcohols. Not much time and capital have been invested in developing more cost-efficient production techniques, compared to what is the case with fossil fuels. Production of ethanol as a by-product in the pulp industry is taking place today, but the volume of ethanol available for transport purposes from these factories are, however, limited, due to the low number of such factories.

Since motor-alcohols have lower energy content per volume than petrol and mineral diesel, it could be necessary to build extra storage tanks at the depots. The extra costs related to the distribution chain is an important barrier towards large scale use of (biological) motor-alcohols.

The experiences with motor-alcohols that have taken place in the Nordic countries (mostly in Sweden) have shown that there are no major technical problems regarding use of these fuels in vehicles. Due to the experiences carried out, a lot of minor technical problems have been solved. The engines in heavy duty vehicles have been adapted to ethanol. New types of additives have been developed. Although the ethanol vehicle technology

has improved much, there is still a considerable room for improvements. The heavy duty engines can be optimised even further for alcohol fuels.

Use of alcohol fuels in heavy duty vehicles increase the operating costs for the respective transport companies. In addition, it is more costly to purchase heavy duty vehicles running on ethanol than purchasing corresponding vehicles driving on mineral diesel. The profit margins in transport companies are normally small. They have to avoid extra costs when it is possible. In other words, the extra costs related to the use of motor-alcohols have to be covered by others (i.e., the authorities). This is the case in Sweden today. If these subsidies are removed, the respective transport companies will stop using ethanol as fuel. This will further reduce the incentives for vehicle producers to work with motor-alcohol issues.

The Nordic stakeholder group network on motor-alcohols has had two seminars for all members and active contact between the meetings on e-mail and by the project web-site.

The main aim of the first seminar was to identify barriers against deployment of biologically produced alcohols in the transport sector in the Nordic countries. The stakeholder group network includes participants from the whole product chain from production, distribution to users of alcohol, as well as vehicle producers and research institutions. By having all these different types of actors represented in the stakeholder group network, a broad view on the issues and challenges regarding market penetration for motor-alcohols can be obtained.

The aim for the second meeting was to continue identification and also formulation of barriers, and to identify strategic actors outside the stakeholder group. Four prepared lectures was held:

E-mail has been used intensive to be in contact with the partners and members of the project between the meetings. The technology has been used to call for meetings and to distribute program and reports, and to get information from the member’s work on motor-alcohols.

E-mail has also been used systematically to create information from the members to identify and define barriers for a marked penetration for motor alcohols. A questionnaire to identify important actors and their appropriate role has also been distributed by e-mail (scheme in attachment).

A quantification of the communication shows that 18 e-mail is sent to the whole network and about 50 e-mails to single members from the project leader. Western Norway Research Institute has received about 150 e-mail from the project partners and network members.

The project web-site is used as an information channel between the project leader, the partners and the members of the stakeholder group. The web-site gives information of the project, from the meetings (program and report) and presents the members of the network. The web-site address: http://2171.vestforsk.no.

From the activities in the stakeholder group networks during the project period the following preconditions for implementation of bio-alcohols as a major motor-fuel were identified:

- Bio-alcohols for vehicles are primarily a long-term strategy for the reduction of CO_2.
- An important strategy is the blending of small amounts of alcohol in petrol/diesel, before entering into using pure methanol and ethanol.
- Alcohol as a fuel is applicable for both light and heavy duty vehicles.

Some of the critical questions and issues that were raised by the stakeholder group network included:

- Fuel production costs. How may the costs of producing bio-alcohols be reduced? A common energy-market in Europe would make it difficult to introduce more expensive alternative fuels. It is hardly possible to come down to the cost-level of fossil-fuels. But if the law regulates the use of renewable energy sources, the price-difference between the renewable fuels will determine which will be preferred.
- What form of economical measures and regulations by governing bodies at national and international levels are applicable? What forms of regulation-strategies might best promote the use of alcohol as fuels? Two strategies were emphasised; I)requirements that a certain percent of energy consumed is renewable, and II) standards limiting the amount of CO2 emitted from the vehicles motors.
- Long-term political aims and programmes. The absence of a long-term policy for bio-fuels by governmental authorities is an obstacle for the further development of these fuels as real alternatives to fossil fuels. A more long-term perspective should be employed.
- Standardisation processes. There are no common basic-rules for renewable fuels at present that can restrict constructive competition. There is a need for standardisation. For alcohols, this should be an easy task, except for additives. Flexibility is important. The point was made that today competition between the alternative fuels constitute an obstacle for development.
- Competition between alternatives. A "fuel of the year" attitude is undesirable. This can avoided by setting long-term goals. The official approval of alternative fuels by the transportation authorities would help prevent the tendency towards a "fuel of the year" strategy. There is a need for a more critical evaluation of new fuels upon their introduction.
- Establish a co-operative channels with major governing bodies which could aid in resolving the barriers to increased use of bio-alcohols.

1. Introduction

This report is from a research project in the EU ALTENER programme and is carried out as a pilot action within the area of liquid biofuels. This project has focused on bio-alcohols for use as fuels in heavy-duty vehicles in Norway, Sweden and Finland. The goal has in addition to generate knowledge of the barriers to wood-based motor-alcohols, also evaluate the functioning of "case" – stakeholder group networks that can be used to resolve the main barriers.

Transport takes a large share of total energy consumption both in the Nordic countries and in the European community as a whole. While other sectors generally have stabilised or reduced their energy consumption in the later years, it has continued to increase both in transport of passengers and goods. This implies that the sector is an important source to emissions of greenhouse gases, but also to other emissions of air-pollutants of local/regional environmental and health importance.

It is a situation emphasising the necessity to transform the transport sector to the use of biofuels in order to achieve both long-term and short-term environmental goals. Motor-alcohols can in general be neatly fitted into existing motor- and vehicle-concepts. This applies both to passenger cars and to heavy duty vehicles. The alcohols methanol and ethanol can be produced from many different biological resources. This gives a large flexibility when developing larger common markets for these alcohols. In the Nordic countries Norway, Sweden and Finland there are large wood resources from the forests that can form the basis for production of both methanol and ethanol. Such production is even taking place today as by- or side-products in wood-processing industries. Even so, the use of biological motor-alcohols is today mostly limited to field experiments and there is no real market penetration. Our main thesis is that this stems from the existence of several different types of barriers. An aim of this project is thus to gain knowledge about the importance of these barriers. However, barriers are related to interest groups and actors. In our project they are termed *stakeholder* groups and actors. The major aim of the project is to gain knowledge about how one through stakeholder group networks can achieve resolvement of barriers and create conditions for market-penetration of biological motor-alcohols.

This report systemises the existing knowledge about barriers against deployment of wood-based alcohols. The focus is particularly on barriers against increased use of wood-based motor-alcohols in heavy duty vehicles, buses and trucks. The report also identifies stakeholder groups in Sweden, Norway and Finland involved in creating or resolving these barriers.

The report first gives an overview of Nordic national and EU policies on renewable fuels. We then present three main types of barriers. First the barriers in the *production chains* of wood-based methanol and ethanol is outlined. Then the different types of barriers in the *distribution chains* of wood-based methanol and ethanol are identified. The third type of barrier presented in this report, are different types of barriers when applying wood-based methanol and ethanol as fuels in heavy duty vehicles.

The report also presents and evaluates the most important field experiments on motor-alcohols in the Nordic countries.

The actors in the field of motor-alcohols in Sweden, Norway and Finland are also identified. The interests of the different actors in the field of motor-alcohols are analysed. This concludes with a presentation of institutions included in the Nordic stakeholder group network. The activities of the Norwegian and the Nordic networks during the project period is then presented.

The project is thus divided in six main parts:

- Nordic national and EU policies on renewable fuels
- Barriers in the production chains of wood-based alcohols
- Barriers in the distribution chains of wood-based alcohols
- Barriers when applying wood-based alcohols
- Field experiments with motor-alcohols in the Nordic Countries
- Stakeholder group networks

2. Nordic national and EU policies on renewable fuels

A presentation of the national policies on motor-alcohols in Norway, Finland and Sweden, is given in this report. In addition the policies of the European Union on renewable fuels is analysed. In particular the focus is on the Mineral Oil Directive of the European Union. The study of the national as well as the EU policies on motor-fuels in carried out in order to understand the possibilities of introducing motor-alcohol as fuels in heavy duty vehicles. The presentation is to a large extent based on a study of government documents and other relevant literature listed in the reference section of the report. Contributions from the partners in Finland and Sweden are included in the presentation. An earlier interview study carried out by Western Norway Research Institute also forms the basis for this overview (Andersen et al 1998).

The national authorities in Norway, Sweden and Finland have taken quite different approaches to motor-alcohols. Motor-alcohols have been on the political agenda in Sweden for a long time. The Swedish authorities became interested in motor-alcohols already in the beginning of the 1970s, an interest triggered by the international oil crisis at that time. In comparison, the Norwegian and Finnish authorities have in general shown little interests for motor-alcohols.

National policies can create hindrances or opportunities for an introduction of motor-alcohols. In this chapter we will outline the most important aspects of the Norwegian, Swedish and Finnish policies on renewable fuels. Before this is done, however, we will give a brief overview of the policies of the European Union on renewable fuels. Two of the countries included in this study, Sweden and Finland, are members of the European Union. This means that legislation adopted by the EU in the area of fuels also will apply to these two countries. The EU legislation in the area of fuels will, however, also apply to Norway because of its membership in the European Economic Area.

2.1. EU Policies on Renewable Fuels

The EU Commission has established a future target for renewable energy sources. By 2010 renewable energy sources within the EU is to stand for 12% of the total energy consumption, compared to 6% in 1997. The increase in use of renewable energy sources is expected to be mainly a result of increased use of biomass for stationary energy purposes. However, liquid biofuels is also expected to play a role in achieving this target. 13% of the increase in use of renewable energy sources from 1997 to 2010 is believed to be taken care of by increased use of liquid biofuels (Fischler 1998; Versteijlen 1998).

The EU allocates funds to research related to renewable fuels. A goal within the ALTENER-programme of the EU is to replace 5% of the fossil fuels used in the transport sector with biofuels by 2005. Although the EU allocates funds to research related to renewable fuels, the EU lacks a coherent policy for renewable fuels. The responsibility for biofuels is divided between several different directorates. There is no common understanding between these directorates about a common EU strategy on biofuels (Månsson 1998: 113).

An important barrier against increased used of motor-alcohols is the uncertainty regarding the level of future taxes on motor-alcohols. Today the Mineral Oil Directive in the EU is an important hindrance against increased use of biofuels. According to this directive, taxes at a certain minimum level are to be imposed on all fuels (fossil and non-fossil fuels). Only when running so-called pilot-projects biofuels can be fully exempted for all taxes. Until date all biofuel use in European countries, although sold from regular petrol stations, have been defined as "pilot projects". This is done in order to obtain full tax exemption on the fuel. It is likely that the EU sooner or later will intervene towards this way of evading the rules. There are, however, a political process going on within the EU in order to change the content of the Directive. The Directive could be changed in such a way that it allows permanent tax exemption for biofuels. Without full tax exemption or sufficient tax differentiation, alcohols produced on renewable sources will not be competitive to mineral diesel and petrol.[1] It is especially important for the oil companies that a permanent tax exemption or differentiation for motor alcohols come into place. Without such a guarantee, the oil companies will be very restrictive in investing capital in the motor alcohol market.

International trade is important in order to create a motor-alcohol market. However, the tariff barriers on the import of (motor-) alcohols to EU countries have pushed up the price of ethanol (Månsson 1998: 113).

In the context of the EU Agricultural Reform of 1992 it was decided to bring a better balance into the cereal and oilseeds market. This was done by a policy of compulsory set-aside. However, the farmer could use the set-aside to produce non-food crops while keeping the special set-aside premium (Versteijlen 1998). The set-aside policy of the EU has created an incentive for farmers to produce feedstock for biofuels, included motor-alcohols. The set-aside instrument will continue to exist in the years ahead, but the goal is to improve the market balance and reduce the set-aside area to 0% (ibid.). This means that subsidies received for producing biofuels on set-aside land can not be expected to continue in the long term.

[1] The production price for renewable methanol is today about 3-4 times higher than the corresponding production price for fossil fuels. The production price of renewable ethanol is even higher (but with larger prospects of reduced production costs in the future than renewable methanol).

2.2. Norwegian Policies on Renewable Fuels

As mentioned above, the EU legislation in the area of fuels also apply to Norway, because of its membership in the Economic Area (EEA). However, the agricultural sector is not included in the EEA-treaty. This means that the set-aside policy of the EU is not part of the agricultural policies in Norway. In fact, the policy in this area is the exact opposite. The authorities want to protect agricultural land from alternative use. Farmers in the European Union have been an important actor in promoting the production and use of liquid biofuels. Due to the lack of a set-aside policy in Norway, farmers in Norway are in general not much concerned with liquid biofuels. Without interest groups strongly promoting biofuels, it is less likely that the authorities will pay much attention to these issues. This is especially the case with Norway, because Norway is a large producer of fossil fuels. The energy security aspects of using domestic produced renewable fuels, an argument valid for most countries, do not apply to Norway. The lack of important interest groups advocating liquid biofuels and the fact that Norway is a large producer of fossil fuels, might to a large extent explain why the Norwegian authorities have shown little interest for liquid biofuels.

The most important governmental activity in the area of renewable fuels is the funds on alternative fuels and environmental friendly technology within the transport sector. This fund is administrated by the Norwegian Directorate of Public Roads. It started in 1991 and is to continue in the years ahead. Approximately 10 mill NOK is allocated each year to projects related to alternative fuels. When this fund originated in 1991, the Parliament made it clear that projects related to use of natural gas in the transport sector should receive most attention (and money). This was linked to the fact that Norway is a large producer of natural gas. Another important reason for preferring natural gas projects was that the research institution MARINTEK (part of the Norwegian University of Science and Technology) already had ongoing activities in this field (Meissner 1996). The authorities believe that natural gas is a realistic future alternative to mineral diesel in the larger cities on the western coast of Norway. Lately electric cars have ascended on the agenda as well, due to the start up of domestic production of the electric car "Think".[2] Renewable fuels such as ethanol and methanol from biological raw materials have, however, received little governmental attention. Furthermore, the Norwegian Government has not formulated any goal in the area of renewable fuels.

The co-ordination of the national policy on fuels is taken care of within the general frame of co-operation between the different Ministries. There is no specific inter-ministerial committee in the area of fuels. However, there are at least two inter-ministerial committees where issues related to fuels could

[2] The company producing Think was in 1999 bought up by Ford.

be discussed - one committee that discusses the national climate change policy, and one committee considering issues related to the implementation of EU-directives. From time to time, it is decided to form a specific committee that is to look at a specific problem. However, so far no such committee has had as an objective to evaluate the policy of fuels on general or renewable fuels (Andersen et. al 1998).

2.2.1. Fuel Tax Policies

As described above, the Government is willing to subsidise research projects on renewable fuels and sometimes also the first period of commercial use. However, they are not in favour of subsidising commercial use of renewable fuels in the long term. In the long term renewable fuels have to be competitive to traditional fuels. The taxes imposed on fuels are to reflect the real socio-economic costs of their use. The fuel taxes are to reflect three types of socio-economic costs: accidents, road wear and environmental effects. According to the Government, it is only the environmental tax component that ought to vary between the different fuels. The number of accidents as well as the amount of the road wear is independent of fuel type. Hence, the tax level related to accidents and road wear ought to be equal for all fuels, included renewable fuels (Finansdepartementet 1998a).

The tax component related to environmental effects ought to vary according to the environmental properties of the different fuels. Fuels have emissions of different types of components – some are harmful for health and the local environment, while others contribute to global environmental problems. A differentiation of the environmental fuel tax component between the various fuels presupposes that it is possible to estimate the real environmental costs related to mobile use of the respective fuels. The uncertainty regarding such estimates is considerable, especially regarding global environmental effects. According to the fuel tax principles of the government, wood-based alcohols are to be exempted from the carbon dioxide tax, since the net direct emissions of carbon dioxide from wood-based alcohol use is zero. This is also the case today – all biofuels are exempted for the carbon dioxide tax.

The carbon dioxide tax imposed on petrol and mineral diesel has increased somewhat in the last years. However, the increase is marginal and is done only in order to adjust for the inflation. The Government is of the opinion that these taxes are to be kept on the same level as today in the next years to come (i.e., only adjusting for inflation) (Finansdepartementet 1998a). At present (year 2000) the CO_2-tax is 0,94 NOK per litre petrol and 0,47 NOK per litre mineral diesel (http://www.toll.no/kunde_info/).

In 1998 an inter-ministerial committee evaluated the level of taxes imposed on goods traffic on roads (Finansdepartementet 1998b). The committee is of the opinion that the level of the auto diesel tax is not sufficient to internalise the external costs. According to the inter-ministerial committee, estimates done by researchers indicate that the auto diesel tax has to be about 4,50-5,00 NOK per litre, in order to internalise all external costs.[3] However, the committee also emphasises that the uncertainty regarding these estimates is considerable. The advise from the inter-ministerial committee has partly been realised by the Government. The Government has with the state budgets for the fiscal years 1999 and 2000 started a process of equalising the petrol- and auto diesel taxes (Finansdepartementet 1999). This has reduced the price gap between mineral diesel and petrol considerably.[4]

The auto diesel tax was introduced in 1993. Before 1993 all mineral diesel vehicles in Norway had to pay a fuel tax per kilometre driven. Buses in public transport were, however, exempted from the auto diesel tax. In practical terms this was arranged by having two types of mineral diesel - a blank mineral diesel that was fully taxed, and a coloured mineral diesel that was tax-exempted. Hence, bus companies have since 1993 paid a much lower price for mineral diesel than other users of mineral diesel. In 1998 bus companies paid about 2,10 NOK per litre mineral diesel, compared to about 7,50 per litre for the fully taxed mineral diesel. The exemption from the auto diesel tax made it unacceptable for bus companies to consider renewable fuels such as biodiesel or bio-ethanol. However, since January 1, 1999, bus companies have not been allowed to use the coloured mineral diesel any longer.[5] Since that date bus companies have used fully taxed mineral diesel, dramatically increasing the total fuel costs for the companies. However, the authorities are fully compensating the companies for the increased costs. By the removal of the tax exemption, the most important barrier toward use of motor-alcohols in buses in Norway was removed. In June 2000 the price of mineral diesel at the petrol stations is approximately 10,50 NOK per litre.[6]

Several alternative fuels are more or less tax-exempted today. Use of auto gas (LPG, LNG and CNG) as a fuel in vehicles is fully tax-exempted today (Finansdepartementet 1998a). However, only a few vehicles use auto gas as a fuel in Norway today. Most of these vehicles are combined petrol- and auto gas driven. In addition a few auto gas buses are running in the cities of Trondheim and Haugesund. These buses are part of two research projects. The tax exemption for auto gas in vehicles is in accordance with the general fuel principles of the Government: It is willing to subsidise research projects on alternative fuels and the first period of commercial use. The present Government (the Labour Government) has, however,

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[3] Except for the costs related to the emissions of carbon dioxide. These external costs are to be taken care of by the CO_2-tax.

[4] At present (year 2000) the auto diesel tax is 3,74 NOK per litre mineral diesel. In addition a CO_2-tax and a SO_2-tax is imposed on mineral diesel. The petrol tax is 4,34 NOK per litre for petrol free of lead.

[5] The reason why the Parliament removed the tax-exemption for buses, was partly to create an incentive for bus companies to reduce their fuel consumption. Another reason for the decision was to reduce the competitive advantage of buses compared to adjoining modes of transport such as maxi-taxis (Finansdepartementet 1998a).

[6] Large transport companies normally pay a lower price, due to long-term agreements.

previously proposed to introduce an auto gas tax that is to internalise the external costs related to accidents and road wear. In addition the Labour Government has previously proposed to introduce a CO_2-tax for auto gas. The emission of CO_2 from auto gas use is approximately on the same level as the CO_2 emission from petrol use and mineral diesel use. These proposals did not, however, receive a majority vote in the Parliament. The present Parliament is not willing to consider an introduction of an auto gas tax or a CO_2 tax for auto gas until a decision regarding the future level of the petrol tax and the auto diesel tax is taken. If the number of vehicles using auto gas is increasing substantially, it is more likely that the Parliament will adopt fuel taxes on auto tax (Finansdepartementet 1998a). Otherwise, the overall revenues from fuel taxes will be reduced. This is also in accordance with the governmental principle that it is not in favour of long-term subsidising of regular alternative fuel use.

Use of electric cars is not imposed to fuel taxes since electricity is the energy source. The external environmental costs for this type of vehicle is low.[7] However, the external costs related to accidents and road wear is about the same as for vehicles driven by other fuels. The Government is therefore of the general opinion that use of electric cars ought to be imposed to taxes externalising these costs (Finansdepartementet 1998a).[8] However, the number of electric cars in Norway is low. The Government is not willing to consider to introduce fuel taxes for electric cars until the number of such vehicles has increased substantially. Again, the tax policy regarding electric cars is in accordance with the general fuel principles of the Government: it is willing to subsidise the first period of commercial use of alternative fuels.

Biofuels are fully tax exempted (except VAT) today. The Parliament decided in 1992 that biofuels are to be exempted for the auto diesel tax. Originally this was a temporarily decision and a more long-term decision was to be taken later. In 1999 the Ministry of Finance decided that the tax exemption is to continue in the years ahead (Finansdepartementet 1999). The use of biofuels in Norway is marginal. As long as this is the case, the Ministry is not in a hurry to introduce an auto diesel tax on biofuels. Biofuels are exempted also for the CO_2-tax. It is likely that it will continue to be so in the future. The net emissions of CO_2 from biofuel use are considered to be zero. According to the fuel principles of the Government, biofuels are therefore to be exempted for the CO_2-tax. We have seen that this is also the case.

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[7] In a life cycle perspective, this is not necessary true. The energy source is a crucial factor in this respect. In Norway almost all of the electricity consumed is based on hydro power.
[8] How this is going to be done in practical terms, is an another question. One possible option is to introduce a tax per kilometre driven.

