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"Biodiesel in heavy-duty vehicles in Norway – Strategic plan and vehicle fleet experiments"

Final report from European Commission ALTENER-project XVII/4.1030/Z/209/96/NOR

By
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Summary:
This report presents the results from a pilot action project on biodiesel use in bus companies in Norway. Biodiesel is a renewable resource fuel that can be used in diesel engines without major difficulties. Hence biodiesel has a major advantage compared with other alternative fuels. The use of biodiesel in Norway is however very limited. The project has identified the most important barriers to increased use of biodiesel in heavy-duty vehicles in Norway. In addition to increasing the knowledge of the major barriers, the project has resulted in a handbook for use of biodiesel in bus companies and their national branch organisation.
The national barriers are identified through an analysis of the national strategies for alternative fuels, and biodiesel in particular. Barriers in the branch organisation for the bus companies are also identified. Vehicle fleet experiments with biodiesel usage in two bus companies have been conducted in the project. Barriers connected to driving and starting in cold ambient temperatures and technical, environmental and health aspects of biodiesel and use of additives are identified. Barriers in the production of the biodiesel raw materials rape and turnip rape (colza) can be illustrated by the fact that it is only with the use of a high-technological intensive agricultural system that it is possible to replace a significant portion of the fossil autodiesel use in Norway. In addition, the reduction of greenhouse gas emissions with a transition to biodiesel will only be marginal when the N_2O –emissions from the agricultural production of the raw materials (rape and colza) are included in the calculations.

Other publications from the project :

Lundli, H. E. (1998): *Handbook in biodiesel use* (In Norwegian: *Håndbok for bruk av biodiesel i tyngre kjøretøyer. Barrierer mot bruk av biodiesel i tyngre kjøretøy i Norge og mulige tiltak for å overvinne disse*.) Rapport 20/98. Vestlandsforsking, Sogndal, 1998.
Lundli, H. E. and M. Simonsen (1998): *Biodiesel test driving in Sogndal and Førde.* Notat 17/98. Vestlandsforsking, Sogndal, 1998.
Andersen, O. and H. E. Lundli (1998): *Biodiesel in heavy-duty vehicles –Strategic plan and vehicle fleet experiments.* The Liquid Biofuels Newsletter, No. 12, p 7-9, June 1998. Bundesanstalt für Landtechnik, Wieselburg, Austria.

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Preface

This report presents the results of a pilot action project under the European Commission DG XVII ALTENER –programme. The additional financing is from the Norwegian Dept. of Transport and the Norwegian Water Resources and Energy Administration. In addition to this report a handbook for bus companies and their branch organisation on the use of biodiesel is written (In Norwegian). The handbook presents barriers to increased biodiesel use in heavy-duty vehicles and possible actions to overcome these barriers. The vehicle fleet experiments with biodiesel are reported separately and in more detail than in this final project report.

The final report is edited and partly written by researcher Otto Andersen, who also has been responsible for co-ordinating the project. The report is based on contributions from several other researchers at Western Norway Research Institute; Morten Simonsen has written the chapter on organisational barriers. He also documented and evaluated the field experiments in the early part of the project. Hans-Einar Lundli wrote the chapter on national policies on biodiesel. Most of the documentation of the fleet tests is also based on his contributions. In addition, he authored the handbook on biodiesel use, which is published in Norwegian language, separately from this report. Eivind Brendehaug has written the chapter on barriers in the production of biodiesel.

The project was carried out in co-operation with the bus-companies Sogn Billag and Firda Billag, and the branch organisation National Federation of Transport Companies. We express our gratitude to Jarle Molde, Halvard Holm, Johannes Barsnes, Anders Fardal, Brynjulf Vines, Nils Agnar Svedal and Oddvar Nondal in Sogn Billag for a most productive co-operation during the project. Similar thanks goes to Bjørn Nordberg, Jon Austrheim, Bjarne Aasen, Bjørn Grytås and Arild Hansen in Firda Billag. In addition we owe thanks to Terje Hansen and Dankert Freilem in National Federation of Transport Companies, Einar Teslo in the biodiesel distribution company Habiol plus Arnstein Neset and Thor Eriksen in AutoLast A/S (MAN-Norway) for their participation in the project.