2.2.2. *Bio-alcohols and Climate Change Policy*

There are several reasons explaining why countries may want to promote the use of biofuels such as bioethanol and biomethanol. Increased use of domestic produced biofuels will increase the energy security of a nation, improve the trade balance, create jobs in the agricultural and forestry sector, and reduce the emissions of various air pollutants. When launching a new US Program on Biofuels in September 1999, Bill Clinton strongly emphasised the energy security aspects as a main reason for promoting biofuels.

As stated earlier in this chapter, Norway is a large producer of fossil fuels. The energy security aspects do therefore not apply to Norway. In addition there is not much focus on production of biofuels as a mean to create new jobs in the agricultural and forestry sector. From our point of view, the CO_2-argument is the main reason for introducing bioalcohols in Norway. In the present section we will therefore give a short presentation of the Norwegian climate change policy. This will be done in order to consider whether climate change policy might promote an introduction of motor-alcohols in Norway or not.

According to the Kyoto Protocol, Norway is allowed to increase its emissions of climate change gases by 1 percent by 2010, compared to 1990. If no new measures against emission of greenhouse gases are adopted by the Parliament, the emission of these gases is expected to be 23 percent higher in 2010 than what it was in 1990. In April 1998, the Government presented a plan on how to fulfil the Kyoto commitments. If the plan had been adopted by the Parliament, the expected growth in emissions would have been reduced from 23 percent to about 14-17 percent, according to the emission models used. Hence, it would still have been a large gap between the national Kyoto commitment and the expected emissions of greenhouse gases in 2010. Not all of the climate action measures suggested in the plan were approved by the Parliament. Instead of introducing a carbon tax on CO_2-emissions that today are exempted from the carbon tax, the Parliament decided to elucidate a national quota system (Miljøverndepartementet 1998).

The Government stresses that the national climate change policy has to be as cost-effective as possible. The least costly measures are to be implemented first, regardless of what type of climate change gas, economical sector or country. This is to obtain the largest environmental effects in relation to the socio-economic costs for the society, nationally as well as internationally. One reason for not proposing further actions than what is proposed in the plan described in the previous section, is that the Government is unsure about the price of buying CO_2 quotas internationally. The Kyoto agreement opens up the possibility of international CO_2-trading as well as Joint Implementation projects. The international carbon trading regulations are, however, not yet decided upon. Until these regulations are in place, it is difficult to estimate the price per ton CO_2 when trading CO_2-quotas. However, the Government believe that the costs will be substantially lower than most other domestic climate change actions. Hence, the Government is of the opinion that parts of the Kyoto commitments is to be fulfilled abroad.

The Government has in the climate change plan briefly discussed alternative fuels and biofuels. However, measures related to renewable fuels in order to fulfil the Kyoto target are not seriously considered. Biofuels are not seen as a cost-effective measure against climate change (Andersen 1998). Hence, a whole range of other climate change measures are considered to give CO_2 reductions at a much lower cost than a substitution of fossil fuels with biofuels in the transport sector. Furthermore, the Government has made it clear that it is not in favour of a substantial increase in the CO_2-tax imposed on petrol and mineral diesel.

2.3. Finnish Policies on Renewable Fuels

Finland is one of the leading countries in the use of biomass for energy production. The share of renewable energy sources of the country's total energy use increased in the 1990s and is highest in the EU countries after Sweden and Austria. In 1997 the share of wood was 19% of the total energy consumption, that of hydropower 3% and that of wind power 0.005%. The share of peat was 7%. For comparison, the set target of the EU is to double the share of renewable energy sources from 6% to 12% by 2010 (Helynen et. al 1999).

The Finnish government's report on energy policy was approved by the Parliament in autumn 1997. The report specifies Finland's energy strategy, which contains the energy scenarios that were drawn up by the Ministry of Trade and Industry's Energy Department. An important target in the energy strategy of Finland is to further increase the use of wood in energy production so that it becomes a notable energy source in district heating plants and heating plants in places where natural gas is not available (Ministry of Trade and Industry 1997).

An example of the actions mentioned in the energy strategy is the "Action Plan for Renewable Energy Sources" set by the Ministry of Trade and Industry. This action plan is a national document corresponding to the EU White Paper. It includes all relevant renewable energy sources in Finland.

The most important goal of the Action Plan is to increase the competitiveness of renewable energy sources compared to other energy sources. The long-term goal is to make them as competitive as possible on the open energy market. The target is to increase the use of renewable energy sources by at least 50% (3 Mtoe) by the year 2000 from the 1995 level. Of this increase 90% is expected to consist of bioenergy, 3% of wind power, 3% of hydropower, 4% of heat from heat pumps and less than 0.5% of solar energy. This target involves an increase in the share of renewable energy sources by 5-6 percentage units of the total energy consumption compared to that in 1995. This requires the development and implementation of novel technologies on very tight schedule.

In Finland the most potentially useful biofuels from forest residuals, or wood-based fuels in general, are pyrolysis oil and fuels derived from by-products of the pulp industry. Pyrolysis oil is mainly used as a substitute for fuel oil in district heating plants. Fuel oil can also be made from by-products of the pulp industry, but such biofuels are not yet commercially available and their manufacturing technique is under development. The pyrolysis technique gives from dry sawdust a 75-80% yield of pyrolysis oil that has an efficiency of 65-90%. Pyrolysis oil is currently being tested in oil vessels and diesel and gas turbine power plants.

In coming years the cost-effectiveness of especially biofuels used in transportation will depend essentially on taxation, if production costs cannot be lowered substantially through development work. Wood-based methanol produced in an existing power plant would be the most economic biofuel (Solantausta et. al 1997).

In January 1990, Finland introduced the first-ever CO_2 tax in Europe. This environmental tax was imposed on fossil fuels according to carbon content.

Once a member of the European Union, Finland harmonised its existing VAT system to comply with EU regulations by amending the VAT Act. The reforms came into force in January 1995. These amendments saw the removal of existing support modes applied to some energy forms through the VAT. In the earlier VAT system, a special tax deduction was granted to wood- and peat-based biomass, meaning that the primary energy component of biomass was tax-exempt at all stages of production and use. The removal of these forms of support is now partly compensated for in the excise duties on energy. Fuels, electricity and heat are subject to the full 22 per cent tax.

The excise duty on liquid fuels is levied in Finland on car petrol, diesel oil, on light fuel oil for commercial, industrial or heating purposes, and on heavy fuel oil. Excise duties are also imposed on coal, peat, natural gas, pine oil and electricity. The fuel duty consists of a basic duty and an additional duty. The basic duty is essentially a fiscal tax set annually in the State Budget. The basic duty is differentiated to promote environmental protection, so that in the case of motor petrol there is a lower tax on unleaded and reformulated grades, and in the case of diesel oil the desulphurised grade has a lower levy. The basic duty is also imposed on light fuel oil and pine oil. Fuel tax revenues derive mostly from liquid traffic fuels though.

The additional, environmentally based duty is determined on the basis of the carbon content of the fuel. The earlier surtax component based on energy content was abolished. Since the beginning of September 1998 the additional duty has been 102 FIM per tonne of carbon dioxide for liquid fuels and coal. The energy tax system was revised in early 1997 in the case of taxes levied on fuels for the production of electricity, so that the earlier tax model based on the source of energy was replaced by an output tax on electricity. The electricity tax falls into two classes: a lower rate (2,5 p/kWh) for manufacturing industry and professional greenhouse cultivation, and a higher rate (4,1 p/kWh) for households and the service sector. A strategic stockpile fee imposed on fuels is included in this tax model.

Aviation fuel and kerosene used in aviation, methane, liquid petroleum gas, and light fuel oil used by vessels (which contains a reactive reagent to expose unauthorised use) are exempt of this duty.

Since the new tax model adopted at the beginning of 1997 resulted in an electricity tax being levied on all electricity regardless of the production method, renewable energy sources lost competitiveness, making it necessary to introduce some supportive measures for these energy forms. To improve the competitiveness of renewable energy sources, taxes on electricity produced by wind, wood and wood-based energy were made refundable (Ministry of Finance 1999).

Production costs of grain alcohol and rape-seed diesel oil are estimated to be so high in Finland that the subsidy needed would clearly exceed subsidy levels designated by the EU for growing grain.

As is evident from above, there are many users of the same energy source. Many district heating plants already use wood chips. Forest residuals can be used after chipping as source for energy production, also in small heating units. The gasification process for motor alcohols would then be an excess link in energy chain.

A precondition for effective methanol production from forest residuals is massive production units. This keeps logistics costs high, whereas to ensure low feedstock prices transport distances should be short from many small production units. Dispersed feedstock restricts the use of otherwise abundant (2 MTOE/a) unused biomass for production of motor alcohols (Solantausta et. al 1997).

Finland is still seeking a balance between support for new alternative transport technologies and developing traditional ones. The alternative solutions solve environmental problems in the long term (15-20 years), while development of current technology has a short-term effect.

In line with the Finnish transport strategy the government promotes research and development of alternative fuels. Financial resources are, however, very restricted. There are no separate governmental funds on liquid biofuels in Finland. The government does not recommend any specific primary fuel, the only criteria being the fuel's friendliness to the environment. Not having a particularly powerful vehicle or engine industry, Finland is not forced by industrial actors to favour any given motor fuel.

In the years 1998 and 1999 there were two working groups appointed by the Ministry of Transport and Communications dealing with CO_2 emissions from traffic. Working groups studied the development of carbon dioxide emissions and measures to restrict them. The result was a recommendation of a number of measures aimed at road traffic with which the 0-growth target could be achieved in road traffic (Ministry of Transport and Communications 1998; 1999). According to the Working Groups there is no need in Finland to use motor alcohols to meet the Kyoto Protocol. The transport sector's share of total CO_2 emissions is only 20%, and the contribution of motor alcohols to solving the CO_2 problem would therefore only be minor. The Finnish government has not taken a specific stand on motor alcohols. In the Spring 2000 the Finnish Government will make a decision on allocation of CO_2 zero growth-target to different sectors. In the Autumn a final Action Plan for the transport sector will be made.

Progress in traditional engine technology and successes in fuel reformulation have decreased the motivation to substitute diesel oil with alcohols, although the CO_2 problem has brought new facets to the discussion. Emission standards can be met without special efforts in the use of alcohols, and motor alcohols are not essential in Finland to secure the oil supply.

2.4. Swedish Policies on Renewable Fuels

Until 1955 a considerable amount of ethanol for transport purposes was produced and consumed in Sweden.[9] It was normal to use a blend of 25% ethanol and 75% petrol in private cars. The Government had shaped a fuel tax model that encouraged such a blend. However, in 1955 the amount of ethanol available for transport purposes had become too small to cover the need (Larsson 1997). The amount of fossil fuels available on the world market had at the same time increased and the price of it had become more acceptable.

Almost 20 years later, in the beginning of the 1970s, the first international oil crisis triggered a new governmental interest in alternative fuels. The Government recognised that Sweden was vulnerable to the amount of oil available on the world market. In the first national research program on energy, launched in 1974, research related to developing alternative fuels (mostly motor-alcohols) was included (Larsson 1997). It was energy security reasons alone that motivated the governmental funding for research projects on alternative fuels.

Pilot projects with methanol in Sweden started in the late 1970s. The Swedish Methanol Company was a key actor in these pilot projects. Between 1000 and 1100 light vehicles (otto-engines) drove on M15 until 1983. More than 19 petrol stations located throughout Sweden offered the M15-blend during the test period. The purpose of this relative large pilot-

[9] The otto-engine was originally designed for motor-alcohols.

project was to demonstrate that only minor engine modifications were necessary in order to drive on M15.[10]

The Commission for Oil Substitution concluded in a report in 1982 that increased use of methanol could reduce the dependency of fossil oil and increase the domestic production of fuels.[11] It recommended that future research and fleet tests in the field of alternative fuels should concentrate on 100% methanol. In 1983 the Parliament agreed on a plan for an introduction of alternative fuels. The plan was in accordance with the proposal from the Commission for Oil Substitution, that governmental funding ought to be allocated to 100% methanol (Sterner 1997).

The governmental funded pilot project that now followed was the so-called M100-project. In the M100-project 22 light vehicles were driving on 100% methanol for two years (1984-86). Several vehicle manufacturers were included in the M100-project. It was the vehicle manufacturers that decided which engine technology to use (SDAB 1987).[12]

In 1985 the Government decided to change the research focus in the area of motor-alcohols from private cars to heavy-duty vehicles. The Government believed that in case a new international oil crisis was to occur, it was strategic important to have secure energy sources for fleets of buses and trucks. Furthermore, by substituting diesel fuelled heavy-duty vehicles with motor-alcohols, the environmental effects obtained would be larger than a similar substitution of petrol fuelled private cars (Sterner 1997).

In 1986 the price of crude oil on the world market dropped dramatically. The Swedish Government changed its position on alternative fuels somewhat as a result of this. It was decided that no larger fleet tests should be carried out as long as the price of crude oil was low. However, limited fleet trials and a maintenance of the competence in the area of alternative fuels should continue. It was also decided that the work on motor-alcohols not should be confined to a particular motor alcohol and that development work on both methanol and ethanol should continue with emphasis on ethanol in heavy-duty vehicles. The environmental arguments for introducing alternative fuels had now become more important (in particular emissions related to heavy duty vehicles in urban areas) (SDAB 1987; Sterner 1997).

In 1991 the Parliament decided to fund a large 6-year research program on liquid biofuels (The KFB-program on liquid biofuels). The purpose of the program was to gain substantial practical experience with liquid biofuels

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[10] Similar projects were carried out in Germany and Italy at the same time. The energy security aspect was the main reason for conducting fleet tests with methanol in all three countries (Brandberg, personal message).

[11] The first thorough policy document from the Swedish Government regarding motor-alcohols was published in 1980 by Swedish Ministry of Industry (1980).

[12] Similar projects were carried out in other countries, especially in the USA. In the USA flexible fuel vehicles (FFV) were used. FFVs are vehicles that can drive both on methanol, ethanol or petrol, or a blend of these.

and to stimulate further improvements in technology. The major part of the resources in this program was allocated to motor-alcohols, especially ethanol (Sterner 1997). The Parliament also decided to offer subsidies for the building of ethanol production facilities in Sweden (ethanol production based on agricultural crops). Hence, it was decided also to develop an active agricultural policy in order to promote the introduction of motor-alcohols in Sweden, not only the energy- and environmental policy (ibid.).

In the beginning of the 1990s the climate change issue became an important reason for the governmental support for renewable fuels, especially motor-alcohols. In the 1993 White Paper on Climate Change (Miljödepartementet 1993) a strategy for reducing the CO_2-emissions from the transport sector is outlined. An important part of this strategy is to increase the use of biofuels. Wood is seen as a promising future feedstock for both the production of methanol and ethanol.

In the second half of the 1990s, several governmental reports and White Papers treating alternative fuels have been produced. The governmental report *Ny kurs i trafikpolitiken* (A new Course in the Transport Policy) (Kommunikationskommitten 1997) suggested that the emissions of CO_2 from road transport should be 15% lower in 2010 than in 1990, and that this could be achieved by a substantial yearly increase in the CO_2-tax, regulations demanding more energy efficient vehicles and a fast introduction of biofuels. The introduction of biofuels was suggested to take place by adding 5% ethanol (or another type of alcohol or ether) to all petrol by the year 2002. This proposal was not approved by the Government. In the opinion of the Government, the effects of introducing such a blend had not been thoroughly studied in the report (Kommunikationsdepartementet 1997). KFB was thereafter given the task to elucidate the effects of several different strategies for an introduction of biofuels.

The Parliament decided in 1997 to launch a 7-year research program (1998-2005) on developing technology for ethanol production based on wood as raw material. In total 210 million SEK was allocated to this research program (Brandel 1997). Research related to combining ethanol production for transport purposes and biomass from wood resources (lignin) for electricity production is also to be supported.

In the beginning of 1997 the governmental report *Bättre klimat, miljö och hälsa med alternative drivmedel* (Improved climate, environment and health with alternative fuels) was published. This report is, however, mostly concerned with the technical issues related to alternative fuels and it contains little policy-related material.

In March 1998 the Government put forward a White Paper called *Transportpolitik för en hållbar utvecling* (Transport policies for a sustainable development) (Kommunikationsdepartementet 1998). It establishes a CO_2-goal for the transport sector. The CO_2-emissions from the transport sector is in 2010 not to exceed the corresponding level in

1990. The Government believes that this to a large degree can be achieved by developing more energy efficient vehicles. In this respect the Government believes that an agreement between the EU and the car industry will result in the production of fuel-minimising vehicles. The Government also sees a further introduction of biofuels, mostly motor-alcohols, as a further contribution to combating the CO_2-emissions from the transport sector. It has engaged researchers in suggesting a strategy for an introduction of biofuels within the year 2002. This will include an evaluation of which segment of the transport sector can utilise biofuels at the lowest socio-economic costs. The Government stresses that also other alternative fuels and technologies, such as natural gas, fuel cells and electric driven cars can have an important role to play.

The report also discusses, among other things, the future level of the liquid fuel taxes. Today three types of taxes are imposed on liquid fuels. The energy tax, which is proportional to the energy content of the fuel. The sulphur tax, which is proportional to the level of sulphur in the fuel. And finally the CO_2-tax, which is proportional to the content of carbon in the fuel. In the report the Government makes it clear that it is not in favour of a change in the level of these three types of taxes in the near future. It stresses that the level of taxes has to be harmonised with similar taxes in the EU, which are lower than in Sweden (Kommunikationsdepartementet 1998).

Motor-alcohols are today fully exempted for taxes in Sweden. Despite the exempt for taxes due to temporary government waiver, it is somewhat more expensive to use motor-alcohols than to use fossil fuels in diesel engines. The use of liquid biofuels in Sweden is defined as pilot projects, in order to be in accordance with the Mineral Oil Directive of the European Union. In the White Paper on Sustainable Transport Policies the Government makes it clear that it is in favour for a full tax exemption for liquid biofuels in the future as well. The tax exemption is limited to an introductory phase. The Government has not decided what will happen with the tax level if the use of these fuels increase substantially. The Government will also consider whether it is to apply for an exemption from the Mineral Oil Directive regarding the taxes on liquid biofuels, i.e., that liquid biofuel use can be tax exempted regardless if the use is defined as pilot projects or not (Kommunikationsdepartementet 1998).

The Parliament has so far not amended a plan on how to fulfil the national climate change commitments agreed upon in Kyoto. However, in April 2000 a parliamentary committee presented a proposal for such a plan, after two years work (SOU 2000:23). The committee's proposal will be circulated among Swedish agencies, municipalities and organisations. Thereafter the Government will present a Bill to the Swedish Parliament, probably during the second half of year 2000. Then, what type of measures does the committee propose in order to reduce the emissions of CO_2 from the transport sector? Most of the measures have as a goal to increase the fuel efficiency in vehicles, especially in lorries and buses. Other important measures are introduction of road pricing in cities and transferring goods from roads to railways. A 5% blend of ethanol in petrol is also listed among the proposed measures. The production of ethanol in the Norrkoping plant is calculated to reduce the emissions of CO_2 from the transport sector with 60.000 tons per year. This measure is, however, among the most costly measures proposed. The cost per ton CO_2 reduced is estimated to 2.500 SEK. Cost-effectiveness is the most important principle shaping the Swedish policy on climate change. A whole range of measures are much more cost effective than producing ethanol for motor-fuel purposes. Buying CO_2-quotas abroad is therefore a measure that is highly emphasised in the report. However, the committee proposal underlines that the Norrkoping plant can promote further research in order to reduce the production costs of ethanol. In this respect Sweden is highly interested in participating in an international CO_2-quota system (Kommunikationsdepartementet 1998).

3. Barriers in the Production Chains of Wood-based Alcohols

Motor-alcohols can in principle be produced by two different techniques – fermentation or gasification. The former one is the dominating technique today. So far the gasification technique has only been tested with fossil fuels as raw materials. However, development work is in progress on developing techniques for the gasification of biofuels (Månsson 1998).

In this chapter we will give an overview of the most important feedstock and production techniques used in the production of motor-alcohols. We will to a large degree focus on wood as feedstock. The Nordic countries have large wood resources which could be utilised for transport purposes. The aim of this chapter is to identify the most crucial barriers in the production chains of wood-based alcohols.

3.1. Feedstock for the Production of Ethanol and Methanol

There are several feedstock that can be used as raw material for the production of alcohols. Today, are almost all of the methanol produced world-wide, as well as parts of the ethanol produced, based on fossil fuels as raw materials. Natural gas is the dominating raw material for the production of methanol. A small amount of the methanol produced is based on other types of fossil fuels, such as oil and coal. Very little of the methanol produced today is based on renewable raw materials. Ethanol produced for technical purposes, is to a large degree based on naphtha (a derivative of crude oil). However, our project focuses on motor-alcohols from renewable sources. This implies that fossil based raw materials not will be further referred to in this chapter. Fossil based raw materials such as natural gas can, however, play an important role as a feedstock for methanol in a transition phase to biological based feedstock (creating a market and a distribution system for methanol).

In order to reduce the amount of greenhouse gases released to the atmosphere, the feedstock have to be based on biomass. There are a lot of different biomass feedstock that can be used in the production of methanol and ethanol. Promising biomass feedstock are wood, agricultural crops and agricultural and forestry residues. Energy crops can be grown on surplus agricultural land to produce sugars (e.g. sugar beet), starches (e.g. corn and maize) and lignocellulose. The climatic conditions decide where such productions can take place (see Table 1). For example, the climatic condition in tropical countries is favourable for the production of sugar canes at low costs. In Brazil, large amounts of ethanol is produced each year from sugar cane, and used in the transportation sector. Similar to crude oil, motor-alcohols can then be traded internationally (NUTEK 1996).[13] The climatic conditions outside the tropics, and especially in the Nordic countries, are not favourable for producing sugar canes for transport purposes. The feedstock costs would be too high. Outside the tropical region, starch-containing biomass such as maize and corn can be produced at lower costs than sugar canes. However, the supplies of starch-containing biomass are limited. In comparison, lignocellulose biomass provides an abundant and inexpensive source of sugars that could be used for the production of liquid fuels. The processing costs have historically been much higher for lignocellulose materials than for sugar canes and corn, but recent advantages in technology have made it possible to substantially lower the production costs (Wyman 1999). In the short term, residues from the forest industry and agriculture is the most economically attractive feedstock.