Heinrich Prankl and Manfred Wörgetter at Bundesanstalt für Landtechnik in Wieselburg, Austria, have provided help in identification of the main barriers to biodiesel use. Werner Körbitz at the Austrian Biofuels Institute has contributed with information on various aspects of biodiesel properties and use.

We would also thank Bård Stenberg of Norske Fina AS and André Demoulin of Fina Research S.A. for both financial contribution and the sharing of biodiesel-knowledge.

Erling Holden co-ordinated the early phases of the project. Karl Georg Høyer has headed the project.

Sogndal, January, 1999

Karl G. Høyer

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Summary

The project *”Biodiesel in heavy-duty vehicles in Norway - strategic plan and vehicle fleet experiments”* was carried out with financing from the ALTENER-programme in the European Commission DGXVII. Additional financing was obtained from the Norwegian Dept. of Transport and the Norwegian Water Resources and Energy Administration

Biodiesel is a renewable raw material-based fuel, which can be used directly in diesel engines without larger modifications to the engines and vehicles. Hence biodiesel has a great advantage compared with other alternative motor-fuels. Biodiesel has been available for several years in Norway, but the use of the fuel has been minimal. This project has focused on the use of biodiesel in busses and other heavy-duty vehicles in Norway. The goal has in addition to generate knowledge of the *barriers to biodiesel*, also been to develop a model for *strategic planning* that can be used to overcome the main barriers.

As a background for developing a strategic plan for increased use of biodiesel, it has been important to generate knowledge of the *national barriers* for, and what national strategies exists for alternative fuels in general and biodiesel in particular. This is obtained through interviews with key personnel within national authorities and interest organisations. The barriers that the institutions consider the most important in relation to increased use of biodiesel are identified through the project. Barriers and strategies for overcoming the barriers within the branch organisation (National Federation of Transport Companies) for the bus companies are also included.

In order to generate more knowledge of the barriers, several fleet experiments with biodiesel have been conducted in the project. In connection with these, it has been important to identify barriers when driving and starting in cold winter temperatures and technical, environmental and health aspects of fuel- and additive-usage. The barriers in all the three company levels administration, driver and workshop personnel are identified through interviews in connection to the fleet experiments. The knowledge of the barriers is disseminated to the bus companies in the form of inputs into a company strategy. This is

facilitated through the development of a handbook for use of biodiesel. In the handbook the *barriers on company-level* are identified, and in addition possible strategies that the bus companies can utilise to overcome the barriers.

Through a separate sub-study the most important *barriers connected to production of biodiesel* based on the energy-crops rape and turnip rape (colza) has been identified.

National barriers
In order to identify national barriers, interviews were conducted with stakeholders from Ministry of Transport and Communications, Norwegian Directorate of Public Roads, Ministry of Finance, Ministry of Environment, Norwegian Pollution Control Authority, Ministry of Petroleum and Energy, Ministry of Agriculture, Norwegian Petroleum Association, Habiol, and The Federation of Transport Companies.

The identified barriers among national stakeholders are of four different categories:

1. *Price/production costs*. Biodiesel can not compete with mineral diesel which is exempt from autodiesel tax (coloured diesel) which bus companies use today.
2. *Emissions*. Biodiesel has increased NO_x -emissions compared to mineral diesel.
3. *Land-consuming production*. As a consequence of the very land-demanding production of biodiesel from energy crops, the amount of biodiesel production possible in Norway is very limited.
4. *Winter properties*. Biodiesel has worse winter properties than mineral diesel.

In addition, three barriers were identified within The National Federation of Transport Companies:

1. Lack of a strategy in the area of alternative fuels.
2. Lack of a proactive attitude towards central authorities in the area of alternative fuels.
3. Effort to maintain cheap autodiesel-exempted mineral diesel for busses.

Barriers in the different company-levels
Various barriers were identified on the three different company-levels:

1. *Management*: The price of biodiesel is too high. Maintaining the tax-exemption for mineral diesel for busses is important. The vehicle manufacturers are reluctant to give full approvals for biodiesel use.
2. *Drivers*: Biodiesel gives reduced engine-power.
3. *Workshop*: More work from more frequent oil- and filter-change. Uncertainty regarding the composition and health effects of additives.