Table 1 Overview of feedstock used for production of ethanol for transport purposes

Feedstock	**Time scale for technical availability**	**OECD Regions most likely to produce biofuel**
Sugar canes	present	None (limited to tropical countries such as Brazil)
Sugar beet	present	Southern Europe
Maize	Present	North America, Europe, Australia
Wheat	Present	North America, Europe, Australia
Lignocellulose	2000-2010[14]	Northern Europe and North America

Source: Pilo (1996)

Energy crops grown on set-aside land in the EU countries is economically attractive because of the agricultural subsidies. It is, however, not likely that the set-aside policy of the European Union will continue in the long run. One of the goals of the agricultural policy of the EU, is to reduce the overproduction of food. Residues arising from agriculture and forestry, on the other hand, are mainly subjected to market forces, with the result that they may provide a more stable long-term supply (NUTEK 1996).

There are at least four crucial feedstock factors affecting the competitiveness of motor-alcohols. Firstly, the feedstock production costs are too high. This can be improved by a better yield, reduced inputs, developing more efficient harvesting, storage and supply logistics. The conversion costs can be reduced through higher efficiencies, use of integrated systems and utilisation of by-products. Secondly, the quality of the feedstock, i.e., the chemical composition, is important in relation to the efficiency of the conversion process. It would for example be an advantage

[13] But as pointed on earlier, there is a tariff barrier on the import of alcohols to EC countries.
[14] It has to be emphasised that production of ethanol from lignocellulose have taken place in many years as *by-products* in the pulp industry.

to increase the carbohydrate composition of the tree or crop. Furthermore, a reduction of the content of pentoses (such as xylose) in a specific type of wood would further reduce the production costs, since ordinary yeast not are able to ferment pentoses. Genetically engineering is seen as having large potentials in manipulating the chemical composition of the feedstock in order to optimise the conversion processes. Research in this area is taking place in several countries, especially in the USA. Tools like metabolic engineering, protein engineering and plant biotechnology have a key role in the United States Department of Energy's (DOE) Ethanol Program (Finkelstein and Glassner 1999). Genetic engineering is, however, a highly controversial topic, especially in the European Union and in the Nordic countries.

Thirdly, the environmental acceptability of producing biomass feedstock for transport purposes is questionable. Producing energy crops could result in a more intensified agriculture and forestry. It is less controversial to use agricultural or forestry wastes and residues. It is necessary to conduct full life-cycle analysis and risk assessments in order to illuminate these issues (Pilo 1996).

The fourth crucial factor concerning the competitiveness of biomass feedstock is the quantity of feedstock available at a reasonable price. In order to substitute a substantial part of the fossil fuel used in the transport sector in the Nordic countries, it is necessary to use lignocellulose materials.

Several studies have been conducted in Sweden regarding the amount of feedstock available for transport purposes. The area of set aside land in Sweden is about 300.000 ha. If all of the set aside area in Sweden was used to produce wheat for transport purposes, about 550.000 m^3 of ethanol could be produced at a cost of about 4,0 SEK/litre (Brandel 1997).[15] This amount of ethanol would be enough for adding 5% ethanol to all petrol sold in Sweden.[16] However, in the short term, it is necessary to import a substantial part of the ethanol needed for obtaining a 5% ethanol blend in all petrol in Sweden. The amount of ethanol possible to import from EU countries varies over time due to several reasons, making it difficult to have a stable supply of ethanol. Import of ethanol from countries outside the EU is not economically attractive because of the tariff barriers.

In order to substitute a substantial part of the fossil fuel used in the transport sector in the Nordic countries, it is necessary to use lignocellulose materials. The high price of lignocellulose feedstock is an important barrier in the Nordic countries. Particularly in Sweden and Finland, it is not possible to obtain very cheap agricultural and forestry residues because these residues already are being used in energy recovery facilities and

[15] If production of wheat for transport purposes is to take place on other areas than set aside areas, then the production costs will be higher than 4,0 SEK/litre. This is due to the economical compensation that is given to farmers having set aside areas.

[16] About 320.000 m^3 of ethanol corresponds to a 5% ethanol blend in all petrol sold in Sweden (Brandel 1997).

biomass facilities. The situation in for example the United States is exactly the opposite – large volumes of cheap agricultural and forestry residues are available for alcohol production (Energimyndigheten 1999). However, a large and not yet utilised biomass resource in the Nordic countries is tree fuels from the forestry, particularly tree residues (branches and stem tops) at clear cuttings. At the planned levels of cuttings during the period up to 2008, today's potential expansion reserve for tree energy raw materials in Sweden is about 10 MT/year dry biomass (Brandberg et. al 1999).

3.2. An Overview of the Various Production Technologies for Wood-based Ethanol and Methanol

3.2.1. Ethanol

Production of ethanol today is based mostly on molasses from sugar canes (Brazil) and on agricultural crops containing starch (for example maize in USA and Canada, wheat in EU). In comparison, the industrial production of ethanol from cellulose and hemicellulose in wood and waste paper is marginal. Several process techniques to break down cellulose and hemicellulose to fermentable sugars are known, but the production costs are high.

The technology for fermentation of sugar (sucrose) is well known and the process design is simple. The production of motor-ethanol in Brazil is fully based on sugar canes. Tropical countries have a favourable climate for producing sugar canes at prices competitive to fossil fuels. This is not the case with countries outside the tropical region, such as the Nordic countries.

Starch-containing feedstock such as maize, wheat and potatoes, have to be hydrolysed to sucrose/fructose before fermentation is possible. This technology is well developed, but the production costs are high compared to the production costs of fossil fuels.

In the Nordic countries Norway, Sweden and Finland, there are large wood resources from the forests that can form the basis for production of ethanol and methanol. Wood contains large amounts of carbohydrates in the form of cellulose and hemicellulose. About 40 to nearly 50% of lignocellulose biomass is typically cellulose and 25 to 30% is hemicellulose (Wyman 1999). Cellulose and hemicellulose consist of polymers of simple sugar-molecules.[17] Before fermentation is possible, the polymer molecules have to be released from the protecting lignin (which normally represents 10 to 30% of the biomass) and broken down to monomer sugar molecules.

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[17] Cellulose is a crystalline polymer made up of long chains of glucose covalently joined by beta linkages. Hemicellulose is an amorphous polymer comprising five sugars: arabinose, galactose, glucose, mannose and xylose.

Chemical speaking this is a hydrolysis.[18] Hydrolysis of cellulose gives to a large degree hexoses, while hydrolysis of hemicellulose gives much pentoses.[19] Previously it was only possible to ferment the hexoses, and not the pentoses. However, in the recent years progress has been achieved in transforming the pentoses into ethanol (either by transforming the pentoses into fermentable sugar molecules, or by developing new types of yeast that can ferment the pentoses).

There are two main techniques for converting cellulose-containing material to fermentable sugar. The most used technique is by using mineral acids. The production costs are high, due to high consumption of mineral acid, low yield or long reaction times. Development work is going on to develop more energy efficient production concepts. The second technique for converting cellulose-containing material to fermentable sugar is by enzymatic hydrolysis. In addition to the two techniques described above, ethanol can be produced from cellulose as by-products in the pulp industry. Borregaard in Sarpsborg (Norway) produces about 22 million litre of ethanol per year as a by-product from the production of sulphite pulp. There is a similar, but smaller factory, in Örnsköldsvik in Sweden (10-12 million litre ethanol/year).

The Mineral Acid Production Concept

Cellulose can be hydrolysed in highly concentrated sulphuric acid, phosphoric acid, and in less concentrated hydrochloric acid.[20] Hemicellulose, on the other hand, is hydrolysed in weak mineral acid solutions at room temperature.

Several different production concepts involving mineral acids have been developed. The two most used production concepts, the CASH-process and the CHAP-process, is shortly presented below (the details of the processes are normally proprietary).

The CASH-process

The CASH-process has been developed in a co-operation between **C**anada (Bio-Hol), **A**merica (TVA) and **S**weden and it consists of a **H**ydrolysis in one or two steps by using sulphuric acid followed by a fermentation to ethanol. The amount of lignin produced as a by-product in the process exceeds the energy requirement in the process. The excess lignin can be sold as a fuel to district heating systems. The process is developed for wood residues and wood waste (for example saw dust) as raw materials (Ecotraffic 1996).

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[18] Hydrolysis is a concept used on processes where complex organic compounds are broken down to smaller and less complex molecules by temperature/pressure, acid or other methods, in water (Cambi 1995).
[19] Hexoses and pentoses are sugar molecules with 6 and 5 carbon atoms, respectively.
[20] In addition it is soluble in a water solution containing complexes of copper.

The CHAP-process
The CHAP process (**C**oncentrated **H**ydrochloric **A**cid **P**rocess) is based on a hydrolysis with strong hydrochloric acid followed by a fermentation to ethanol. It is developed for the production of ethanol from raw materials with a very high content of cellulose, such as paper waste. The CHAP process has a high ethanol yield, but it is an energy demanding process and no solid fuels (lignin) is produced in the process (Ecotraffic 1996).

There has been a substantial progress in reducing the processing costs in the mineral acid technique. This can be attributed to two primary classes of advancements: reductions in the cost of breaking down carbohydrate polymers into sugars and development of technology to ferment all pentoses to ethanol and thereby increasing the yield. The latter achievement was accomplished by genetic engineering of various bacteria to ferment all pentoses (Wyman 1999). In addition, Arkenol, a US engineering company, has identified naturally occurring yeast that ferment pentoses (Energimyndigheten 1999).

With the exception of the breakdown of pentoses, little progress has been obtained in the acid hydrolysis technique in the last half of the 1990s. Most aspects of the acid hydrolysis process technique was known in the beginning of the 1990s (Energimyndigheten 1999).

The cost reductions achieved have made bio-ethanol competitive in the US blending market. This is also a result of the US tax system on blends. However, the cost of bio-ethanol is still too high to be viable as a pure fuel produced in volume in an open market. Feedstock represent the single most costly item in the estimated cost of bio-ethanol. However, increased yields are not sufficient to obtain a competitive price on ethanol. Substantial reductions in the processing costs are also necessary. This will partially take place as the production volumes increases. But there are also potentials to optimise the process by for example reducing the high consumption of mineral acid, increase the yields or reduce the reaction times. These factors are in the short term believed to have the largest cost reduction potentials. However, the US program on ethanol has clearly stated that enzymatic hydrolysis techniques in the long run have a high potential to obtain a competitive ethanol price than the acid hydrolysis technique.

Enzymatic hydrolysis

Enzymatic hydrolysis is a more "gentle" way to break down lignocellulose materials to monomer sugar molecules, than the mineral acid technique. The ethanol yield is higher than for the mineral acid technique due to less by-reactions and loss of sugar.[21] However, the process is much more time consuming than the acid hydrolysis process. Previously to the enzymatic

[21] The yield is up to 80% of theoretical yield (Energimyndigheten 1999).

hydrolysis, it is also necessary to pre-treat the lignocellulose in order to increase the surface area available for enzyme activities.

Enzymatic hydrolysis is a technique that is little developed today, and the current production costs are higher than by using mineral acids. One important factor contributing to the high production costs is the high consumption of costly enzymes. The price of the enzymes is about 0,13 US$/litre ethanol, which is unacceptable high and it is also higher than the costs of the feedstock (Energimyndigheten 1999). However, it is believed that the enzymatic technique have a large potential for future reductions in production costs. Development work is going on, mainly in the USA, but also in other countries, with the aim of finding effective production methods for breaking down cellulose and hemicellulose to fermentable sugars (Ecotraffic 1996). Again genetic engineering is believed to be the tool that can lower the production costs. Genetic engineering is applied in the development of new enzymes that can break down lignocellulose material.

US Experiences with Ethanol Production from Lignocellulose

In the US bio-ethanol is currently mainly produced from maize. The ethanol price is about 0,3 US$/litre, taxes included. Production of ethanol from lignocellulose is today on the pre-pilot facility level in the US. Price estimates of lignocellulose ethanol indicates a somewhat higher price than what is the case today in the US for ethanol produced from maize. However, large efforts are carried out in trying to build and run the first large scale production facility for ethanol based on lignocellulose. More than eight such facilities are being planned with start up earliest in the next few years. Based on the experiences with ethanol production from maize, it is believed that the production costs will be substantially reduced when large scale production facilities are established (Energimyndigheten 1999). The factories being planned will use agricultural and forestry residues as raw material (low feedstock costs). One of the eight factories being planned, is to be based on the enzymatic hydrolysis technique. The other seven projects will be based on different acid hydrolysis techniques.

Production of Bio-ethanol as By-products in the Pulp Industry

Another option to the ones described above is to produce ethanol as by-products in the pulp industry. There are two such factories in the Nordic countries today, one in Sweden and one in Norway. The factory in Sweden (Örnsköldsvik) produces about 10-12 million litre of ethanol per year, while the production capacity of the factory in Norway (Borregaard, Sarpsborg) is about 22 million litre per year. The ethanol produced is used mostly in industrial production such as pharmaceutical industry. Each year about 12-14 million litre of ethanol is exported. Borregaard is interested in having alternative domestic applications for the ethanol that is exported today. The ethanol exported is exposed to taxes due to EU tax policies.

Borregaard is therefore interested in selling ethanol for domestic transport purposes – thereby achieving higher prices for the ethanol (Kälvesten 2000).

The ethanol is produced by a fermentation of sugars from wood (spruce). When producing cellulose, the hemicellulose is converted to hexoses and pentoses. About 2/3 of the sulphite lye that becomes a by-product when producing cellulose, consists of fermentable hexoses. Lignin is also produced in the process. About 37% of the CO_2 that is formed in the fermentation process is regained and sold to the company AGA A/S. After the fermentation process is completed, the ethanol concentration is increased by distillation (Kälvesten 2000).

3.2.2. Methanol

The first step in the production of methanol is to convert the raw material into a synthesis gas – a process called gasification. Synthesis gas is mainly a mix of carbon monoxide and hydrogen. Methanol is then produced according to the principal reaction mechanism shown below (Egebäck et. al 1997).

(I) $CO + 2H_2 \Rightarrow CH_3OH$ + energy
(II) $CO_2 + 3H_2 \Rightarrow CH_3OH + H_2O$ + energy
(III) $2CO_2 + 4H_2 \Rightarrow C_2H_5OH + H_2O$ + energy

In reaction I carbon monoxide enters into an exothermic reaction with hydrogen gas forming methanol. If the synthesis gas also contains carbon dioxide, more hydrogen will be consumed, resulting in a less energy efficient reaction (reaction II). Heavier alcohols such as ethanol will also be produced (reaction III). By controlling the H_2/CO-rate the formation of methanol in accordance to reaction I may be increased. Use of catalysts will also increase the methanol yield.

The production of synthesis gas can be based on several feedstocks. The choice of feedstock decides to what degree the synthesis gas needs to be purified. A more complex purification technique is necessary if using biogas instead of the relative clean and simple natural gas. The synthesis to methanol results in only a few tenths percentages of by-products (heavier alcohols, aldehydes, ketones, ethers and esters). If the methanol produced is to be used as a raw material in the chemical industry, it is important that the amount of by-products is extremely low. This is not necessary if the methanol is to be used as motor fuels. The water content in the methanol produced in the synthesis is in the range 2-20 %, depending on the raw material used. After distillation the methanol is almost free of water (less than 0,15% water). Methanol has an advantage in the distillation process, compared to ethanol, since methanol does not form an azeotropic mixture with water (Egebäck et. al 1997; Ecotraffic 1996).

At present natural gas is the dominating feedstock for the production of methanol. There is one factory using this production technique in the Nordic countries – located to Tjeldbergodden, 200 km west of Trondheim, Norway. This methanol factory, owned by Statoil and Conoco, produces about 830.000 tons of methanol per year, corresponding to 15% of the methanol market in Europe (www.scandoil.com; www.tbu.org).

Today there are no commercial factories producing methanol from wood (cellulose). However, several development projects with the goal of optimising gasification of biomass have been conducted, mainly in Sweden and Finland. At present the production costs for methanol from biomass is too high. Improving the gasifier efficiency is necessary. Small improvements are also possible in the methanol synthesis process. However, no major gains can be expected due to theoretical limits. However, there is a large potential for improvements in the management of the heat released in the exothermal processes and in the way electricity is used in the process (Ecotraffic and Nykom Synergetics 1997). This is exactly the goal of a present study being conducted in the Trollhättan region in Sweden (the BioMeeT-project). The key idea is to have a combined methanol/power/heat plant (a bio-energy combine), implying that the loss of energy and heat in the process is reduced to a minimum. The plant is to produce its own electricity need and to sell the excess heat and solid fuel (pellets) to the local district heating system. Such a bio-energy combine presupposes that there are markets for all its products in the region the plant is located. Similarly, the feedstock needed have to be available from the same region. However, the BioMeeT-project has so far concluded that there is no reason to strive for small plants, as the energy usage for transports is a small part of the energy turnover in the whole chain from feedstock recovery to end products. The additional cost of transporting long distances is small compared to the economical benefits of having a large plant (Brandberg et. al 1999).

4. Barriers in the Distribution Chains of Motor-alcohols

In Sweden today motor-alcohols are used as E95 (heavy-duty vehicles) and as E85 (Flexible Fuel Vehicles). In addition the Government is preparing strategies for introducing E5 as a fuel quality.[22] Hence, 3 different ethanol fuel qualities might exist on the Swedish fuel market in the future. Due to the introduction of ethanol, the total number of fuel qualities on the market has increased. If methanol had been used as a fuel in Sweden today, the number of fuel qualities would have been even higher. For each new fuel quality on the market, the total fuel distribution costs increase. In this chapter we will explain why. This chapter is mainly based on a report made by Ecotraffic (1996).

4.1. Storing Facilities for Alcohols

Since motor-alcohols have lower energy content per volume than petrol and mineral diesel, it could be necessary to build extra storage tanks at the depots. This is especially the case if the motor-alcohol fuel qualities supplement the existing fuel qualities on the market. If the motor-alcohols replace some of the existing fuel qualities, the need for new storage tanks at the depots will be reduced.

If the motor-alcohols are to be used as low level blends, then one possibility is to add the oxygenate (ethanol/methanol) to the petrol in the depots. The advantage of this method is that the low level blend then can be distributed to targeted areas of a country, for example to large cities. A system with adding alcohol to petrol at the depots presupposes that all oil companies that distribute fuels from the depots in question take part in such a system. The deliveries of petrol to depots normally take place in a common system for all oil companies. Blending of ethanol or methanol in petrol might demand technical modifications in the refineries and also a new petrol quality. If the motor-alcohols are to be added to the petrol in depots, the operation of blending is expected to cost 0,5 SEK/litre ethanol (1997-figures; Elam and Östman 1997).

At present, depots for petrol are to a large extent located within rock formations. Storing alcohols or petrol containing alcohols/ethers on water baths within rock formations is, however, not possible. This is due to the high rate of water-exchange that occurs during the process of transferring

[22] The goal of an ongoing project is that all 95-octane petrol sold in Stockholm, Södertälje and Norrköping by 2001 is E5 (Kälvesten 2000).

fuels from and to such tanks. Storing alcohols above ground is the only option today. This could become a problem if a large-scale use of alcohols is to take place in the future. It is little likely that an extensive building of above ground depots in larger cities will be allowed.

The present equipment for dealing with petrol at depots includes materials that are only limited resistant towards alcohols and alcohol vapour. This could lead to leakage problems. It is therefore necessary to investigate the materials and substitute materials that are not resistant towards alcohols.

The alcohols have to be stored in locked areas and the ethanol pumps and related equipment have to be sealed, in order to avoid misuse of ethanol. The denaturing of the ethanol (which has to be done according to law) ought to take place already when the ethanol is produced.

Storing alcohols at petrol stations is probably the most critical point in the distribution chain. This is due to the high number of petrol stations, less professional employees and the fact that petrol stations are in direct contact with ordinary customers. The problem of materials not resistant to alcohols does also apply to fuel equipment at the petrol stations. Measures to avoid water contamination of the alcohol fuels have also to be implemented. New and extra large storage tanks might have to be built at the petrol stations, due to the low energy content per volume alcohol. Some petrol stations do not have the area necessary for such an expansion in the number and size of the storage tanks. This will reduce the number of petrol stations able to offer motor-alcohols. Furthermore, it is recommended to install a filter in the fuel pump in order to avoid deposits reaching the vehicle fuel tanks.[23]

From a cost perspective, it would be an advantage if there were regulations in place demanding that materials resistant to alcohols have to be used when building new petrol stations or when renovating existing petrol stations.

Also the vehicle fuel tanks have to be resistant to alcohols. Plastic material is more and more used in petrol vehicle fuel tanks, and this material is resistant to alcohols. It is also necessary to secure that the fuel vehicle system is resistant to alcohols. Petrol vehicles have for many years now had a fuel system that copes with alcohols. Furthermore, the vehicles have to have a system that makes it impossible to remove fuel from the vehicle fuel tank.

If the use of alcohol is to take place in vehicle fleets, the alcohols can be transported directly from the depots to the respective transport companies. Larger transport companies normally have their own storage tanks. Today fuel tanking at the transport companies often take place inside their own garages. The question whether this can be done with alcohol fuels, have not been investigated. It is probable that a modification of the garages is necessary in order to satisfy the safety aspects. Until the question of

[23] Alcohols dissolve deposits more easily than the case is for petrol and mineral diesel.

alcohol tanking inside garages has been settled, the alcohol tanking has to take place outside (this is the case in Sweden today). This will imply some additional work for the personnel responsible for the filling.