Barriers connected to driving and starting in cold winter temperatures.
Biodiesel does not work as well as mineral diesel in cold winter temperatures. This implies that special precautions must be taken when operating in cold weather. The use of special additives in winter-biodiesel represents potential environmental and health-related problems. Several of the most common winter-additives in use today are carcinogenic and exhibit potential pollution threats in the case of spillage and accidents.

Barriers in the production of biodiesel
The project has attempted to visualise the most important barriers connected with the production of biodiesel in three different scenarios for future of agricultural systems in Norway. The three different systems are:

1. An organic agricultural system
2. A traditional agricultural system
3. A high-technological intensive agricultural system

It is only within the scenario of a high-technological intensive agricultural system that it is possible for biodiesel to replace a significant portion (>15 %) of the autodiesel consumption in heavy-duty vehicles. Major environmental barriers are however connected with this scenario. Problems from the excessive application of genetically engineered plants, use of chemicals for pesticide control and artificial fertilisers are some examples. For the two other scenarios for agricultural systems, the most important barriers are unfavourable climatic conditions and limited land for agricultural production of rape and turnip rape.

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. The focus is on the use of biodiesel in heavy-duty vehicles in Norway, particularly in relation to starting and driving in low ambient temperatures.

The main aim of the project has been to develop a model for strategic planning as a tool to achieve a broader deployment of biodiesel as fuel for vehicles. The strategic planning covers both a national branch organisation and two companies. At both these levels the model is based on identifying key barriers working against a deployment of biodiesel, and analysing the necessary means to overcome these. Such barriers might be of economic character, but are also related to organisational, technical, environmental and health problems.

In order to support the development of strategic planning as a tool for deployment, the project has included field tests on the application of biodiesel in busses within the vehicle fleets of two large, regional transport companies. This has been in accordance with the ALTENER priority area of "Establishment of local plans for the development of renewable energy sources". In this context, it has been of particular importance, as emphasised, to gain experiences on problems caused by starting and driving under low ambient temperatures, and about technical, environmental and health issues connected to this fuel and the additives being applied under such extreme driving conditions.

The result of the project is published in a user handbook, and distributed to different levels of the Norwegian Federation of Transport Companies (TL) being members of this organisation. A material has thus been produced that can be used in information actions and seminars/courses. This has placed the project within the context of the ALTENER priority area of "Extension or creation of infrastructures for training information and pre-feasibility evaluations with regard to renewable energies".

The main objectives of the project has been:

- To develop a strategic plan for deployment of biodiesel as fuel in Norwegian heavy-duty vehicles. The strategic plan covers both a national organisation-level and a company-level.

- To execute experiments on applying biodiesel as a fuel in busses and trucks within the vehicle fleets of two large transport companies. In this context to gain experiences particularly related to starting and driving in low ambient temperatures and about technical, environmental and health issues related to this fuel and the additives used.

- To analyse major aspects of the production of biodiesel based on the oil plant rape and turnip rape (colza).

2. Methodology

The project has been divided in five main parts:

- Part 1 National strategies
- Part 2 Company strategies
- Part 3 Field Experiments
- Part 4 Special winter barriers: Additives
- Part 5 Production chain analysis

2.1. National strategies

The aim of this part of the project was to develop a strategy for a major national transport organisation (Norwegian Federation of Transport Companies - TL) necessary to achieve a deployment of biodiesel as fuel in heavy-duty vehicles. This strategy is related both to a national policy-level (external) and to the transport companies being members of the organisation (internal). The project work has been based on the following issues:

- What are the key barriers against introduction of biodiesel as a major fuel in Norwegian busses and trucks? What sort of external strategies can the Norwegian Federation of Transport Companies (TL) adopt to overcome these barriers?

- What are the key barriers on an organisational level, that is within TL? What sort of internal strategies can be applied to overcome these barriers?

- How can TL work to inform and motivate its member companies on applying biodiesel?

This part of the project was carried out by performing a study of the national policies on biodiesel. In addition to TL, it was desirable to interview several other national authorities and interest organisations to obtain a wider knowledge of the policies today on biodiesel. In addition to this, relevant governmental documents were reviewed.

The interviews were carried out by telephone between October 6th and Christmas 1997. This period of time coincided with a change of government in Norway, but since the interviews mainly focused on issues of a descriptive character, the change of government would only influence the findings of this study to a small extent.

Two sets of questions were made, one for the interviews of the national governmental agencies, and one for the interest organisations. The questions were sent to the different institutions some days before the interview, so that the persons interviewed had time to obtain information from other persons in their institution if they wanted to. Later on the interviewed persons received a transcript of the interviews so that they could adjust their answers if desirable.

2.2. Company Strategies

The aim of this part of the project has been to develop strategies for two larger transport companies necessary to achieve a deployment of biodiesel within these companies. The strategies are related to different parts of the two companies' organisational structure. The project work has been based on the following issues:

- What are the key barriers within the different transport companies against a substantial application of biodiesel in their busses and trucks? What are the most pressing barriers at different levels in the company structure, for instance in the garages, among the drivers or within the management?

- What experiences within the involved transport companies can be drawn from relevant vehicle fleet experiments abroad, particularly in Austria? How can the use of foreign experts and employees to guide at the different levels in the companies be carried out? What can be learnt through this?

- What are the major infrastructural requirements for the vehicle fleets to function with biodiesel? How can these requirements be addressed and become parts of the company strategies?

As a mean to obtain and disseminate a wider range of knowledge of barriers to biodiesel use, *seminars, workshops and study trips* were arranged during the project period. Experts from the Austrian partner Bundesanstalt für Landtechnik, as well as representatives from the bus companies and the vehicle manufacturers, participated at these seminars and workshops.

2.3. Field experiments

The aim of this part has been - through actual field experiments with use of biodiesel in different heavy-duty vehicles - to gain experience on important technical, environmental and health barriers possibly limiting the prospects of such application. This is important empirical knowledge-input to the strategic parts of the project. The project work in this part has been based on the following issues:

- What are the key technical, environmental and health barriers against applying biodiesel in busses and trucks? What are the particular problems in connection with starting and driving in low ambient temperatures? To what extent can such problems be overcome through efforts at the garage-level, through the use of different fuel blends and/or additives? What other technical, environmental and health problems might be connected to such fuel and additives usage?

- What experiences can be gained in these contexts from field experiments with biodiesel in different busses in the transport companies?

- How can we one learn to address these issues precisely and adequately by connecting foreign experts from Austria to the project?

The field experiments were evaluated using the two techniques *participatory observation* and *interviews*. During the preparation for the tests, several meeting with the bus companies and the vehicle manufacturer were arranged. At these meetings the bus companies at all the three levels; 1)management, 2)driver and 3)workshop were given the necessary knowledge to perform the tests. The method used by the researchers in this phase was participating in a *constructive dialog* with the personnel at the bus companies. In connection with the field tests the researchers participated as observers in some of the runs. During the test periods and shortly after, meetings were arranged with the personnel in order to evaluate the results of the tests. Interviews with all three company levels were carried out.

2.4. Special winter barriers: Additives

Due to the cold climate in Norway, it has been important in the project to analyse the use of additives to improve the winter properties on biodiesel. A literature study was carried out where the main focus was on winter additives. Other types of additives and approaches for improving biodiesel was however also included. It was important in this study to identify the potential and actual barriers associated with the use of these different biodiesel performance-enhancing approaches.

2.5. Analysis of the production chain

The aim of this part has been to analyse main aspects of the production of biodiesel based on the oil plant rape and turnip rape (colza). This has been restricted to a Norwegian context. Aspects that were covered were resource potentials and limitations, besides the technical, economical and environmental merits and barriers. This part of the project has been based on the following issues:

- What are the main aspects of the production chain for biodiesel based on the oil plant rape and turnip rape in Norway?
- To what extent are there important barriers against a deployment, other than those identified in the use analysis and field tests?

This part has been analysed using a scenario-approach. The task has been to identify the main barriers against a replacement of a substantial quantity of mineral diesel with rape seed methyl ester (RME) produced in Norway in heavy-duty vehicles in Norway in year 2005 within the following three scenarios:

- An organic agricultural system
- A traditional agricultural system
- A high technology and intensive agricultural system

This included an analysis of to what extent there are important environmental impacts related to these three different agricultural systems for producing the oil seed rape and turnip rape.

3. National strategies for biodiesel

This chapter starts with a description of the sub-study of national policies on biodiesel in Norway. Subsequently, an analysis of barriers to biodiesel introduction on a national level, and possible strategies the national branch organisation for bus companies (TL) can use to overcome these barriers is presented.