4.2. Transport of Alcohols

Transport of alcohols from the production facilities to the refineries or depots would most likely take place with boats. Water contamination is normally not a problem for sea transport of alcohols, as long as the respective ship companies follow existing regulations to avoid this from occurring. Sea transport of water sensitive fuels already takes place today (aviation fuel, winter mineral diesel). The most crucial part of the sea transport chain is probably when unloading alcohols from the boat to the depot. It is important that the pumps and the pipelines used in the process of unloading are totally free of water. Water is normally used as a cleaning medium between the unloading of different products.

The transport of alcohols to depots would in general not imply increased costs, given that the alcohols are produced domestically or in a nearby country. For Sweden and Finland, the transport distance for the alcohols will be somewhat shorter than the corresponding transport distance for the imported fossil fuels. This will not necessary apply to Norway, since Norway is a producer of fossil fuels.

The transport of fuels from the depots to the petrol stations normally take place by tank lorries. Lorry tanks are normally made from aluminium, a substance that is not especially suitable for transport of alcohols in general, and methanol in particular. However, modified aluminium tanks resistant to alcohols do exist. The tank pipelines, valves and hoses have to be examined in order to guarantee that such equipment tolerate alcohol.

When transporting pure alcohol or alcohol blends in tank lorries, one has to be careful to avoid water contamination (e.g. rain water, rinsing water, tank cleaning water). This is especially the case when transporting petrol containing alcohols.

5. Barriers when Applying Alcohols in Heavy-duty Vehicles

In this chapter we will analyse on the barriers that are related to the use of alcohols in vehicles, particularly heavy-duty vehicles. The barriers in this part of the alcohol chain are independent of whether the alcohols are based on renewable raw materials or not.

The main part of the chapter is concerned with the level of emissions from alcohol vehicles compared to fossil fuel vehicles. At present the emissions from alcohol vehicles are substantial lower than the emissions from corresponding vehicles using fossil fuels. This will, however, not necessarily be the case in the future.

5.1. Emissions from motor-alcohols

One of the main reasons for introducing motor-alcohols is that motor-alcohols in general have lower emissions of both regulated and unregulated emissions than the case is for petrol and mineral diesel. This is especially the case if motor-alcohols are used in diesel engines. The magnitude of the benefits resulting from such a substitution of fossil fuels with biological produced motor-alcohols, depends on several factors. For example, the selection of engine technique is of major importance for the emission levels. The difference in emissions between motor-alcohols and petrol/mineral diesel is substantial at present. However, cleaner petrol and low sulphur diesel in combination with new Euro-regulations (Euro 3 year 2000 and Euro 4 year 2005) for emissions from advanced heavy duty engines, are reducing the level of hazardous emissions to the same level as previous alcohol engines. Furthermore, new after-treatment devices, such as the CRT-filter, catalysts and EGR (exhaust gas recirculation) are reducing the emissions even below the current levels for alcohol engines. This means that there is only one long-term overriding global driving force for using alcohols in the transportation sector – that motor-alcohols can contribute to reduce the emissions of greenhouse gases and reduce the dependence on fossil fuels. In the short term, there are also other driving forces, mainly agricultural/employment policies and rural development, trade balance and local air quality (Pilo 1996). The fact that it is "only" the CO_2-argument that in the long term is the reason for using motor-alcohols, makes it more difficult to obtain a substantial market penetration for these fuels. In the remaining part of this chapter, we outline in more detail the emission characteristics of motor-alcohols compared to petrol and diesel.

Ethanol and methanol have very similar emission profiles (although some differences exist in the aldehydes emissions between the two fuels[24]). Furthermore, the accuracy in the measured emission levels is such that it is not meaningful to differentiate between ethanol and methanol. They are therefore often considered as one fuel when comparing their emissions with other fuels (Månsson 1998). This is also done below. Before describing the emissions from heavy duty vehicles, which are the type of vehicles this report mainly focus on, a short description of different emission aspects regarding use of alcohols in passenger cars is given.

5.1.1. Emissions from use of alcohols in passenger cars

More reliable data exists on emissions from passenger cars than from heavy-duty vehicles. Especially data regarding the *regulated* emissions from passenger cars (both otto-engines and diesel engines) are considered reliable.

Alcohol in passenger cars can be either used as low level blends in otto-engines or as 85% in Fuel-flexible vehicles (FFV). The positive environmental effects of using blends have been clearly demonstrated in USA. In some very polluted areas (such as Los Angeles and New York City) petrol cars have to use reformulated petrol, containing oxygenates. Oxygenates are oxygen-rich compounds which are added to motor vehicle fuels to make the fuel burn more cleanly. By adding oxygenates to the petrol, the emissions of CO and VOC are reduced compared to ordinary petrol. The most common oxygenate used is MTBE (methyl tertiary butyl ether). Methanol is used in the production of MTBE. However, MTBE is only to a small extent biodegradable. In some cases the presence of MTBE in groundwater has caused alarm. This is mainly a result of spills from storage tanks. Some states in the USA have banned the use of MTBE. Ethanol is a possible replacement of MTBE as an oxygenate. In contrast to MTBE, ethanol is fully degradable.

The question whether the environmental load exposed by FFV-vehicles is lower than from regular vehicles is, however, more controversial.[25] This should be studied more closely in the future. The problem is that the engines in the FFV-vehicles are optimised for the lowest quality fuel, i.e., petrol. It is therefore a large potential for further development of the engines in these vehicles in order to bring the emissions to a lower level than today. This will, however, imply large costs for the vehicle manufacturers.

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[24] If a catalyst is used for cleaning the exhaust gases, the difference in emissions of aldehydes (formaldehyde and acetaldehyde) between methanol and ethanol is minimal (Månsson 1998).

[25] The emissions of CO_2 is substantially lower for FFV-vehicles than for petrol vehicles.

5.1.2. Emissions from use of alcohols in heavy-duty vehicles

There are more existing data on emissions for buses than for lorries. This is due to the much higher number of buses than lorries running on alcohols running on alcohols. At the end of 1999 there were 382 buses running on ethanol (E100 with ignition improver) in Sweden. Besides Sweden, a relatively high number of buses have been driving on alcohol in the United States (Los Angeles) (Sävbark 2000).[26] In comparison to buses, very few lorries world-wide have been driving on alcohols. In Sweden there are at present 7 lorries driving on E100. Outside Sweden, there are some lorries running on either ethanol or methanol in the United States and Japan (Sävbark 2000).

As part of the different motor-alcohol research programs carried out in Sweden since the beginning of the 1980s, a considerable amount of emission data have been produced. The engine technology has improved a lot since the first ethanol buses were introduced around 1980. However, there is still a considerable potential to reduce the emissions from buses running on alcohols (Månsson 1998).

One of the benefits of using motor-alcohols in heavy-duty engines is the ultra-low content of sulphur in methanol and ethanol. This results in much lower emissions of sulphur dioxide (SO_2) compared with the case for mineral diesel. Sulphur dioxide is a component causing acid rain as well as local air pollutant problems. However, in the last years, mineral diesel with a low content of sulphur have entered the fuel market. This is especially the case in Sweden, were 90% of all mineral diesel sold in 1999 was environmental class 1 diesel (maximum 10 PPM sulphur) (Sävbark 2000). This development will most likely continue in the years ahead, consequently minimising the SO_2-advantage of alcohol fuels.

NO_X is another component that both leads to acidification and local air quality problems. At present the emissions of NO_X from alcohol are substantially lower (30-50%) than the corresponding emissions from mineral diesel. However, new Euro-regulations (Euro 3 year 2000 and Euro 4 year 2005) for emissions from heavy duty engines will reduce the emissions of NO_X from mineral diesel use considerably. The new Euro-regulations for NO_X -emissions will be fulfilled partly by taking into use new after-treatment devices, such as the De- NO_X -catalyst (Sävbark 2000). Again, technology improvements resulting from the Euro-regulations, will reduce the emission advantage of alcohols compared to mineral diesel.

Emissions of particles from road transport represent a considerable health problem. Heavy duty vehicles running on alcohols have much lower emissions of these substances than heavy duty vehicles running on mineral

[26] 600 buses used methanol (M100) as fuel in Los Angeles at the end of the 1980s. When the methanol prices went up halfway in the 1990s, the engines were converted to ethanol. Later on, when the methanol prices dropped, the engines were converted back to methanol again. Recently the buses have been converted to mineral diesel fuel (Sävbark 2000).

diesel.[27] The difference in emissions of particles between the two fuels have been reduced in the last decade. This development is expected to continue in the decade ahead. Installation of CRT-filter in city-buses will sharply reduce the emissions of particles from buses and lorries running on mineral diesel.

It has to be underlined that compared with the case for mineral diesel, very little effort have been carried out in optimising diesel engines for alcohol use. It is therefore a considerable potential for developing new alcohol engines with lower emissions than today. But if the new Euro-regulations manage to bring down the emissions of different components from heavy duty engines to a level that is found "acceptable" by authorities and the public opinion, it is questionable whether the alcohol engines will be further developed.

A decade ago the emission profile for alcohols in heavy duty engines was very favourable compared to mineral diesel. Since then technology improvements have reduced the emissions from the diesel engine, thereby reducing the emission gap between mineral diesel and alcohols. The outlook for further reductions in the emissions from the diesel engine in the years ahead, have reduced the environmental arguments for introducing motor-alcohols. In contradiction to what was the case ten years ago, it is mainly the lower emissions of CO_2 that is the environmental reason for taking alcohols into use.

Regarding emissions from heavy duty vehicles, the authorities and the transport companies are most concerned with the emissions harmful for the local environment. In comparison the emissions of greenhouse gases from heavy duty vehicles have received relatively little focus in the Nordic countries. However, this can change over time. If the Kyoto Protocol is ratified by enough countries in order to enter into action, the CO_2-emissions from the transport sector may receive much more attention than they do today. In both Sweden and Norway the transport sector stands for a considerable proportion of the total emission of greenhouse gases. Due to the dominant role hydro power (Norway and Sweden) and nuclear power (Sweden) play in the energy production in these two countries, ambitious climate change measures in the transport sector are likely to be considered. As described in chapter 2, however, both the Norwegian and the Swedish government have so far to a large extent focused on implementing measures abroad in order to fulfil their national Kyoto-commitments. Climate change measures in the transport sector are mainly considered to be expensive and not optimal for trade and industry.

[27] At present the emissions of particles are 5-10 times higher for mineral diesel than for ethanol (Månsson 1998).

6. Field experiments with motor-alcohols in the Nordic countries

In this chapter the practical experiences with motor-alcohols in Finland, Norway and Sweden is presented. Most of the Nordic experiences in this field has taken place in Sweden. The practical experiences are valuable in revealing necessary technical improvements preparing the ground for increased use of motor-alcohols in the Nordic countries.

Originally and as a part of the project it was an intention to carry out a minor field experiment on the use of motor-alcohols in heavy duty vehicles within a Norwegian transport company. Contacts were taken with several bus transport companies. However, it was not possible to attain a sufficient interest to take part in such an experiment within the time limits of the project. At the same time the first Nordic network meeting made it clear that the whole project would be better served by following the ongoing and more extensive field experiments in Sweden. It was thus decided to make the crucial stakeholders in these Swedish experiments members of the Nordic network and participants in the network meetings and activities.

6.1. Experiences with motor-alcohols in Finland[28]

In the 70s and 80s VTT, Neste Oy and PRIMALCO (formerly ALKO) performed joint studies on pure alcohols and mixtures of petrol and alcohols (both ethanol and methanol), the results of which are no longer relevant to modern vehicle techniques. These tests used 20 cars and 20.000 km with each to study different oxygenate-petrol mixtures to reach 2.0 and 2.7 oxygen content. Besides emissions, also engine functioning, like cold starting, driving characteristics etc. were tested.

During 1992-1996 VTT Energy carried out a comprehensive project within the IEA Alternative Motor Fuels Agreement on service life and emissions of alternative fuel vehicles (cars). The project fleet consisted, besides gas vehicles, of two M85 fuel FFV vehicles that had been driven 200.000 km (1998), with regular inspections and measurement of emissions. One result to emerge was that FFV vehicles still had significant material problems.

The test vehicles VW Jetta Multifuel, Dodge Spirit FFV, Dodge Ram CNG, and VW Caravelle LPG (new in 1996) were used for normal everyday driving in southern Finland (VTT Energy 1997). Complete driving records were kept. The facts recorded were driving distance, driving time, ambient temperature when starting, and the route used. For monitoring the driving conditions, besides other facts, also the number of start-ups for each drive

[28] This chapter is written by Kari Mäkelä, VTT

was recorded. One drive consists of one or more start-ups, which the driver has recorded in the driving record book as one entry. Methanol fuelled vehicles have started at temperatures down to -20 ^{o}C. However, engine block heater was used during the coldest periods. The gas fuelled vehicles, too, started reasonably well at low temperatures, unless there was too much moisture in the fuel.

Sampling of engine oil and fuel were performed regularly at oil the changes. Metal concentrations and occasionally Total Base Number (TBN) were analysed from the oil samples. In the case of the M85 fuel, metal and water concentrations were monitored. The purpose of the analyses was to find out if the methanol fuel causes corrosion and wear stronger than normal. The conclusion was that they did not find any essential engine wear compared to normal gasoline engine.

At the end of 2002 a test laboratory with chassis dynamometer and transient engine facilities will be built at VTT Energy. This adds considerably possibilities to make research with heavy duty vehicles.

In 1981-1994 Helsinki University of Technology (TKK) performed a number of studies on alcohol use in the VALMET diesel engine (both ethanol and methanol). Although no commercial applications emerged, several doctoral dissertations did. According to the studies, the durability of the injection systems and possible ignition/glow plugs are problematic in direct injection alcohol engines. During one test period very low NO_X emission levels (ca 1 g/kWh) with a stoichiometric three-way catalyst engine were observed.

In the research period 1986-89 engine tests were carried out with two different alcohol engine types. Focus was on combustion research. In the first stage of the experimental part of the research, an engine modified from VALMET 311 DS6 turbo charged diesel engine equipped with two separate injection systems was tested using methanol as main fuel and diesel oil as pilot fuel. With optimised injection control values the engine performance and the brake thermal efficiency at full load were nearly equal with the corresponding values of the ordinary diesel engine (Pitkänen 1991).

The engine performance was clearly better with methanol than ethanol engine. Mechanical and thermal loads are higher with methanol engine equipped with two separate injection system than with other engine modifications tested. This is why development possibilities for methanol engine are not so good as for turbo-charged spark-assisted engine.

As a conclusion, the spark-assisted, turbo charged, direct-injection engine using ethanol fuel got the highest rating for the further development of the three types of engines tested.

According to the alcohol fuelled diesel engine research experience at Helsinki University of Technology, the technical problems with alcohol use in heavy vehicles could be solved. The most important barriers of large-scale use of alcohols in heavy duty vehicles are not technical ones.

Helsinki City Transport had motor alcohols under consideration 5 years ago when the Finnish alcohol company ALKO was interested in motor alcohols. Two years ago the Helsinki City Transport Committee choose gas as an alternative fuel for city buses and there is no longer any interest in motor alcohols.

6.2. Experiences with motor-alcohols in Norway

There is very limited experience with the use of ethanol as fuel in Norway in "modern times". In the beginning of the 1980s, there was a fleet test with methanol in petrol. The raw material for the methanol used was natural gas, which Norway is a large producer of. The fleet test was a research project carried out by the National Institute of Technology (TI) in collaboration with the oil company Statoil (then Norol). Different types of blends were used in the project (2%, 4%, 6%, 8%, 10% and 15% methanol). More than 100 passenger cars were involved in the project. The involved passenger cars filled up their tanks at a particular petrol station in Oslo. However, the drivers did not know when the fuel quality changed from ordinary petrol to a blend of petrol and methanol. The drivers filled out regularly a scheme with different questions regarding the driving performance. The project was a success in that the drivers did not notice any difference between petrol and methanol blend. No serious technical problems occurred during the fleet test period. However, the main conclusion of the project was that it is too costly to introduce a methanol blend as a fuel quality in Norway. Later, it has not been considered to resume the fleet tests with (fossil) methanol in Norway (Bang 2000, personal message[29]). The start up of a methanol factory at Tjeldbergodden in 1998, not far from Trondheim, has not changed this view.

As described in chapter 2.2, fleet tests with alternative fuels in Norway in the 1990s have mainly focused on natural gas and lately also electric vehicles. When the fund for alternative fuels was launched in 1991, the majority of the members of Parliament underlined that natural gas was to be given the highest priority of the different alternative fuels. Such a priority was related to the fact that Norway is a large producer of this fuel. One possible complementary reason for giving natural gas a high priority was that the research institution MARINTEK in Trondheim already had substantial activities in this field. Gjøen and Buland (1996, referred to in Meissner et. al 1996) claim that the intensive lobby activities carried out by representatives from MARINTEK towards different governmental committees were highly successful.

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[29] According to Jon Bang at the National Institute of Technology (TI), whom participated in the fleet tests, several research reports were produced from the project. However, these reports do not any longer exist in the archive at TI (Ørjaseter 2000, pers. mess.).

Besides natural gas, and lately also electric vehicles, the Norwegian authorities have been little interested in being a forerunner in the area of alternative fuels. Instead they prefer to observe and gain knowledge of the activities with alternative fuels that take place in other countries. Neither transport companies or other relevant actors in Norway have in any large degree tried to push the authorities to do more in this field. The experiences with methanol and ethanol in Norway are therefore very limited.

6.3. Experiences with motor-alcohols in Sweden

In contradiction to what is the case in Norway, a lot of experiences with motor-alcohols have been gained in Sweden. As described in chapter 2.4, the first fleet tests with motor-alcohols in Sweden in "modern times" started in the late 1970s. Until about 1985 most of the fleet tests carried out was with methanol in passenger cars (as blends or as neat methanol). In the 1990s the focus has been on ethanol in heavy duty vehicles, mostly buses.

Fleet tests with ethanol in buses in Sweden started in Örnsköldsvik in 1985. Initially the tests were conducted with two Scania buses that had engines with normal or only slightly elevated compression ratios. The then available additives to raise the cetane number were used. However, these additives were replaced by different additives as engine problems occurred. Other modifications were also implemented, such as increased compression ratios of the engine's (to reduce the need of additives) and new and more advanced catalysts. The trials in 1985 were continued in the period 1993-97. Now the bus fleet running on ethanol counted 9 buses. The buses used were Scania buses that were equipped with new types of ethanol engines and with newly developed oxidising catalysts. Different types of additives were tested out. The 9 buses using ethanol have been running in regular traffic all the time, i.e., they have been on the road just as much as the buses running on mineral diesel. Emission tests and other types of measurements have been carried out regularly. The two first test buses (from 1985) have now driven more kilometres on alcohol fuel than any other buses in the world (Månsson 1998).

The largest fleet with ethanol buses in Sweden is located to central parts of Stockholm. It started in 1990 as a research project with 32 buses running on ethanol. At present about 250 buses on ethanol are in regular traffic in Stockholm. The introduction of ethanol buses in Stockholm in 1990 was a political decision based on environmental considerations. Especially the lower emissions of NO_X compared to mineral diesel buses was an attractive factor for the politicians (Hjertstrand 2000, personal message). The administration of the bus company running these ethanol buses, Busslink AB/Stockholm Local Transport, has lately suggested that all new buses to be purchased in the coming years are to be mineral diesel buses. The reason for putting forward this proposal is twofold. Firstly, ethanol buses have much higher operating costs than mineral diesel buses. Secondly, new mineral diesel buses have substantially lower emissions of NO_X and other components harmful for health and local environment than what were the case with previous mineral diesel buses. However, the bus company board has turned down this proposal. The municipality politicians (who also have several positions in the board) are in favour of choosing ethanol buses when purchasing new buses.

The experiences with ethanol buses in Stockholm have shown that these buses are just as reliable as ordinary mineral diesel buses. The infrastructure (filling stations) has not been a problem. Some other problems, mostly of technical nature, have occurred in the period since the start up of the ethanol project. One problem has been deposits on filters, injection pumps and on fuel injectors. It is believed that the problem is caused by a combination of reactions between the ignition improver and ethanol. Similar types of problems have occurred with the ethanol bus fleets in other cities in Sweden. It is the currently used ignition improvers which are the cause of the deposit problems. In the long term new types of ignition improvers have to be developed. Today's problems with deposits on filters, injection pumps and on fuel injectors, can in the meantime be solved by more frequent servicing. This would however result in higher operating costs (Månsson 1998).

Another problem that has occurred with the first fleet of ethanol buses was that they produced a characteristic vinegary odour. This was due to leaking fuel injectors. The leaking fuel passes through the engine in non-combusted form and it is finally oxidised when it reacts with the reactive surface of the catalyst, thereby resulting in the odour of vinegar. As a respond to the problem of vinegar odour (which people feel unpleasant), a research project was started in order to develop new types of catalysts. The research project succeeded in that it managed to develop a new generation of catalysts, removing the vinegar odour. Most of the ethanol buses in operation in Stockholm are equipped with this new type of catalysts (Månsson 1998).

A fleet of ethanol buses started also to run in 1993 in the County of Skaraborg. 10 of the 15 buses used in the project were older buses that had been converted to ethanol use. At the start of the project the cost for converting one bus to ethanol was around 100.000 SEK. This amount corresponded approximately to the additional cost of a new ethanol bus. However, the converting costs are lower today than what was the case in 1993. There are no doubt, however, that there are considerable extra costs associated with either converting existing buses to alcohol use or buying new ethanol buses. As pointed on earlier, the operation costs are also considerably higher than for diesel buses. This implies that the bus companies are dependent of having the additional costs related to the ethanol use covered by local, regional or national authorities (or others). This is the case with all ethanol buses running in Sweden today. If these subsidies are removed, the ethanol buses will be converted to ordinary mineral diesel use. At the end of 1999, a total of 382 buses were running on ethanol in Sweden.