3.1. National policies on biodiesel

When studying the possibility of introducing biodiesel as a fuel in busses and trucks run by transport companies in Norway, it is important to understand how national authorities think and act in this area. In addition, the attitudes of relevant interest organisations to alternative fuels in general, and biodiesel in particular, is important to map in order to get an idea of the likelihood of increased biodiesel use in Norway. This knowledge would facilitate the development of a strategy that transport companies can adopt to overcome these barriers.

Hence, this study has three objectives:

1. Identify which national authorities and interest organisations are working in the area of fossil fuels and alternative fuels, and what activities the different institutions have in this regard.
2. Describe the national policies on liquid fuels and possible changes. Investigate to what extent there is a coherent policy for introducing biodiesel and other alternative fuels between the different national authorities.
3. Identify which barriers the different institutions consider to be the most important against increased use of biodiesel.

3.1.1. Approach used when analysing national policies

To fulfil the objectives of the study, interviews with national authorities and interest organisations were conducted. In addition relevant governmental documents were reviewed.

The interviews were carried out by telephone between October 6th and Christmas 1997. This period of time coincided with a change of government in Norway, but since the interviews mainly focused on issues of a descriptive character, the change of government would only influence the findings of this study to a small extent.

Two sets of questions were made, one for the interviews of the national governmental agencies, and one for the interest organisations. The questions were sent to the different institutions some days before the interview, so that the persons interviewed had time to obtain information from other persons in their institution if they wanted to. Later on the interviewed persons received a transcript of the interviews so that they could adjust their answers if they wanted to.

3.1.2. Interviewed institutions

Representatives from the following seven governmental departments and agencies were interviewed:

- Ministry of Transport and Communications
- Norwegian Directorate of Public Roads
- Ministry of Finance
- Ministry of Environment
- Norwegian Pollution Control Authority
- Ministry of Petroleum and Energy
- Ministry of Agriculture

These seven governmental departments and agencies were picked because they are conceived to be the most important governmental bodies in planning and executing national fuel policies. Of the seven governmental bodies, there are five ministries and two directorates. The Norwegian Pollution Control Authority is a directorate placed under the Ministry of Environment. Similarly, the Norwegian Directorate of Public Roads is placed under the Ministry of Transport and Communications. The Ministry of Finance is included because it is an important actor in planning fuel tax policies. The Ministry of Agriculture is only to a small extent involved in shaping and executing national liquid fuel policies. However, if biodiesel production based on Norwegian agricultural products is to take place in the future, the Ministry of Agriculture will have a role to play. It was therefore decided to also conduct an interview with a representative from the Ministry of Agriculture.

The representatives interviewed are section leaders in their respective ministries and agencies. Strictly speaking it is therefore not correctly to say that the above listed *institutions* have been interviewed. For example, the opinions of the Ministry of Environment are strictly speaking the opinions of the *Minister* of Environment. It is therefore important to emphasise that in this study there has been conducted interviews with *representatives* from the mentioned ministries and authorities.

The study will also to some extent focus on *policies* in the area of fuels and alternative fuels. The interviews will therefore be supported with a review of various governmental documents relevant to the issues in question.

Furthermore is if of interest to map the attitudes of some relevant interest organisations to alternative fuels in general, and biodiesel in particular. Representatives for the management of the following three interest organisations were interviewed:

* Norwegian Petroleum Association
* Habiol
* The Federation of Transport Companies

The Norwegian Petroleum Association is the interest organisation for the oil companies in Norway. Habiol is a producer of various biological oil products and it also is an importer of biodiesel. The Federation of Transport Companies is the interest organisation for the bus companies.

3.1.3. The Role of the different governmental agencies on the area of fuels

Several governmental agencies are involved in planning and implementing national policies on the area of fuels and alternative fuels. In this chapter a short presentation is given of the main duties the seven interviewed governmental bodies have in this area. As previously mentioned, these seven agencies are the most important ones in planning and implementing national fuel policy. However, it has to be emphasised that it is the cabinet itself that is the ultimate policy maker. Of course, the policies decided upon by the cabinet have to be within the scope of the decisions done by the Parliament.

The presentation of the main duties the seven governmental bodies have in the area of fuels is solely based on information given by the respective representatives interviewed.

Ministry of Transport and Communications and Directorate of Public Roads

The Ministry of Transport and Communications (SD) is the executive agency to the Government in the areas of transport and communications. It deliberates and implements actions in these two policy areas.

The Ministry of Transport and Communications is the governmental body that has the main responsibility for dealing with issues related to alternative fuels, including policy making. If other ministries receive requests in this field, they normally dispatch them further to the SD.

The SD has since 1991 spent about 10 mill NOK each year on projects related to alternative fuels and development of environmental friendly technology within the transport sector. This is the main activity of SD in the field of alternative fuels. It is the SD that allocates the funds, but it is the Norwegian Directorate of Public Roads that administer them. As previously mentioned, the Norwegian Directorate of Public Roads is a directorate placed under the SD. It is the directorate that possesses the technical expertise on the area of alternative fuels, while the work of the SD is more policy-oriented.

A whole range of different types of alternative fuel projects has received support from these funds. The main focus has been on the use of natural gas in buses, and several tests on busses running on natural gas has been conducted in the cities of Trondheim and Haugesund since 1991.

The Norwegian Directorate of Public Roads and the Norwegian Pollution Control Authority (SFT) are responsible for implementing the directives flowing from the Auto/Oil Programme of the European Union. Norway, as a member of the European Economic Area, has to implement these directives. The Norwegian Directorate of Public Roads is responsible for implementing the directives related to emissions from vehicles, while the

Norwegian Pollution Control Authority is handling directives related to the quality of petrol and diesel. The two governmental agencies participate in the respective working groups within the Auto/Oil Programme.

Ministry of Finance and Customs

Within the limits set by the Government and the Parliament, the Ministry of Finance plans and implements economic policy, co-ordinates the work on the state budget and is responsible for collection of taxes and customs duties.

The Ministry of Finance and Customs has a very important role in the area of fuels, since it has the main responsibility for shaping and implementing the Government's fuel tax policies. Although the Ministry of Finance is responsible for the tax system on fuels, other Ministries have some influence on how the tax system is shaped. Especially the Ministry of Environment and the Ministry of Transport and Communications play a role in deciding any changes of the tax system.

The Directorate of Customs and Taxes, a directorate placed under the Ministry of Finance and Customs, is the governmental agency that in fact collects the various taxes in Norway, fuel taxes included. In addition, it supports the Ministry of Finance in shaping the details of the fuel tax system.

Ministry of Environment and the Pollution Control Authority

The Ministry of Environment has the main responsibility for planning and implementing the Government's environmental policy. However, it is important to emphasise that all ministries are to take environmental aspects into consideration when planning and implementing policies in their respective areas of responsibility.

The Ministry of Environment is working with issues related to fuels and alternative fuels only at a superior level. Its activity in this area is mainly connected to an evaluation of possible measures to reduce the emissions of carbon dioxide and other greenhouse gases, in order to fulfil the Kyoto commitments. In addition, the Ministry continually considers possible measures to reduce local pollution, especially in the largest cities. Again, the Ministry evaluates possible measures within the transport sector.

The Norwegian Pollution Control Authority (SFT) is placed under the Ministry of Environment. As previously mentioned, the SFT together with the Norwegian Directorate of Public Roads, is responsible for implementing the directives flowing from the Auto/Oil Programme of the European Union. SFT is handling directives related to the quality of petrol and diesel.

The Norwegian Pollution Control Authority is working with several projects related to electric cars. One of the projects SFT has supported is the development of the electrical car CityBee. From time to time SFT carries out studies of the most cost-effective measures to fulfil given environmental targets, for example for the emissions of NO_X and VOC. Measures within the area of fuels are among the measures evaluated.

Ministry of Petroleum and Energy

The Ministry of Petroleum and Energy (OED) is responsible for planning and implementing the Government's oil policy, natural gas policy and energy policy. Norway is a large oil- and natural gas producer. OED is therefore highly engaged in issues related to fuels. However, the work of OED is to a large extent concerned with the production of energy (included fossil fuels) and stationary energy use. Matters related to mobile energy use are mostly taken care of by other ministries, foremost the Ministry of Transport and Communications. It has to be emphasised, however, that OED participates in inter-ministerial meetings on mobile energy use, and thereby it influences the policy making in this area.

There are two exceptions from the general rule that OED is little engaged in