The experiences with lorries running on ethanol in Sweden are much more limited than what are the case with buses. At present 7 lorries (Volvo) are running on neat ethanol in Sweden. The trials with ethanol lorries started in 1995 under the project name SVENOL. The lorries that were used in the trials had conventional diesel engines which had been modified in some respects in order to run on ethanol. In general, all the lorries had a satisfactorily driving performance. No serious engine breakdowns have occurred. Some technical problems did, however, occur. Similar to what happened with the ethanol buses, there were some problems related to deposits on the fuel filter. In addition the ethanol lorries had some cold starting problems during winter times. Furthermore, the fuel consumption was slightly higher than expected. One reason explaining the higher fuel consumption was the fact that the engines had not been optimised for ethanol use. In addition, the engines were according to Volvo optimised for low emissions (of compounds harmful for the local environment) rather than low fuel consumption. There is still a large potential for improving the ethanol engines in lorries (Månsson 1998).

In addition to fleet tests with ethanol buses and ethanol lorries, a considerable number of FFV-vehicles are running in Sweden. A network of petrol stations throughout Sweden offering ethanol has been established in this respect. Some cold-starting problems have been experienced also with these vehicles.

6.3.1. Introduction of Ford Focus FFV in Sweden

In October year 2001 Ford Focus FFV will be introduced on the Swedish marked, as the first country in Europe. Commercial introduction of FFV-cars is possible in Sweden due to the large marked interest (Ramstedt, 2001). This marked interest today is unique, no other country in Europe is in this position. By February 2001 Ford has 3000 orders on the car, and expects more before the production starts in August.

The initiative to produce FFV-cars came from a group of institutions, companies and organisation with the city administrations in Stockholm and Göteborg in front. These actors made inquiries to several car-companies and asked what kind of environmental cars they could deliver. The best offer came from Ford with their Ford Focus FFV. The city administrations in Stockholm and Göteborg, companies and organisations have formed the Swedish FFV-Buyer Consortium which organise the marked interest and functions as a joint voice during the purchasing process. They expect a total order at about 4000 Ford Focus FFV before August 2001.

Another important assumption for a commercial introduction of FFV-cars is the availability of ethanol at a competitiveness price to the car owners. During the 1990's developing projects have been carried out in order to build a marked for FFV-cars and an infrastructure of ethanol fuelling stations in Sweden. The goal has also been to stimulate production of bio-ethanol as an attempt to stabilise the growth in global CO2 emissions. After an introduction of the technology in 1994 the interest increased and in 1995 a total of 50 Ford Taurus FFV were imported from USA. At the same time the fuel distribution company OK started building an infrastructure of ethanol fuelling stations throughout the country. In 1997-98 another 300 new FFV-cars were imported and 40 ethanol fuelling stations were operating (BAFF, 2001). The Bioalcohol Fuel Fundation has played a crucial role for this development. The Swedish government has given some factories tax reduction for the production of bioalcohol.

6.3.2. Ethanol as 5 % blend in petrol

The test production at the factory Agroethanol AB in Nörrköping started in January 2001. During the first quarter this year it is expected ordinary production, and at the same time about 20 % of the Swedish private cars are driving on a blend of 5 % ethanol in petrol (Werling, 2001). Nearly all the fuel distribution company in Sweden (Jet, Preem, Hydro, Shell, Statoil and OK-Q8) is involved in the project. The ethanol fuel blend is mainly distributed in the eastern part of the country.

6.3.3. Marked penetration for ethanol

With the introduction of about 4000, or more Ford Focus FFV in 2001, and the distribution and use of 5 % ethanol blend in petrol for 1/5 of the private cars in Sweden, a marked penetration for ethanol as a motor fuel for cars is established.

7. Identification of stakeholder groups members

Previously in this report we have summarised the most important barriers towards use of motor-alcohols in heavy-duty vehicles. This research is based on the thesis that in order to resolve these barriers and to achieve market penetration it is necessary (but not sufficient) to establish well-functioning stakeholder group networks in this field.

Stakeholder group networks fall within the concept of environmental co-operative regimes. Such regimes have hardly been tried before within the area of expanding the use of alternative energy resources. However, the idea of stakeholder group networks was an important idea behind an international workshop that was held in 1995 in Saltsjöbaden, Sweden. This was a one-time event with the goal to "bring together stakeholders in industry, government and science to identify technical, economic and institutional opportunities and/or barriers to the market penetration of biofuels and to tackle these issues in an international environment" (Pilo 1996: 3).

An important part of the ALTENER-project has been to identify stakeholder groups involved in creating or resolving the most important barriers to increased use of wood-based alcohols. This has been done in all the three countries this ALTENER-project embraces (Norway, Sweden and Finland). We have chosen to focus on mainly four types of stakeholder groups. First of all, we believe it is necessary that a stakeholder group network include representatives for the producers of biological alcohols. Farmers, forest owners and their respective interest organisations are key actors in this respect. The set-aside policy of the EU has made it economically attractive for farmers to promote production of alcohols (and other biofuels) on set-aside areas. Forest owners also have an incentive for promoting the production and use of motor-alcohols. If wood-materials are used in the production of motor-alcohols, the forest owners could obtain higher and more stable incomes than today. On the other side, the forest and paper industry might see their interests threatened by such a situation (considered from a narrow self-interest perspective). A stakeholder group network should not include actors that will work against a market penetration of motor-alcohols. The goal of establishing such a network is, as stated above, to try to resolve barriers and increase the use of motor-alcohols. It is therefore not natural to include actors that actively will work against this goal. It has to be underlined that this does not mean that the stakeholder group network only is to consist of actors 100% in favour of motor-alcohols. The network is not to function as a lobbying group. It is necessary to include crucial actors from the whole fuel chain, also actors that have critical remarks concerning different aspects of motor-alcohols.

But let us turn back to the main types of stakeholder groups in our project. As stated above, actors close to the production chain have to be included in the network. In addition to farmers and forest owners, this could also include wood-processing industry that produces alcohols as a by product as well as manufacturers of alcohol production facilities. The second main type of stakeholder groups in our project is the distributors of motor-fuels. As pointed out earlier in the report, it is necessary to use the existing infrastructure for fossil fuels in order to keep the distribution costs for motor-alcohols as low as possible. It is therefore natural to include oil companies in the stakeholder groups.

The third important group of stakeholders is the manufacturers of vehicles (especially manufacturers of heavy duty vehicles, but also manufacturers of light vehicles). As stated in the previous chapter, there are still a considerable potential to optimise vehicle engines for motor-alcohol use. There are also some minor technical problems still to be solved. It is therefore of great interest to include representatives for vehicle manufacturers in the stakeholder group networks.

The most appropriate way of deploying alcohols in heavy duty vehicles is to deploy it in fleets. Transport companies are therefore important actors and they constitute the fourth main type of stakeholders in our project. Different types of transport companies might be relevant to include in our network – bus companies, companies transporting goods or companies transporting both persons and goods. Transport companies might see a conversion to alcohol fuels as an option to improve their environmental image. However, they will also be very concerned about the total costs associated with alcohol use as well as how the vehicles operate with this type of fuel.

The four types of stakeholder groups described above are the ones to be included in our Nordic stakeholder group network. In addition to the four main groups mentioned, it could also be relevant to include two more groups of actors – research institutions and governmental bodies. Research institutions will have a key role to play in order to overcome several of the barriers pointed on in this report. For example, researchers can contribute in developing new alcohol production techniques with lower costs than the ones used today. However, we have decided not to include other research institutions in the stakeholder group networks than the research partners in the project. The main reason for doing this is that we want to have the main focus on the other types of actors. In addition we want to limit the number of stakeholder group members, in order to have a well-functioning network. This is also one reason for not including governmental bodies in the stakeholder group network. Barriers are related to interests.

Governmental bodies is a type of actor that have to be careful when expressing opinions regarding the interests of different actors. On the other hand, the presence of governmental bodies in the network can make these actors more familiar with the various interest conflicts and barriers that have to be solved in order to increase the market penetration of motor-alcohols.

Below we have presented what we believe to the most important actors in the field of motor-alcohols in Sweden, Finland and Norway, respectively. A more thorough presentation of each member of the network is given in Attachment 1.

7.1. Important Swedish Actors in the Field of motor-alcohols

The farmer organisations are important actors in the field of motor-alcohols. In general the farmers want to utilise more of the agricultural land (because of the set-aside land policy), and they therefore promote the production of biodiesel and motor-alcohols. The national interest organisation for the farmers in Sweden is called *Landtbrukarnas riksförbund* (LRF). In this field LRF operates through their own company Agroethanol. Agroethanol is interested both in wood and agricultural crops as feedstock.

The oil companies have to be involved if motor-alcohols are to be used to a great extent in Sweden (and other countries). It would be an advantage if motor-alcohols can use the same distribution system as fossil fuels. So far the oil companies have not been especially keen on accepting ethanol blends. However, they have now accepted a 4-5% ethanol blend. All car manufacturers accept low blend use. There is not much difference in attitude towards blends/motor alcohols between the various oil companies. But if one oil company moves ahead in this area, the other ones will follow (Brandberg, personal message).

The only factory for ethanol production in Sweden today is owned by a company called the Swedish Ethanol Chemical Company (Svensk Etanolkemi AB) (SEKAB). It is a promoter of ethanol use in Sweden.

The Swedish Bioalcohol Fuel Foundation (BAFF) is an important actor in the area of motor-alcohols in Sweden. The goal of the foundation is to develop the production and use of ethanol within Swedish industry as well as within the transport sector.

There are some research related to motor-alcohols going on at the following universities in Sweden: Lund Technical University (the Department of Chemical Engineering and the Department of Microbiology: studying the chemical process and the enzyme process), Gothenburg University (technology development, energy research), Stockholm University (exhaust emissions; use of motor-alcohols), Royal Technical University in Stockholm (work related to catalysts, in co-operation with industry) and Luleå University and the Agricultural

University with projects concerning feedstock and biogas (Brandberg, personal message).

The forest industry in Sweden is participating in the Swedish Bioalcohol Development Foundation. However, it has invested only a small sum of money in the foundation. In general the attitude of the forest industry is that motor-fuels are not their business. The forest industry has to become an important actor in the field of motor-alcohols in the future, if the use of motor-alcohols are to increase substantially. About 50% of the forest in Sweden are spread out on many different landowners. Additional 20% is owned by the state. The (small) landowners are organised through forest interest organisations, where *Svenska Skogseierföreningen* (The Association of Swedish Forest Owners) is the most important one. These interest organisations are very interested in motor-alcohols. The forest-/papermill industry, however, wants to avoid that other actors than themselves are buying wood resources. They do not believe that it is only the waste fraction of the wood that is to be used for transport purposes. The paper mill industry buys timber and pulp wood from remote forests only when the price of paper on the world market is acceptable (often every 3-4 year). The forest owners have to wait until the forest industry gives the signal for the felling of trees. This means unstable economic conditions for the forest owners. The forest owners want to sell timber every year. This is also important for them in order to invest capital in reforestation (Brandberg, personal message).

The vehicle manufacturers (Scania, Volvo and Saab) are important actors in the field of motor-alcohols in Sweden. Volvo participated in the foundation of the predecessor of Ecotraffic – the Swedish Methanol Company. At that time (in the 1970s) the possibility of building a natural gas pipeline from the North Sea to Sweden was being considered among Norwegian and Swedish industrialists and politicians. If such a pipeline was to be built, Volvo was interested in participating in the pipeline building process. The idea of Volvo was to produce methanol from the natural gas. The methanol produced could then be used as a fuel in the transport sector. This was the reason why Volvo contributed in the foundation of the Swedish Methanol Company. Methanol was the first alternative fuel that Volvo considered to be possible to introduce at some scale in to the Swedish market. Volvo preferred methanol instead of ethanol because of the price. It was much cheaper to produce methanol from natural gas than to produce ethanol from agricultural crops. Volvo was of the opinion that also methanol produced from renewable sources (wood-based) would be cheaper than ethanol produced from agricultural crops. However, the production costs of methanol produced from fossil fuel was considered to be 25% higher on petrol-equivalent basis (60-65% on volume basis) than the corresponding costs for petrol (Brandberg, personal message).

The support from Volvo in the area of alternative fuels (methanol) was mainly in the form of subsidising various research projects. Volvo did not give any economical support for actual use of methanol. Volvo participated also in the development of the FFV-vehicle in the United States. The present policy of the Swedish vehicle manufacturers is to produce the engines that the market asks for. They are not willing to take the lead in the motor-alcohol marked (or to work for an expansion of this market) (Brandberg, personal message).

Saab does not have any preferences in the area of alternative fuels, according to Brandberg. Saab has, however, participated in various research projects regarding motor-alcohols (Brandberg, personal message).

Scania has developed its own ethanol diesel engine. The company received governmental support for the development of this engine. One main reason for the decision of Scania to develop an ethanol diesel engine was that the company saw a possible marked in Brazil. In total Scania has sold about 1000-1200 ethanol buses. 400 of them have been sold in Sweden. Sweden has so far been the largest "ethanol market" for Scania. In Stockholm approximately 200 buses (all of them are Scania) are running on ethanol. It was somewhat occasional that Scania preferred ethanol instead of methanol. But Scania has to some extent emphasised that the ethanol to be used in these buses would be renewable. In comparison, it was not thought to be possible to produce considerable amounts of renewable methanol (Brandberg, personal message).

Several bus companies in Sweden have experience the use of motor-alcohols. The bus company Bus Link is running more than 200 buses on ethanol in Stockholm. These buses are produced by Scania (modified diesel engines). In addition the company has about 6-8 hybrid buses. In Sweden outside Stockholm 200 more buses are running on ethanol (10 bus companies in 10 cities). Besides motor-alcohols, there are some interests in natural gas and biogas among the bus companies in Sweden. Natural gas is especially considered to be a realistic option among bus companies on the western coast of the country. There are some buses in Sweden running on biogas. The price of biogas is low (surplus sludge). Biogas is viewed upon as a niche fuel, with a market potential of 5-10% (Brandberg, personal message).

Using ethanol as a motor-fuel imply extra costs for the bus companies compared to mineral diesel. The local and regional authorities cover the extra costs. There is, however, a discussion going on in Sweden whether one should continue to spend public money on subsidising ethanol use in bus companies. Originally the ethanol bus project was a demonstration project. Now it is more appropriate to denote it as regular bus transport. It is likely that the bus companies will stop using ethanol if the subsidises from local and regional authorities are removed. The bus companies in question are private owned and have to focus on the costs (Brandberg personal message).

Table 2 below summarises what we believe to be the most important actors in the field of motor-alcohols in Sweden.

Table 2 Important actors in the field of motor-alcohols in Sweden

Institution	*Business related to alcohols*	*Persons*
Manufacturers of renewable alcohols and wood-processing industry		
Agroethanol AB	A company established by farmers. Agroethanol promotes the production of ethanol. It is interested both in wood and agricultural crops as feedstock. Agroethanol is currently erecting its second ethanol plant in Sweden.	Göran Wadmark
SLR (Svenska Lantmännens Riksförbund)	50% owner of Agroethanol AB	Göran Wadmark
The Swedish Ethanol Chemical Company (Svensk Etanolkemi AB) (SEKAB).	The only factory for ethanol production in Sweden today is owned by SEKAB. It is a promoter of ethanol use in Sweden. Parent company is Akzo Nobel AB.	Bertil Persson (Marketing Manager), Charlie Rýden
Swedish Forest Industries Ass.	Raw material holders	Staffan Thonfors
The Federation of Swedish Forest Owners (Skogsägarföreningen)	Raw material holders Skogsägarföreningen is interested in motor-alcohols, in order to improve and stabilise the economy of the forest owners.	Sven Hogfors
MoDo	Site for ethanol plant based on sulphite process	See SEKAB
Interests organisations promoting renewable motor-alcohols		
The Swedish Bioalcohol Development Foundation (Stiftlelsen Svensk Bioalkoholutveckling)	The goal of the foundation is to develop the production and use of ethanol within Swedish industry as well as within the transportation sector.	Per Carstedt, Sten Flodin, Jan Lindstedt
The Federation of Swedish Farmers (Landtbrukarnas riksförbund, LRF)	LRF is the interest organisation for farmers, forest owners and agricultural co-operatives in Sweden. LRF promotes the production of biodiesel and motor-alcohols. The farmers interests are related to the set-aside land policy of the EU.	Erik Herland, Anette Hellström
The County Governors Group For Ethanol Fuels (CGGEF)	An organisation consisting of several counties interested in promoting the production and use of motor-ethanol. It has established networks with France, USA and Brazil. One of the goals is to organise a Stakeholders' forum	Per Carstedt (Sten Flodin)

Transport companies and transport organisations		
Stockholm Local Transport, Västtrafik, Dalatrafik, Luleå Trafik, Örnsköldsviks Buss,	These bus companies have had several years of experience with running ethanol-fuelled buses.	Leif Magnusson, SLTF Roland Ax, Västtrafik
BTL AB - Schenker	BTL is a very large transport company (>10.000 employees, including 5.500 outside Sweden). BTL has conducted fleet tests with ethanol-operated Volvo trucks for urban use (the project Svenol).	Johan Trouve (environmental manager)
Distributors of motor-fuels		
OKQ8	A fuel distributor that currently is selling E85 at 24 petrol stations throughout Sweden. Also participated in fleet tests with methanol (in the 80s) and ethanol. OK also offers RME at 17 petrol stations and biogas (1 petrol station). Low level ethanol/petrol (5%)	Håkan Neuman (Director of Fuels Department)
Statoil	Fuel Distribution E85, E10 and biogas	Bo Wideberg Lene Krogstadholm
Shell	Fuel Distribution E85, E10 and biogas	Per Olof Lindh Leif Kronberg Daniel Danielson
Manufacturers of heavy duty vehicles dedicated for motor-alcohols		
Volvo	Developed FFV-vehicles (not commercial available) and trucks and buses equipped with engines that are adapted to ethanol (for ex. the Svenol-project). Willing to develop and provide vehicles for pilot fleet tests but not in larger quantities until there is an economically sound market.	Stephen Wallman, Lars Greger, Bengt Johansson, Jan Kemlin, Bo Ljungström, Henrik Landälv
Scania	Developed trucks and buses equipped with engines that are adapted to ethanol.	Ronnie Klingberg Eva Nyström
SAAB	Light cars	Tommy Bertilsson Gunnar Kinbom
Research institutions		
Lund Technical University, Department of Chemical Engineering and Department of Microbiology	Studying the chemical process and the enzyme process	Guido Zacchi Bärbel Hahn - Hägerdal
Chalmers	Department of Combustion Engine Technology	Erik Olsson
Gothenburg University	Fermentation research	Lena Gustavsson
Stockholm University	Exhaust emissions and biological analysis	Roger Westerholm (Analytical chemistry) Ulf Rannug

Royal Technical University in Stockholm	Work related to catalysts, in co-operation with industry. Chemical/Engineering/Technology/ Energy processes	Lars Pettersson, Annika Wahlberg Katarina Maunsbach
Energicentrum Norr	Ethanol processes	Jan Lindstedt
Luleå University of Technology	Emission tests	Karl-Erik Egebäck, Ulrik Sundbäck, Bror Tingvall, Grover Zurita
The Agricultural University	Projects concerning feedstock and biogas	Bo Hektor
JTI (Swedish Institute of Agricultural Engineering)	Projects concerning feedstock and biogas	G. Hadders
Ecotraffic	Consultants - Motoralcohols	Bengt Sävbark
Other actors		
KFB (The Swedish Transport and Communications Research Board)	Government agency with planning, initiating, co-ordinating and supporting functions in Swedish transport and communications research.	Sören Bucksch, Arne Kihlblom
Statens energimyndighet (STEM) (Swedish National Energy Administration)	Research programs for motor-alcohols	Lars Tegnér Lars Wallander Anders Levald Birgitta Palmberger
City of Stockholm	The City of Stockholm (and Helsinki) participates in the ZEUS program (8 European cities in total). The main objective of ZEUS is to procure and put into use more than 1000 "zero and low emission" vehicles. Focused on removing market obstacles in the area of alternative motor-fuels. Demonstrate that municipalities of European Cities can play an important role in heading towards a more sustainable transportation system.	Gustav Landahl (head of the Environment and Health Protection Department) Eva Sunnerstedt Charlie Rydén
Trafikkontoret i Göteborg	Purchase requirements for vehicles and machineries	Ma-Lou Wihlborg
Vägverket (National Road Administration)	Sector responsibility for environment	Olle Hådell
Naturvårdsverket (National Environmental Protection Agency)	Responsible for outdoor air quality	Eva Jernbäcker Alexandra Norén
SIKA, Länsstyrelsen i Stockholm, Ministry of Transport and Communications	Transport statistics and planning	Staffan Widlert Lennart Thörn Helena Asp
Vattenfall Utveckling	Production processes	Claes Ekström

7.2. Important Finnish Actors in the Field of motor-alcohols

Of the research institutes in Finland concerned with motor-alcohols VTT (Technical Research Centre of Finland) and Helsinki University of Technology are the most important ones. VTT Energy has conducted research on alcohol as fuel in Flexible Fuel Vehicles as well as research on wood based biofuels. Another department of VTT, VTT Building and Transport, is interested in emission inventories from different types of fuel and transport modes. The third important department of VTT in relation to motor-alcohols is VTT Biotechnology and Food Research – doing basic research on enzymes for alcohol production. Helsinki University of Technology, department of mechanical engineering, are conducting research on the use of alcohol in heavy-duty engines.

Another important actor in the field of motor alcohols in Finland is JPI Process Contracting Oy (JPI). JPI is an international contractor executing projects for process industries, partly based on proprietary technologies. During the last few years JPI has executed projects in e.g. China, France, Spain, Sweden and Finland. An important business field for JPI is to plan and build alcohol plants, including alcohol plants for motor fuels.

The key oil company Finland is and Fortum Oil and Gas Oy (formerly Neste Oy). It manufactures products and offers services to both retail consumers and company clients. As an oil company Fortum Oil and Gas Oy manufactures all of the most important petroleum products for use by traffic, industry and energy production. As a manufacturer of chemical products, Fortum Oil and Gas Oy focuses primarily on adhesive resins and coatings. The energy business encompasses natural gas, liquefied gases, heat generation and sales as well as solar and wind energy systems. Of particular interest for Fortum in the area of motor-alcohols is the use of methanol in MTBE production. Furthermore, Fortum owns a fuel delivery company called Neste Service Stations. Neste Service Stations has 255 petrol stations located throughout Finland.

The transport companies in Finland have shown little interest in motor-alcohols. One exception is the transport company Helsinki City Transport. 5 years ago this company considered motor-alcohols as one of several possible new motor fuels for its fleet. However, the Helsinki City Transport Committee finally chose natural gas as an alternative fuel for city buses. At present there is no interest in motor alcohol in this transport company.

7.3. Important Norwegian actors in the field of motor-alcohols

7.3.1. Oil companies

The present interest for motor-alcohols in Norway is limited. It is therefore very few actors that have activities in this area. There are no production, distribution or consumption of biological motor-alcohols at present. However, in June 1997 the national oil company Statoil (together with Conoco) started to produce methanol from natural gas at a plant located to a Tjeldbergodden, 200 km west of Trondheim. The production of methanol from natural gas was made possible by building a pipeline from the Heidrun field in the Norwegian sea and to the coast. The methanol factory produces about 830.000 tons of methanol per year, which makes it the fifth largest methanol factory in the world. The production volume at Tjeldbergodden corresponds to 15% of the methanol market in Europe. It is sold to world market prices (which varies a lot) (www.scandoil.com; www.tbu.org). At Tjeldbergodden there is also a production plant for LNG (capacity 7.500 tons/year), the first of this kind in Norway. The LNG produced is mainly used in a limited number of buses running in Trondheim and burned in the waste combustion facility in Trondheim. Statoil is interested in selling fossil methanol for transport purposes. As mentioned in chapter 5.1, Statoil (then Norol) was involved in a large fleet test with fossil methanol in the beginning of the 1980s. When it comes to biologically produced motor-alcohols, Statoil does not have any particular activities in Norway. However, several of Statoil's petrol stations in Sweden offer biofuels.

The second largest Norwegian oil company is Hydro. In addition to having considerable oil and gas activities, metal production and fertiliser production are important fields for Hydro. Hydro has been somewhat engaged in issues related to biofuels. In 1997 Hydro Texaco opened the first fuel pump in Norway with biodiesel. Several fleet tests with biodiesel have been carried out with Hydro as a partner. In Sweden the company is offering biodiesel and ethanol at several petrol stations. Hydro has also been involved in the building of the new ethanol production facility in Norrköping. Similar to what is the case with Statoil, most of the biofuel activities in Hydro have taken place in Sweden.

Both Hydro and Statoil support the international climate change agreement (the Kyoto Protocol). This has not always been the case. Earlier Hydro (along with most other oil companies in the world) was a member of the "Global Climate Coalition", a lobby organisation working against an international climate change agreement. Hydro, along with other oil companies has since then changed position and is now supporting the Kyoto Protocol.

7.3.2. Producers of motor-alcohols

There is one factory in Norway producing wood-based ethanol as a by-product. This is the company Borregaard ChemCell, located to Sarpsborg, southeast of Oslo. Borregaard is a chemical company with 20 production units in 12 countries. Borregaard ChemCell is a leading producer in Europe of speciality cellulose for chemical related applications. Speciality cellulose is used as a raw material in a number of products and areas of application that require special physical and chemical properties. In addition to producing speciality cellulose, Borregaard also produces a number of non-cellulose chemicals. These products include sulphuric acid, caustic soda, hydrochloric acid and ethanol. The products are used for captive use in the production of cellulose, sold within the Borregaard Group or to external customers.

The ethanol production capacity of Borregaard is about 22 million litre per year. It is used mostly in car polishing products and within the pharmaceutical industry. Each year about 12-14 million litre of ethanol is exported. Borregaard is interested in having alternative domestic applications for the ethanol that is exported today. The ethanol exported is exposed to taxes du to EU tax policies. Borregaard is therefore interested in selling ethanol for domestic transport purposes – thereby achieving higher prices for the ethanol.

Another producer of ethanol in Norway is the national alcohol company Arcus. Arcus produces ethanol for drinking purposes.

Besides Borregaard and Arcus, there are no producers of biological motor-alcohols in Norway at present. However, two researchers at the Bergen College have developed a new industrial process for producing ethanol from wood material. As described in chapter 3.2, several process techniques to break down cellulose and hemicellulose to fermentable sugars are known, but the production costs are high. This is due to high consumption of mineral acid, low yield or long reaction times. Karl Weydahl and Knut Helland at Bergen College has developed a production method that is more energy efficient than what is known in existing production facilities today, thereby lowering the production costs. They are now in the process of taking a patent on their production method as well as seeking investors for financing a pilot ethanol-production facility. A pilot production facility could further improve the energy efficiency and the ethanol yield already obtained in laboratory experiments. The research behind the production method started in the second half of the 1980s. Weydahl carried out this research as part of his job as a teacher at Bergen College. Today, however, the Weydahl and Helland are in the phase of establishing their own company. This means that the Weydahl and Helland, in the context of our stakeholder concept, must be characterised as "alcohol producers", and not as researchers (any longer).

7.3.3. Transport companies

No transport companies in Norway have experiences with motor-alcohols. In comparison to Sweden, there is not much focus on renewable fuels in Norwegian transport companies. The federation of bus companies in Norway (TL) does spend some money and time on being updated on this topic, but is not willing to actively encourage their own members in this field unless the authorities decides to focus more on alternative and renewable fuels. There are, however, some bus companies that have vehicles running on alternative fuels. Previous in this report we have described the bus fleets running on natural gas in the cities of Trondheim and Haugesund. The companies in question are Trondheim Traffic Company and "Nettbuss Vest", respectively.

8. The stakeholder group networks on motor-alcohols

8.1. Introduction

The use of biological motor-alcohols is today mostly limited to field experiments and there is no real market penetration. The main thesis behind the research project "Motor-Alcohols from Wood Resources in Heavy Duty Vehicles" is that this stems from the existence of several different types of barriers. Barriers are often related to interest groups and actors. These interest groups and actors are in the project termed stakeholder groups and actors. An important assumption in the project is that the establishment and functioning of stakeholder group networks is necessary in order to achieve resolvement of barriers and create conditions for market-penetration of biological motor-alcohols.

Stakeholder group networks fall within the concept of environmental co-operative regimes. Such regimes have not been tried before within the area of expanding the use of alternative energy resources. The project is based on the thesis that they are necessary to resolve barriers and to achieve market-penetration of alternative energy resources in general and biological motor-alcohols in particular.

An important part of the ALTENER-project has been to identify stakeholder groups involved in creating or resolving the most important barriers to use of wood-based alcohols. During the project period has a stakeholder group network has been set up on a Nordic (Norway, Sweden and Finland) as well as on a national level in Norway. Besides the participating research institutions (WNRI, Ecotraffic and VTT), the members of the network are transport companies, transport organisations, wood-processing industries and manufacturers of wood-based alcohols, distributors of motor-fuels, and manufacturers of vehicles dedicated for motor-alcohols.

8.2. Members of the Nordic stakeholder group

The stakeholder group has had members from Sweden, Finland and Norway. The networks have included large engine- and fuel producers important for the market penetration of motor alcohols in the Nordic countries. The member institutions and the participating persons are listed below.

Sweden

Federation of Swedish Farmers (LRF)   Erik Herland

BioAlcohol Fuel Foundation	Jan Lindstedt, Per Carstedt
Swedish Shell	Per Olof Lindh
Stockholm Local Transport	Bo Hjertstrand
Scania	Urban Wästljung
Saab Automobile AB	Nils-Gunnar Svensson
Swedish Association for Public Transports	Leif Magnusson
BTL Sweden AB	Thomas Sandström
Chalmers University of Technology	Tomas Kåberger
Ecotraffic R&D AB	Bengt Sävbark, Åke Brandberg, Henrik Boding, Peter Ahlvik
Swedish Farmers' Supply & Crop Marketing Association (SLR)	Göran Wadmark
Busslink	Per Wikström

Finland

JPI Process Contracting	Kari Sarkkinen
FORTUM Oil and Gas	Marrku Laurila
VTT	Kari Mäkalä, Jukka Räsänen

Norway

Borregaard	Ole Kristian Günther, Hanne Kristoffersen
Hydro	Vera Ingunn Moe
WNRI	Karl Georg Høyer, Otto Andersen, Hans-Einar Lundli, Eivind Brendehaug

8.3. The activities in the stakeholder group

The Nordic stakeholder group network on motor-alcohols has had two seminars for all members and active contact between the meetings on e-mail and by the project web-site.

8.3.1. The project web-site

The project web-site is used as an information channel between the project leader, the partners and the members of the stakeholder group. The web-site gives information of the project, from the meetings (program and report) and presents the members of the network. The web-site address is: http://2171.vestforsk.no.

8.3.2. Contact by e-mail

E-mail has been used for establishing and maintaining the contact between the partners and members of the stakeholder group network between the meetings. This technology has been used to call for meetings and to distribute program and reports, and to get information from the member's work on motor-alcohols.

E-mail has also been used systematically to create information from the members to identify and define barriers for a marked penetration for motor alcohols. A questionnaire to identify important actors and their appropriate role has also been distributed by e-mail (scheme in Attachment 2).

A quantification of the communication shows that 18 e-mail is sent to the whole network and about 50 e-mail messages to members. Western Norway Research Institute has received about 150 e-mail messages from the project partners and network members during the project period.

8.3.3. The first meeting (mars 2000)

The main aim of the meeting was to identify barriers against deployment of biologically produced alcohols in the transport sector in the Nordic countries. The stakeholder group network includes participants from the whole product chain from production, distribution to users of alcohol, as well as vehicle producers and research institutions. By having all these different types of actors represented in the stakeholder group network, a broad view on the issues and challenges regarding market penetration for motor-alcohols has been obtained.

Karl Georg Høyer, Western Norway Research Institute, held the introduction speech of the meeting. He informed that the project is part of the ALTENER II-program, an EU research program with the aim of developing alternative energy-sources in Europe. Høyer does not believe that a market penetration of motor-alcohols will take place during the project period. The goal of the project is to gain knowledge about the conditions for such a market penetration. An important hypothesis in the projects is that non-technical barriers are more important than the technical ones, and that the establishment of a stakeholder group network is important in order to solve these barriers. Høyer invited the participants to present their point of views on these issues, and asked: what kind of actions have to be taken in order to overcome the barriers?

Five prepared lectures, all focusing on barriers towards deployment of motor-alcohols, was held. A brief description of these lecturers is given below.

Barriers Against Deployment of Motor-alcohols in Heavy-duty Vehicles, by Bengt Sävbark, Ecotraffic.

Sävbark presented an overview of experiences with heavy-duty vehicles world-wide. At present most of the buses running on motor-alcohols in the world are running in Sweden. Previously a considerable number of alcohol buses were running in California. However, these buses have since been converted to ordinary mineral diesel buses, due to the high motor alcohol prices. The number of lorries running on motor-alcohols in the world is considerable lower than the number of buses running on these fuels. Sävbark also informed about the present supply situation for bioalcohols in Sweden and Norway. The new ethanol factory in Norrköping (production start in 2001) will improve the supply situation for ethanol considerably in Sweden. He underlined that this factory has to be looked upon as an "exception", meaning that future ethanol factories in Sweden not can expect to obtain tax exemptions when producing motor-alcohols. In his presentation, Sävbark also shed light on different aspects of the present fuel prices. Today the price of bio-alcohols is three to four times the price of fossil fuels. Furthermore, Sävbark presented emission data for heavy-duty vehicles, comparing bio-alcohols with mineral diesel. He argued that improvements in the diesel engine technology, in hand with EU regulations, probably would reduce the present emission advantages of motor-alcohols considerably in the years to come.

Motor-alcohols in Norway: Experiences, Actors, Current policies and Country-specific Barriers by Hans-Einar Lundli, Western Norway Research Institute.

Lundli outlined the Norwegian policies on biofuels. In contradiction to what is the case in Sweden, the authorities in Norway are of the opinion that it is mainly up to the market to introduce biofuels. There is no national goal regarding future use of renewable fuels in the transport sector. However, the government is willing to subsidise research projects in the area of renewable fuels as well as the first phase of commercial use of these fuels. Biofuels are also exempted for all fuel taxes (except VAT) in Norway. So far there have been no practical experiences with ethanol as a motor-fuel in Norway. In the 1980s a relatively large fleet test with fossil methanol was carried out. In the last decade the fleet tests carried out in Norway have been mostly limited to natural gas and electric vehicles. Lundli also made a presentation of the key actors in the field of motor-alcohols in Norway.

Motor-alcohols in Finland: Experiences, Actors, Current Policies and Country-specific Barriers, by Kari Mäkelä, Technical Research Centre of Finland (VTT).

Mäkelä presented an overview of the Finnish policies on renewable fuels. The Finnish authorities have developed a relatively ambitious policy on the area of stationary use of biofuels. This is, however, not the case in the area of liquid biofuels. Mäkelä also informed about the fuel tax policies in Finland. Furthermore, he made an overview of past experiences with motor-alcohols in Finland. Some years ago there were more activities in this field than what is the case today. Transport companies that are considering other types of fuels than mineral diesel, normally prefer natural gas. Finally Mäkelä made a presentation of the most important actors in the field of motor-alcohols in Finland.

Barriers against Motor-bioalcohols from the Standpoint of a Producer, by Erik Herland, Federation of Swedish Farmers (LRF).

Herland made a presentation of a new ethanol plant being built in Norrköping in eastern Sweden, south of Stockholm. The production capacity of this plant is expected to be 50.000 m^3 ethanol per year, and the ethanol produced is to be added to the petrol sold in the Stockholm area (E5). The raw material for this ethanol plant is grain produced on set-asides, thereby reducing the feedstock costs. However, tax exemptions are necessary in order to produce ethanol at an acceptable price. The plans for the Norrköping factory were developed already in the beginning of the 1990s. However, due to the uncertainty regarding the raw-material supply situation, the tax policies and in the end the consumer price, no positive decision was taken at that time. It took several years before the Swedish government finally decided to be in favour of tax-exemptions for the Norrköping factory. The government has not decided whether the tax exemptions are to be continued in a long time perspective. Herland informed that the Norrköping plant is owned by LRF and Lantmannen. Other companies or institutions have not been interested in investing money in this plant, as long as there is a large uncertainty regarding future tax policies in this area.

Barriers Against Motor-bioalcohols from the Standpoint of a Transport Company, by Bo Hjertstrand, Stockholm Local Transport.

A large number of ethanol buses have been running in Stockholm since 1993. At present the bus company Busslink is operating 245 ethanol buses in Stockholm. Bo Hjertstrand informed that the ethanol buses were introduced in order to decrease the emissions of components harmful for the local environment, especially NO_X. In 1993 about 15 percent of all NO_X-emissions in Stockholm came from buses. The introduction of ethanol buses reduced this share considerably. However, Hjertstrand is personally not in favour of continuing running ethanol buses in Stockholm. He argued that new Euro regulations will reduce the emissions of NO_X and other local pollutants from buses considerably in the years ahead. As a result of technology development and Euro regulations, the emissions from mineral diesel buses is expected to be reduced to the same level that ethanol-buses have today. Hjertstrand did, however, underline that the CO_2-emissions still will continue to be much lower for ethanol buses than for buses running on fossil fuels.

Barriers identified during the speeches, comments and discussions included:

-The ethanol consumer price is too high, resulting in too high operating costs for bus companies, other transport companies and private cars.

-Motor-alcohols has high production- and distribution costs .

-National tax- and duty policies on motor-alcohol are not favouring increased motor-alcohol use.

-Farmers and industry are not a sufficient driving force to develop ethanol as a fuel in the transport sector. One exception is the governmental decision to grant the Norrköping-factory in Sweden a duty exemption. Without such a decision, the factory would not have been built.

-Future improvements in diesel engine technology are believed to substantially reduce the emissions of local pollutants from mineral diesel combustion. By 2010, the emissions of local pollutants from mineral diesel would probably be close to the corresponding emission levels for motor-alcohol.

-Different actors are expecting that the fuel cell technology will become mature in the near future (so why wasting time and money on motor-alcohol?). However, the fuel cell technology might also represent an opportunity for motor-alcohol, since motor-alcohol can be used as an energy carrier.

-The FFV-vehicles currently in use are not optimised for alcohol fuel use, but for petrol.

-Unsteady political framework. The market actors need stable and long term policies in order to invest capital in the motor-alcohol market

The stakeholder group continued to emphasise and systematise barriers after the first meeting. Another task was to identify strategic actors outside the stakeholder group network, actors that are important to approach in order to overcome the barriers. Before the second meeting the stakeholder group worked on these issues.

8.3.4. The second meeting (July, 2000)

The aim for the second meeting was to continue the identification and also formulation of barriers, and to identify strategic actors outside the stakeholder group. Four prepared lectures were held:

The need for further research in the area of motor-alcohols, byBjørn Rehnlund, Swedish National Energy Administration.

The background and motives for the efforts of the Swedish authorities to develop motor-alcohols have changed from the 70's to the present:

- During the 70's, methanol seemed desirable because it appeared to be a more reliable source of fuel.
- During the 80's, health and the environment provided the major impetus for motor-alcohols.
- During the 90's, the climactic advantages of alcohol were considered the most important aspect of this motor-fuel.

In 1992, the Swedish government issued the Climate Plan, which concentrated on the production of ethanol from cellulose. 45 million SEK were made available for the project. The Swedish National Board for Industrial and Technical Development (NUTEK) was given responsibility for the project. The Energy Plan of 1997 provided 210 million SEK for testing different methods for the production of ethanol. These tests were carried out by the Swedish National Energy Administration.

Plans exist for a large pilot facility in Örnsköldsvik for experimental projects connected to ethanol production. A new program under the direction of the Swedish National Energy Administration has been funded with 105 million SEK over a 3-year period. Its goal is to develop a technology that can use various types of biological raw materials for the production of motor-fuels. The institution co-operates with consultants in the USA in order to develop, among other things, technologies for the fermenting of grain and using the whole grain, including straw, as the raw material for the production of methanol. One goal of the Energy Administration is to establish a demonstration facility of 50,000 m^3 for the production of ethanol by the year 2004. Concrete plans also exist for the production of ethanol from grain in Gothland and Karlstad.

The National Energy Administration is of the opinion that a major strategy should be the blending of ethanol in petrol and diesel. Even though the number of bio-fuels must be limited, it would be a mistake to focus only on one alternative to fossil fuels. The blending of alcohol and diesel is difficult, but the Energy Administration is putting large resources into solving this problem.

The Energy Administration emphasises that they have reached a milestone when all petrol in the country contains 5 percent ethanol. This will require about 250 000 m^3 of ethanol. The tax regulations must however be changed if this is to be achieved. The motive of the Swedish National Energy

Administration is to use bio-alcohols to reduce the use of fossil energy. The climatic effects are the most important reason for this. Even though today's international agreements (the Kyoto Protocol) possible could be met without the conversion into using bio-fuels, this will be necessary to meet future environmental demands.

Barriers against motor-alcohols from the standpoint of a vehicle producer, by Gunnar Boman, Scania.

Busses account for about 10 percent of the company's capital turnover. Scania is of the opinion that the technical obstacles to the use of motor-alcohols are possible to resolve. Co-ordination and co-operation between the involved actors is of paramount importance. Scania is however not overly enthusiastic about motor-alcohols. Scania is developing many different motors, among these, those which run on mineral diesel (70 years of development), ethanol, natural gas and engines based on fuel cell technology.

There demand for vehicles that run on bio-fuels is quite low for Scania. These vehicles constitute only 0.3 percent of the company's bus sales world wide, but in Scandinavia they account for 16 percent of the buses sold. Sweden, with 420 ethanol-buses, is responsible for this high percentage in Scandinavia. There is a slight increase in the demand for ethanol buses on a world-wide basis. In Europe, it is Italy and Netherlands that have shown the most interest. Scania finds the demand greatest in Latin America (Mexico and Columbia), where ethanol is produced from sugarcane. In Columbia, it is estimated that within 5 to 10 years all busses will be converted to run on non-fossil fuels.

Diesel will remain to be the most important fuel in the foreseeable future, but some ethanol will be used. What fuel (hydrogen or methanol) will be used in fuel-cell motors is not particularly important to Scania. Major investments in development are not undertaken unless there is a potential for long-term demand. The most important concerns for the company are stable prices for raw materials, efficient production and long-term investments.

Barriers against motor-alcohols from the standpoint of a fuel distributor, by Per Olof Lind, Shell.

Shell has entered the field of renewable energy business, which include the following issues:

- wind power
- electricity- and heat- production from biological masses
- solar-power

Work has also taken place with hydrogen for use in fuel-cell motors. Shell has a market-share of 16 percent in Sweden, following Statoil and OK, each of which control 25 percent. Shell has operated a station in Stockholm for alternative fuels for several years. Experiences so far have shown that there are few users of the station. The reason might be that other companies provided this service before Shell. There are today between 50 and 100 FFV-vehicles in Stockholm.

There have been many problems with bio-gas, with regard to distribution as well as practical fuelling. Shell had high hopes, which have not been fulfilled. There have been few or no problems with ethanol. In operating this station, the company has truly experienced that the long-term potential of new fuels is of vital importance. Ethanol 10 percent was launched as a fuel of the future, but was quickly removed from the market.

Shell is involved in the Norrköping project, where ethanol produced from grain will be used to create a 5 percent mixture of ethanol and petrol to be sold in the Stockholm region. It will involve 20 percent of Sweden's petrol market. The decision of the government to allow only one facility for the production of tax-free ethanol is a collective dismissal of further development. Lind considers this an indication that the authorities are uninterested because they fear a loss of income. It might also mean that they feel the reduction of CO_2 through the increased use of ethanol is not cost-efficient. The cost of ethanol as a CO_2-reduction measure is about 2 SEK per kg reduction in CO_2 – emission. Cheaper methods for reducing CO_2 – emission are likely to be found. Energy required for the transport of ethanol also ought to be included in this calculation.

In order for bio-alcohols to enter the market there is a need of public financing measures. It is not likely that such measures can be implemented in any other way than through taxes or possibly through regulations, but until today there are no indications that the Swedish government will allocate further funds to exemptions from tax. The EU mineral oil directive admits a small degree of national freedom on taxation of bio fuels. The government in Sweden has not demonstrated any will to follow this up.

There are some positive elements: Continuously increasing prices on fossil fuels will strengthen the competitiveness of ethanol and other alternatives. Fords plans to introduce Ford Focus FFV in Sweden 2001 might well be the breakthrough for FFVs. This action has to be followed by more manufactures. And lately results from the Örnsköldsviks laboratory-plant in Sweden might encourage scaling-up of motor alcohol production.

Actors outside the stakeholder group network. Approaches to overcome barriers, byEivind Brendehaug, Western Norway Research Institute

He presented the results from the survey answered of the members in the stakeholder group. The survey was distributed and answered by Internet. The results from the survey indicated that the most important actors outside the network are National Parliament, including political parties and the bodies of the European Union. Governmental agencies and bodies at national level and public opinion are also important actors, according to the members of the stakeholder group. The appropriate governmental role in the field of motor-alcohols is to support research and to introduce a temporary tax-exemption. Some members also agreed to introduce a permanent tax-exemption.

He the focused on the important role that companies and organisations play in the shaping of policies through their contact with government authorities. This contact has changed from being structured and formal (the co-operative channel) to more informal and spontaneous contact (lobbying activity). This is a general trend that has developed during the last 20 years. The trend is especially striking in the transportation- and communication-sector. Businesses and organisations in the transportation sector have closer contact with the government authorities than those in other sectors. These businesses and organisations build strong alliances that exercise strong influence when decisions are made.

This is also seen in studies of Norway, where the agricultural, environmental and road sectors have been compared. The road sector appears to be the domain where contact and shared interests between the various parts; car and fuel manufacturers, entrepreneurs, road politicians and bureaucrats, are strongest. Viewpoints not articulated by this coalition of interested parts have little chance of being heard when policy is being determined.

The degree to which bio-alcohols are taken up in discussions between businesses/ organisations and governmental authorities, as well as the views and propositions that are put forth with respect to these fuels, are therefore of great significance.

A Summary of the Debate

- There is a great need for a critical evaluation of all alternative fuels. An optimistic picture has been painted of several alternative fuels whose efficiency is doubtful.

- It appears that the interest for ethanol for busses will continue to exist in future years, partly because it symbolises an interest in the environment on the part of the authorities. This despite that in some years ethanol use will not lead to any substantially better effects on health or the local environment, compared to the use of fossil diesel.

- When the environmental consequences of bio-fuels have been compared with those of diesel, the diesel technology has been much better developed than the inadequately adapted technology for alcohol operation. Theoretical analysis shows that ethanol will produce about half the emission of NOx pollution compared with diesel.

- Questions were raised about why the Swedish Energy Administration focused so little attention on hydrogen as a fuel.

The reason is that they are interested in bio-fuels as a way to reduce the use of fossil energy. It was also noted that relatively little resources were spent on developing methanol as a fuel, considering its potential importance.

- No common international standards exist for cars that can run on alternative fuels. The differing national priorities are obstacles to the establishment of such standards.

- There is a need for changing the EU's mineral-oil regulations to give opportunities to increase the blending of alcohols in petrol. The today's blend-percentage limit (6-7 %) has been chosen arbitrarily.

- The Swedish National Energy Administration has prepared a report for the government concerning the degree to which the dispensations from tax regulations in the production of bio-fuels have actually been utilised. The investigations show that only 40 percent of the dispensations have been utilised. By taking this data into consideration, the income losses for the government are considerably less than earlier estimated.

There was a debate comparing the strategy of blending petrol and diesel with alcohol, versus the use of 100 percent alcohol. Differing opinions were presented:

- Low blending with alcohol would not lead to a wider development of the system. It would not stimulate the development of the vehicles, because today's motors can run on such a mixture. In addition, the distribution system would not evolve, and the consumers would remain unaware of changes in the fuel, because it could be blended without their knowledge.

- There is no contradiction between a strategy for blending and the promotion of pure alcohol. The price-difference between alcohol and petrol/diesel is decisive for the technological development. It is also probable that the use of a certain amount of bio-fuel will become a political goal in the transportation sector.

Some of the critical questions that were raised during the meetings were debated:

- Fuel production costs.

How may the costs of producing bio-alcohols bee reduced? A common energy-market in Europe would make it difficult to introduce more expensive alternative fuels. It is hardly possible to come down to the cost-level of fossil-fuels. But if the law regulates the use of renewable energy sources, the price-difference between the renewable fuels will determine which will be preferred. EU is heading in this direction.

- Economical measures and regulations by governing bodies at national and international levels.

What forms of regulation-strategies might best promote the use of alcohol as fuels? Two strategies were emphasised. Requirements that a certain percent of energy consumed is renewable, and standards limiting the amount of CO_2 produced by motor-vehicles.

- Long-term political aims and programmes.

The absence of a long-term policy for bio-fuels by governmental authorities is an obstacle for the development. A more long-term perspective should be employed.

- Standardisation processes.

There are no common basic-rules for renewable fuels at present that can restrict constructive competition. There is a need for standardisation. For alcohols, this should be an easy task, except for additives. Flexibility is important. The point was made that today's competition between the alternative fuels, is an obstacle for development.

- Competition between alternatives.

We must avoid a "fuel of the year" by setting long-term goals. The official approval of alternative fuels by the transportation authorities would help preventing the tendency towards a "fuel of the year". There is a need for a critical evaluation of new fuels upon their introduction.

- Establish a corporative/cooperative channel with major governing bodies

To what degree are bio-alcohols promoted by varies businesses and organisations in their dealings and dialogues with the authorities? The discrepancies between the official policies of Norway, Finland and Sweden in this respect may be explained by the variably degrees of interest among businesses and organisations

The joint statement from the stakeholder group network as precondition for future work were summarised as:

- Bio-alcohols for vehicles are primarily a long-term strategy for the reduction of CO2.

- There are no major cost-increases for maintenance of vehicles driven by alcohol, compared to fossil fuel.

- It is important to develop both methanol and ethanol as future fuels for vehicles.

- An important strategy is the blending of small amounts of alcohol in petrol/diesel, but pure methanol and ethanol are also relevant.

- Alcohol as a fuel is interesting for both light and heavy vehicles.

8.3.5. The ISAF XIII meeting in Stockholm

The stakeholder group network was highly represented at the thirteenth International Symposium on Alcohol Fuels, ISAF XIII, in Stockholm, 3-6 July 2000. Members of the Nordic stakeholder group network took part in organising this event, as well as presenting the project to the conference participants through a formal paper presentation.250 participants from 29 different countries were taking part in this event. The conference was attended by policy makers, local- and regional authorities including Agenda 21 co-ordinators and local energy planners. Transport companies, fleet managers and other potential and actual motor-alcohol user groups were also present. I addition, the conference functioned as a meeting place for the automotive industry, oil and energy suppliers, researchers, consultants as well as agriculture and forest industries, and farmland and forest owners. The presentation of the stakeholder group network to this extended interest group was important in the dissemination for the project.

8.4. The national network in Norway

Western Norway Research Institute has during the project period participated actively in the Norwegian Bioenergy network. This has functioned as the Norwegian stakeholder group network. The project researchers have taken part in organising the meetings and have contributed at these meetings.

Of particular importance has been to present and discuss issues raised through the Nordic stakeholder network.

Two meetings have been held in this Norwegian network. The first meeting on 23.02.2000 at Hydro in Oslo had 25 participating stakeholders. Large fuel companies (Hydro), ethanol producers (Borregaard), national bio-fuel distributors (Habiol) and policy makers (Ministry for Oil and Energy) and research (University of Oslo, Technical University of Trondheim, WNRI) participated.

The issues raised included the governmental support measures for bioenergy, societal issues connected to the production and use of bio-fuels, marine algae as raw materials for bio-fuel production, and environmental life-cycle assessment of bio-fuels (5% ethanol blend in petrol).

The presentations were made by:

- Elisabet Fjermestad Hagen, Norsk Hydro
- Vera Ingunn Moe, Norsk Hydro

- Ivar Arne Nordrum, Ministry for Oil and Energy
- Jon Strand, Institute for social economics, University of Oslo
- Svein Horn, Institute for biotechnologi, Technical University of Trondheim
- Jostein Søreide/Johanna Øster Hågensen, Norsk Hydro
- Lisa Ringstrøm, Uppsala University
- Britta Kälvesten, Uppsala University

The second meeting on 4.1.2001 also at Hydro in Oslo had 20 participating stakeholders. Large fuel companies (Hydro), bioenergy producers (Energigården Røykenvik), bioenergy organisations (NOBIA), national bio-fuel distributors (Habiol) and research (University of Oslo, WNRI, Stiftelsen Østfoldforskning) participated.

The issues raised included the status of bio-fuels in Europe, feasibility study of bio-fuels in Norway, environmental labelling of energy, resource base and production possibilities for bio-fuels and bio-oils in Norway, barriers to motor-alcohols, and the resolvement of the barriers through stakeholder group networks.

The presentations were made by:

- Elisabet Fjermestad Hagen, Norsk Hydro ASA
- Vera Ingunn Moe, Norsk Hydro ASA
- Gunnar Wilhelmsen, NOBIO, Norsk bioenergiforening
- Helge Stiksrud, Norsk Hydro
- Mie Vold, Østlandsforskning
- Randi Veiberg, SUM, Universitetet i Oslo
- Otto Andersen, WNRI
- Karl Georg Høyer, WNRI

At the last meeting is was concluded that the network would continue to be active, with WNRI continuing to be represented. The main issues from the Nordic stakeholder group network is thus continued after the project is concluded, through the activities of the Norwegian Bioenergy network.

The next meeting in the Norwegian network is a seminar 7-8 March 2001 at the Norwegian Research Council. The aim of this meeting is the preparation of a national research programme on bioenergy including biological motor-alcohols. A topic to be raised at this seminar is research into the national policy conditions for a market penetration of motor-alcohols from Norwegian wood resources.

9. Final conclusions

9.1. National and EU Political Barriers Against Deployment of bioalcohols

National policies are important in creating opportunities or obstacles for an introduction of bioalcohols. In one important aspect the authorities in Norway, Sweden and Finland have taken an important decision in favour of bioalcohols: bioalcohols are exempted for all fuel taxes. In all three countries, however, this tax exemption is most likely to be temporarily. If a market penetration of bioalcohols really takes place, taxes internalising external costs such as road wear and accidents would probably be imposed on bioalcohols. It is probably only the tax component reflecting the lower emissions of CO_2 that also in the long run not would be imposed on bioalcohols. In other words, the bioalcohols have to be competitive to fossil fuels, taxes included, if large scale use of these fuels is to take place. A temporarily tax exemption is though important in order to create incentives for the technology improvements that are necessary to reduce the production costs of bioalcohols. One important barrier in this respect, is the Mineral Oil Directive of the European Union. According to this directive, all fuels are to be imposed with a minimum level of fuel taxes. The three Nordic countries, as well as other countries in the European Union and the European Economic Area, have all evaded this regulation by defining all use of bioalcohols as "pilot-projects". However, as pointed on in this chapter, it is not likely that the European Commission will accept that even regular use of liquid biofuels is defined as pilot projects. The Swedish government, due to its general positive attitude to bioalcohols, is seeking support among other EU members for changing this specific paragraph in the Mineral Oil Directive. And here we are indicating an important difference in the motor-fuel policies of the three Nordic countries: The Swedish authorities have for many years been concerned with motor-alcohol issues. This has not been the case in Norway and Finland. The lack of motor-fuel policies is an important barrier in Finland and Norway. Motor-alcohols are not on the political agenda in these two countries.

The Swedish authorities have spent a considerable amount of money on research related to motor-alcohols in the last decades. Our review of the Swedish policies in this area also revealed that a high number of governmental reports have been produced since 1980. Similar documents are almost non-existent in Norway and Finland. The reason why the Swedish Government became interested in motor-alcohols in the first place was the international oil crisis in the beginning of the 1970s. It wanted to be prepared if new international oil crises were to occur in the future. Later on, since the second half of the 1980s, environmental reasons became the most important argument for the Swedish authorities to support research on liquid biofuels. The set-aside policy of the European Union has created a further incentive to promote production of these fuels (create more jobs in the agricultural sector). In comparison, the Norwegian and Finnish authorities have not been much interested in liquid biofuels. This is especially the case for Norway. Norway is the second largest oil exporter in the world. It does not have any narrow self-interest in promoting or producing liquid biofuels. The governmental research funds for alternative fuels are mostly allocated to research related to the use of natural gas in vehicles – a fuel that Norway is a large producer of. Norway is therefore not concerned about the energy security aspects of using liquid biofuels. We have also seen that the set-aside policy of the European Union does not apply to Norway, further reducing the incentives for the production of liquid biofuels in this country. In Finland there is already an infrastructure for natural gas, reducing the costs for taking natural gas into use in the transport sector. Liquid biofuels is not seen as an option in Finland.

Climate change is the most important driving force for bioalcohols in the long run. We have seen, however, that all the three countries in question stress that their national policies have to be cost effective. International trade with CO_2-quotas is therefore one of the measures that has been given the highest priority in the national climate policies of Norway, Sweden and Finland. None of the three countries have proposed to increase the CO_2-taxes on fuels in order to reduce the emissions of CO_2 from the transport sector. Furthermore, an introduction of liquid biofuels is not seriously considered as a possible climate change measure in the climate change policies of Norway and Finland. The present cost per ton CO_2 reduced is too high compared to other possible climate change measures. The Swedish authorities share this point of view, but believe that this can change in the future. The ethanol produced in the Norrköping plant is listed among the proposed measures that will reduce the emissions of greenhouse gases from the transport sector. At present the Swedish authorities are hesitating to propose a wider use of bioalcohols as a climate change measure. It is also uncertain what will happen with the Norrköping factory after 2003. The Swedish government has granted a tax exemption for this factory only until 2003. It has not decided whether this tax exemption is to continue thereafter. The uncertainty regarding the future tax levels for ethanol production in Sweden makes it too risky for industrial actors to invest time and capital in this field. The lack of stable and favourable conditions for investments in the motor-alcohol field is therefore an important barrier against increased use of these types of fuels in Sweden. However, compared to the situation in Norway and Finland, the Swedish government has done much in order to promote liquid biofuels.

9.2. Barriers in the Production Chains of Wood-based Alcohols

The feedstock costs and the alcohol production costs are important barriers making it difficult to obtain a market penetration for wood-based motor-alcohols. Regarding feedstock, only forestry residues have today an acceptable low price. However, a large proportion of the forestry residues are already being exploited for stationary energy purposes, especially in Sweden and Finland. We see that the biomass resources are open to a number of competing markets. One not yet utilised biomass resource in the Nordic countries is tree residues (branches and stem tops) at clear cuttings.

Biotechnology and genetic engineering are seen as important tools in order to reduce the feedstock costs. One option is for example to use these tools to increase the overall content of carbohydrates in wood and at the same time reduce the amount of pentoses (pentoses are difficult to ferment). Use of biotechnology and genetic engineering in this regard is, however, highly controversial. It could lead to cheaper motor-alcohols and thereby an increased likeliness of market penetration. On the other hand, the use of these tools could make motor alcohols less environmentally acceptable.

If large-scale production of motor-alcohols takes place, it could lead to a more intensified agriculture and forestry as well as changes in landscape. It is therefore important that full environmental impact assessments are carried out for wood-based motor alcohols, in order to illuminate these issues.

Regarding the production of motor alcohols there is a lack of experience with wood-based feedstock. Not much time and capital have been invested in developing more cost-efficient production techniques, compared to what is the case with fossil fuels. Regarding the production of ethanol, there are two different types of techniques in use – the mineral acid production concept and the enzymatic hydrolysis method. The former one has the lowest production costs. The mineral acid production concept can be improved in several ways. At present the different mineral acid techniques either have a too high consumption of mineral acid, too low yield or is too long reaction times. It is believed that these problems can be improved in the coming decade, thereby reducing the production costs. However, in the long run the enzymatic hydrolysis method is believed to be the most promising one. Today one important drawback is the high price of enzymes. Biotechnology and genetic engineering are believed to generate much cheaper enzymes. But as mentioned above, these tools are controversial.

One challenge with methanol production from wood-based feedstock is to reduce the loss of energy and heat in the process. Building combined methanol/power/heat plants would probably reduce the methanol production costs. The lack of experiences in this field has been an obstacle for further developments.

Production of ethanol as a by-product in the pulp industry is already taking place today. The volume of ethanol available for transport purposes from these factories are, however, limited, due to the limited number of such factories.

9.3. Barriers in the distribution chain

It is desirable to integrate motor-alcohols with the existing distribution system for petrol and mineral diesel. The oil companies (or more correctly, the fossil fuel distributors) have to participate constructively in such a process. Using their distribution systems as well as their experience and knowledge regarding motor-fuel handling will imply considerable lower costs than if a distribution system separate of the existing one has to be established.

An introduction of different motor-alcohol qualities will increase the number of fuel qualities on the market, thereby increasing the total distribution costs related to motor-fuel handling. From a cost perspective, the number of motor-alcohol qualities introduced on the market ought to be strictly limited. The optimal solution would be if the motor-alcohol quality could be used for all motor-fuel purposes (for both petrol and diesel engines). This might be the case at one point in the future. If one of the existing fossil fuel qualities could be removed at the same time (most likely one of the petrol fuel qualities), the total number of fuel qualities would remain the same (implying for example that the released storage tanks could be used for the alcohol fuel quality).

Brandberg and Sävbark (1996) estimated that the distribution costs for large scale use of ethanol is approximately 20% higher than the corresponding costs for petrol. For large scale use of methanol they estimated the distribution costs to be 30% higher than for petrol. Brandberg and Sävbark have not made similar comparisons between alcohols and mineral diesel. In the case of substituting mineral diesel with alcohols the extra direct volume-related costs will be higher than when substituting petrol. However, the delivery of fuel takes place directly to the customers (own storage tanks), thereby avoiding extra costs at the petrol stations.

The extra costs related to the distribution chain is an important barrier towards large scale use of (biological) motor-alcohols. In the long run this can be one of the most important barriers, all chains considered. In the short term, however, the barriers in the production chain are more important than the barriers in the distribution chain.

9.4. Barriers when Applying Alcohols in Heavy-duty Vehicles

The experiences with motor-alcohols that have taken place in the Nordic countries (mostly in Sweden) have shown that there are no major technical problems regarding use of these fuels in vehicles. Due to the experiences carried out, a lot of minor technical problems have been solved. The engines in heavy duty vehicles have been adapted to ethanol. New types of additives have been developed. Although the ethanol vehicle technology has improved much, there is still a considerable room for improvements. The heavy duty engines can be optimised even further for alcohol fuels.

The engines in the flexible fuel vehicles are optimised for petrol, the lowest fuel quality. Cheaper and better additives can be developed, and developing spark ignition diesel engines could be an option. The most important barrier to further progress in the alcohol engine technology is the lack of a world market for motor-alcohols. Vehicle producers are not willing to invest much money and time in this field if they do not see a market for these types of vehicles. We have seen that almost all motor-alcohol activities in the three Nordic countries at present take place in Sweden. The Norwegian authorities are very interested in being updated on the motor-alcohol experiences and knowledge that are gained in Sweden – but little interested in spending money themselves in this field. If the authorities in Norway and in other countries, were willing to increase their efforts in the field of motor-alcohols, it would be more likely that vehicle producers (as well as other actors) increase their efforts as well.

Use of alcohol fuels in heavy duty vehicles increase the operating costs for the respective transport companies. In addition, it is more costly to purchase heavy duty vehicles running on ethanol than purchasing corresponding vehicles driving on mineral diesel. The profit margins in transport companies are normally small. They have to avoid extra costs when it is possible. In other words, the extra costs related to the use of motor-alcohols have to be covered by others (i.e., the authorities). This is the case in Sweden today. If these subsidies are removed, the respective transport companies will stop using ethanol as fuel. This will further reduce the incentives for vehicle producers to work with motor-alcohol issues.

One of the most important reasons for taking motor alcohols into use is the lower emissions compared to fossil fuels. In this regard authorities and transport companies have put most emphasis on emission components harmful for the health and the local environment. We have seen that it is likely that the emissions of these substances from heavy duty vehicles will be substantially reduced in the coming years. This can reduce the possibilities of a market penetration of motor-alcohols, given the fact that national authorities seem unwilling to use powerful means to reduce the emissions of CO_2 from the transport sector.

9.5. The stakeholder group networks

An important part of the ALTENER-project has been to identify stakeholder groups involved in creating or resolving the most important barriers to use of wood-based alcohols. During the project period has a stakeholder group network has been set up on a Nordic level (Norway, Sweden and Finland) as well as on a national level in Norway. Besides the participating research institutions (WNRI, Ecotraffic and VTT), the members of the network are transport companies, transport organisations, wood-processing industries and manufacturers of wood-based alcohols, distributors of motor-fuels, and manufacturers of vehicles dedicated for motor-alcohols.

The Nordic stakeholder group network on motor-alcohols has had two seminars for all members and active contact between the meetings on e-mail and by the project web-site. Two meeting has been held in the Norwegian network.

The first seminar identified barriers against deployment of biologically produced alcohols in the transport sector in the Nordic countries. The stakeholder group network includes participants from the whole product chain from production, distribution to users of alcohol, as well as vehicle producers and research institutions. By having all these different types of actors represented in the stakeholder group network, a broad view on the issues and challenges regarding market penetration for motor-alcohols is obtained.

The second meeting continued the identification and also formulation of barriers, and identified strategic actors outside the stakeholder group. Four prepared lectures were held.

E-mail has been used intensive to be in contact with the partners and members of the project between the meetings. The technology has been used successfully to call for meetings and to distribute program and reports, and to get information from the member's work on motor-alcohols.

E-mail has also been used systematically to create information from the members to identify and define barriers for a marked penetration for motor alcohols. A questionnaire to identify important actors and their appropriate role has also been distributed by e-mail.

A quantification of the communication shows that 18 e-mail was sent to the whole network and about 50 e-mails to single members from the project leader. Western Norway Research Institute has received about 150 e-mail from the project partners and network members.

The project web-site is used as an important information channel between the project leader, the partners and the members of the stakeholder group. The web-site gives information of the project, from the meetings (program and report) and presents the members of the network. The web-site address: http://2171.vestforsk.no.

From the activities in the stakeholder group networks during the project period the following preconditions for implementation of bio-alcohols as a major motor-fuel were identified:

- Bio-alcohols for vehicles are primarily a long-term strategy for the reduction of CO_2.
- An important strategy is the blending of small amounts of alcohol in petrol/diesel, before entering into using pure methanol and ethanol.

- Alcohol as a fuel is applicable for both light and heavy duty vehicles.

Some of the critical questions and issues that were raised by the stakeholder group network included:

- Fuel production costs. How may the costs of producing bio-alcohols be reduced? A common energy-market in Europe would make it difficult to introduce more expensive alternative fuels. It is hardly possible to come down to the cost-level of fossil-fuels. But if the law regulates the use of renewable energy sources, the price-difference between the renewable fuels will determine which will be preferred.
- What form of economical measures and regulations by governing bodies at national and international levels are applicable? What forms of regulation-strategies might best promote the use of alcohol as fuels? Two strategies were emphasised; I)requirements that a certain percent of energy consumed is renewable, and II) standards limiting the amount of CO_2 emitted from the vehicles motors.
- Long-term political aims and programmes. The absence of a long-term policy for bio-fuels by governmental authorities is an obstacle for the further development of these fuels as real alternatives to fossil fuels. A more long-term perspective should be employed.
- Standardisation processes. There are no common basic-rules for renewable fuels at present that can restrict constructive competition. There is a need for standardisation. For alcohols, this should be an easy task, except for additives. Flexibility is important. The point was made that today competition between the alternative fuels constitute an obstacle for development.
- Competition between alternatives. A "fuel of the year" attitude is undesirable. This can avoided by setting long-term goals. The official approval of alternative fuels by the transportation authorities would help prevent the tendency towards a "fuel of the year" strategy. There is a need for a more critical evaluation of new fuels upon their introduction.
- Establish a co-operative channels with major governing bodies which could aid in resolving the barriers to increased use of bio-alcohols.

Regarding the *substantial parts* of the project we would in particular draw attention to the following conclusions;

- All major Nordic stakeholders support the use of biological motor-alcohols as important means for the short term reduction of emissions of climate gases from transportation, but also as means in a long term strategy towards a sustainable transport system. However, it should be emphasised that they in an environmental context only consider biological motor-alcohols to serve climate gas reduction purposes. These alcohols are considered neutral or with no considerable effect regarding reductions of other environmental pollutants.
- A short term low-blend strategy is strongly supported by all major Nordic stakeholders,- oil- and fuel-companies, alcohol fuel producers,

motor and vehicle producers, transport companies, etc. Low-blend implies in the current situation a 5-6% blending of biological ethanol in all petrol and diesel fuels, and thus applies both to passenger cars and light and heavy duty vehicles. Such an extensive low-blend strategy for the whole of the Nordic transport fuel market may be achieved within few years. If this is attained there will similarly be 5-6% reductions in emissions of CO_2 from all road transport in the whole Nordic system.

- In a future strategy for higher blends and thus more extensive use of biological motor-alcohols the current (2001) introduction of about 4000 Ford Focus FFV passenger cars on the Swedish market is deemed particularly important. These cars are introduced with the same price as conventional Ford Focus cars, and may run on all blends between 0-100% ethanol. Experiences drawn will be followed up and transferred to the two other countries by participants within the project Nordic stakeholder network. In Norway this will take place through the continuation of the Western Norway Research Institute involvement in a permanent Norwegian stakeholder group, - the Norway Bioenergy network organisation.

Regarding the *procedural parts* of the project attention should in particular be drawn to the following conclusions;

- There are largely positive experiences regarding both the setting up and functioning of the stakeholder group networks, both on the Nordic and the national Norwegian level. The experiences with the Nordic network is particularly interesting. They demonstrate the possibilities there are to connect many different stakeholders together in a common setting and with a common focus on strategies and means to achieve a market penetration of biological motor-alcohols within transportation. Through this it has also been possible to achieve agreement on priority strategies and means and on the tasks to be undertaken by the separate stakeholders in this context. The networks have encompassed as varied a group of stakeholders as major oil-companies from all the three countries, major motor- and vehicle producers, major wood processing industries and biological alcohol producers, transport companies, research institutions, and various interest groups within the subject of bioenergy alternatives. As this has taken place in a setting encompassing three different countries quite new cooperative channels have been established. Both on the Nordic level and within each of the three countries conditions have thus been established for a continued contact and cooperation even after the end of the project. In the Norwegian context this will be undertaken through the Bioenergy network organisation.

- All stakeholders emphasise as a major barrier for a market penetration the lack of clear national goals and political aims regarding the use of biological alcohols as alternatives in transportation. If such goals and aims were established it is emphasised that they all would take part in substantial efforts to achieve a real market penetration. To inspire and oblige the national governments to develop policies in this context may be a task for EU governing bodies. But the stakeholders will also themselves take part in such a process. This may take place through the establishment of formalised cooperative channels and groups between the national governing bodies and some of the more crucial stakeholders within the project network. As an immediate result of the project such an initiative will be taken in Norway through efforts and coordination by the Bioenergy network organisation.

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11. Appendix 1: Members of the stakeholder group network

Below we have given some detailed information about the actors that we have chosen to become members in the Nordic stakeholder group network on motor-alcohols. These members have also expressed their interest in participating in such a stakeholder group network.

A. Swedish members in the Nordic stakeholder group network on motor-alcohols

B.

Swedish Farmers' Supply & Crop Marketing Association (SLR)

Lantmännen

SLR is an organisation for eleven grain and supply co-operatives which are owned by 69 000 farmers.
SLR has a turnover of 10 billion SKr. 10 000 people has their employment in the companies within the organisation or in the administration. 2000 of them work abroad.

The main tasks of SLR are:

- To work for the national and international interests of the Lantmännen co-operatives.
- Support the business of the cooperation.
- Develop and run national and international business through completely or partly owned companies.
- Work for that the Swedish arable land will be used in a optimised way.
- Initiate and carry out research and implement the results in practice.
- Agroetanol AB is a subsidiary company to Lantmännen and they are currently building a plant outside Norrköping for production of ethanol. The capacity will be 50.000 m^3 ethanol and 45.000 tons of feed stuff per year based on 135.000 tons of wheat.

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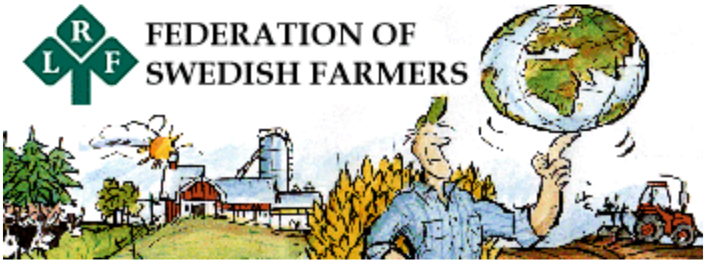
Federation of Swedish farmers (LRF)



Federation of Swedish farmers (LRF) is the interest and industry organisation for Swedish farmers, forest owners and the agricultural co-operative movement. LRF´s aim is to create the conditions for efficient, market oriented and competitive companies. By advancing the economic interest of farmers and developing rural communities, the conditions are also created for promoting and satisfying social and cultural interests. Membership of LRF is designed to provide influence, profitability and fellowship.
LRF-Group is represented at almost 150 places in Sweden, organised in 24 county associations and approximately 15 subsidiary companies.

Key figures	**1997**
Turnover, million SKr	1547,0
Result, million SKr	4,5
Numbers of employees	2664

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Schenker-BTL AB

Schenker-BTL AB has a turnover of approximately SEK 8.5 billion and is part of one of the largest European networks for land transport. Schenker-BTL has a well-developed network of subsidiaries and associated companies in Sweden and sister companies in the rest of Europe. In Sweden alone, Schenker-BTL are represented in 70 locations. This provides the customer with a good market coverage and time-table controlled deliveries. The company has 4,300 employees.

Schenker-BTL now has around 42,000 customers and handles over 15 million consignments of goods and parcels every year. This corresponds to just over 62,000 consignments per working day.
With advanced traffic and information systems, high quality requirements, environmental expertise and functional logistics centres at ten locations around Sweden, Schenker-BTL AB and its subsidiaries take an active part in making our customers more competitive.

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Swedish Association for Public Transports

SLTF is the interest organisation for public transport operators in Sweden. SLTF´s task ist to improve the conditions for public transports and its competitiveness. SLTF work mainly with bench marking, information and to influence the public opinion. They also support development of business and market. An important area is to look after public transports interests in traffic politics. SLTF is a member of UITP, International Association of public transport.

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The Swedish Bioalcohol Development Foundation (SSBU)

The Swedish Bioalcohol Development Foundation (SSBU) was founded in 1983 and is based in Örnsköldsvik. The goal then was to develop the production and use of ethanol within Swedish industry as well as transportation and the name of the foundation was Swedish Ethanol Development Foundation (SSEU). Today SSBU supports both ethanol and methanol based on biomass.

The Foundations Principals are:

Örnsköldsviks Kommun
Jämtlands läns energi AB
Skellefteå Kraft AB
Svensk Etanolkemi AB
Akzo Nobel AB
MoDo Paper
Borregaard/Kemetyl
Aga Gas AB
Chematur Engineering AB
Hifab
Scania Buss AB
LRF Lantbrukarnas Riksförbund

Name:	Per Carstedt
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The Swedish Shell Group

The Swedish Shell group is part of The Royal Dutch/Shell Group of Companies. The work is co-ordinated in the European organisation SEOP, Shell Europe Oil Products. The business includes import and refining of crude oil and import and marketing of oil- and chemical products. The sales is organised in a net of service stations all over Sweden and also via a number of completely owned subsidiaries. Shell also provides direct sales and technical support to large industries and large consumers.

Shell today is not a traditional oil company but an energy company. Besides motor fuels they also supply gas, district heating, electricity and biogas.

Launched in October 1997, Shell International Renewables is the fifth core business (not that Shell are new to renewables; they have been active in forestry for over 18 years and the first solar research started in the 1970's). Setting up this new business marks a major step for the Group based on our commitment to sustainable development. Over the next five years the Group will invest more than half a billion US dollars into the development of renewable resources. The initial focus is in three areas: solar power, biomass energy, and forestry, and they are currently exploring wind power projects to enter the market.
Renewable sources are expected to provide between 5% and 10% of the world's energy within 25 years, perhaps rising to 50% by 2050. With the focus on renewable resources, the Group is taking another step in shaping its portfolio of energy capabilities to supply anticipated world demand in a sustainable and economically viable way.

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Appendix 1

Chalmers University of Technology

CHALMERS GOTEBORG UNIVERSITY

Physical Resource Theory

Physics and Engineering Physics – Chalmers University of Technology

Physical Resource Theory is a multidisciplinary research department conducting research and education within a number of areas connected to sustainable development and complex systems.
The department offers education, both at the undergraduate and the graduate levels.
Chalmers University of Technology assets 100 miljon SEK for environmental research. At the department for Physical Resource Theory a new professorship in Sustainable Industrial Metabolism will be installed.

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Scania

Scania is one of the worlds leading manufacturers of heavy trucks, buses and engines. Scania of today is a truly global corporation, operating in about 100 countries, with approximately 95 percent of unit sales outside Sweden. Scania has a total of about 23,500 employees, about 10,500 of them in Sweden. A further 14,000 or so people work within Scania's organisation in a number of independent importers and service workshops.

Mission statements
Scania's mission is to supply its customers with vehicles and services related to the transport of goods and passengers by road.

Business areas
The core of Scania's operations is the development, production and marketing of trucks for heavy transport work and buses and coaches for more than 30 passengers.

Strategy
Scania's operations concentrate on heavy transport vehicles.

Group Management
The Executive Board within Scania's Group Management aims to achieve a more efficient management and follow-up.

Research & development
One of the reasons for Scania's success is a corporate culture that is based on always being one step ahead of competitors.

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Busslink

Busslink is a new Swedish bus company. It started 1999 when SL Buss AB and Näckrosbuss AB were united. Busslink is the second largest bus company in Sweden with 5 500 employees.. They offer regular traffic in the area between Boden in the North and Jönköping in the South. They offer charter traffic to all over the world.

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B. Finnish members in the Nordic stakeholder group network on motor-alcohols

VTT Building and Transport

VTT Building and Transport can provide various tools and methods for facilitating decision-making in traffic sectors at European, national, regional, and local level. Research fields are e.g. development and assessment of transport policies, optimisation of various transport policy measures, development of transport forecasts, scenarios and other future-oriented issues, and assessment of environmental impacts of traffic, such as emission calculation, air quality episode research, environmental impacts of road maintenance and traffic noise studies, conduction of strategic environmental assessments (SEA).

Special ALTENER2 issues

- Assessment of environmental impacts of traffic, especially emission inventories

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JPI Process Contracting Oy

JPI Process Contracting Oy (JPI) is an international contractor executing projects for process industries, partly based on proprietary technologies. During the last few years JPI has executed projects in e.g. China, France, Spain, Sweden and Finland. JPI's services cover the following aspects of an industrial project:

- engineering
- delivery of equipment and materials
- civil works
- erection and installation works
- training of operation personnel
- start-up of the plant
- project management

Special ALTENER2 issues

- Planning of fuel alcohol plants

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Fortum Oil and Gas Oy (formerly Neste Oy)

Fortum Oil and Gas Oy manufactures products and offers services to both retail consumers and company clients. As an oil company Fortum Oil and Gas Oy manufactures all of the most important petroleum products for use by traffic, industry and energy production. As a manufacturer of chemical products, Fortum Oil and Gas Oy focuses primarily on adhesive resins and coatings. The energy business encompasses natural gas, liquefied gases, heat generation and sales as well as solar and wind energy systems.

Special ALTENER2 issues

- Use of methanol in MTBE production
- Owner of a fuel delivery company (Neste Service Stations, 255 in Finland)

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C. Norwegian members in the Nordic stakeholder group network on motor-alcohols

Borregaard

Borregaard is a chemicals company with 20 production units in 12 countries. The company has 2,600 employees and operating revenues for 2000 is estimated to total NOK 6 billion. Borregaard is a member of the Orkla Group, one of Norway's largest companies.
The company's core areas consist of speciality chemicals, fine chemicals and ingredients.

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Norsk Hydro

Norsk Hydro ASA is an industrial company based on the use of natural resources, with the aim of meeting needs for food, energy and materials

Hydro Energy is a division of Norsk Hydro ASA, and produce, market and trade power, natural gas, NGL, oil- and oil products. The products are mainly available to the professional energy market, through sales to public and private enterprises and trade in the organised energy markets. Hydro Energy do business from offices in Norway, Sweden, UK, Belgium and Germany.

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Western Norway Research Institute

WNRI is a non-profit foundation, established as an independent research institute in 1985. The institute is part of Norway's national research system, and has a close co-operation with the Regional College of Sogn og Fjordane. WNRI employs a staff of about 25. WNRI carries out R&D work and other studies on commission for the public sector, industry, and research councils. The key research areas are in the fields of information technology, environmental research and society and industry. The research staff represents various scientific areas such as social subjects, organisation subjects, technology subjects, the (liberal) arts, economics, and natural science.

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Bergen College

HØGSKOLEN I BERGEN

Bergen College is a state institution of higher education, established August 1994 by merging of six former independent colleges in Bergen. Some of the former colleges are more than a hundred years old, as some are from the 1990's. The total number of students is about 4500 and academic and administrative staff 470. The professional education programmes are of 3 to 4 years' duration. The College offers programs of study in three main areas: Engineering Education - number of students 1300, Health and Social Sciences - number of students 1360, and Teacher Education - number of students 1840.

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12. Questionnaire to the members of the stakeholder group network

1. Identifying important actors in the field of motor-alcohols

Below we have listed five main categories of actors that are important to involve when overcoming barriers in the field of motor-alcohols. We ask you to list important actors within each category that either have considerable activities in the area of (biological) motor-alcohols or that can contribute in creating opportunities and removing obstacles for a market penetration of motor-alcohols. List only actors in your own country (or actors that at least have activities in your own country). Do not list actors that already are included in the Nordic stakeholder group network.

A) Alcohol producers:

B) Fuel distributors:

C) Vehicle manufacturers:

D) Research institutions:

E) Ministries and governmental agencies/bodies:

F) Others (actors that do not fit into the categories above):

Supplementing comments:

2. The relative importance of different actors in the field of motor-alcohols

a) Below we have presented a more detailed list of different types of actors than we did in question 1. We have also included some non-Nordic actors/institutions. We want your opinion of the relative importance of the different types of actors in contributing to overcoming barriers towards use of biological motor-alcohols in heavy duty vehicles. Mark with a 1 for the actor that you believe has the greatest influence on market penetration for motor-alcohols, 2 for the second most important actor, and so on.

Type of actor	**Relative influence on market penetration**
Heavy duty vehicle producers	
Bus companies	
Lorry companies	
Federations of transport companies	
Farmers/ National federation of farmers	
Forest owners/ National federation of forest owners	
Forest industry	
Alcohol producers	
Fuel distributors/Oil companies	
National Parliament, including political parties	
Governmental agencies and bodies at national level	
Local and regional authorities	
The bodies of the European Union (Commission, Parliament and the Council of Ministers)	
Research institutions	
Environmental organisations	
Public opinion	
International Energy Agency (IEA)	
Others (please specify):	

b) Explain why you believe that your "top-five" actors are the most important ones in removing barriers and creating opportunities for motor-alcohols (only a few lines are needed):

3. The importance of politics and bureaucracy

a) From your point of view, which Ministries (in your country) are the most important ones in creating opportunities (and obstacles) for motor-alcohols? List until 5 Ministries, with the most important one listed first:

1.

2.

3.

4.

5.

Supplementing comments:

b) From your point of view, which governmental bodies and agencies at national level (besides Ministries) are the most important ones in creating opportunities (and obstacles) for motor-alcohols? List until 5 governmental bodies/agencies, with the most important one listed first

1.

2.

3.

4.

5.

Supplementing comments:

c) From your point of view, what is the appropriate governmental role in the field of motor-alcohols (mark with an X in the box that reflects your opinion)?

	Agree	**Disagree**	**No preference**
No particular governmental role in this area – it is up to the market to decide the opportunities for motor-alcohols			
Support research related to motor-alcohols			
Introduce a temporary tax-exemption for motor-alcohols			
Introduce a permanent tax-exemption for motor-alcohols			
Impose higher taxes on fossil fuels than today (in order to make motor-alcohols competitive)			
Subsidise domestic production of biological motor-alcohols			
Covering the extra costs for transport companies using motor-alcohols			

Supplementing comments:

13. Appendix 2: Questionnaire to potential members of the stakeholder group network

1. Identifying important actors in the field of motor-alcohols

Below we have listed five main categories of actors that are important to involve when overcoming barriers in the field of motor-alcohols. We ask you to list important actors within each category that either have considerable activities in the area of (biological) motor-alcohols or that can contribute in creating opportunities and removing obstacles for a market penetration of motor-alcohols. List only actors in your own country (or actors that at least have activities in your own country). Do not list actors that already are included in the Nordic stakeholder group network.

A) Alcohol producers:

B) Fuel distributors:

C) Vehicle manufacturers:

D) Research institutions:

E) Ministries and governmental agencies/bodies:

F) Others (actors that do not fit into the categories above):

Supplementing comments:

2. The relative importance of different actors in the field of motor-alcohols

c) Below we have presented a more detailed list of different types of actors than we did in question 1. We have also included some non-Nordic actors/institutions. We want your opinion of the relative importance of the different types of actors in contributing to overcoming barriers towards use of biological motor-alcohols in heavy duty vehicles. Mark with a 1 for the actor that you believe has the greatest influence on market penetration for motor-alcohols, 2 for the second most important actor, and so on.

Type of actor	Relative influence on market penetration
Heavy duty vehicle producers	
Bus companies	
Lorry companies	
Federations of transport companies	
Farmers/ National federation of farmers	
Forest owners/ National federation of forest owners	
Forest industry	
Alcohol producers	
Fuel distributors/Oil companies	
National Parliament, including political parties	
Governmental agencies and bodies at national level	
Local and regional authorities	
The bodies of the European Union (Commission, Parliament and the Council of Ministers)	
Research institutions	
Environmental organisations	
Public opinion	
International Energy Agency (IEA)	
Others (please specify):	

d) Explain why you believe that your "top-five" actors are the most important ones in removing barriers and creating opportunities for motor-alcohols (only a few lines are needed):

3. The importance of politics and bureaucracy

c) From your point of view, which Ministries (in your country) are the most important ones in creating opportunities (and obstacles) for motor-alcohols? List until 5 Ministries, with the most important one listed first:

1.

2.

3.

4.

5.

Supplementing comments:

d) From your point of view, which governmental bodies and agencies at national level (besides Ministries) are the most important ones in creating opportunities (and obstacles) for motor-alcohols? List until 5 governmental bodies/agencies, with the most important one listed first

1.

2.

3.

4.

5.

Supplementing comments:

c) From your point of view, what is the appropriate governmental role in the field of motor-alcohols (mark with an X in the box that reflects your opinion)?

	Agree	**Disagree**	**No preference**
No particular governmental role in this area – it is up to the market to decide the opportunities for motor-alcohols			
Support research related to motor-alcohols			
Introduce a temporary tax-exemption for motor-alcohols			
Introduce a permanent tax-exemption for motor-alcohols			
Impose higher taxes on fossil fuels than today (in order to make motor-alcohols competitive)			
Subsidise domestic production of biological motor-alcohols			
Covering the extra costs for transport companies using motor-alcohols			

Supplementing comments: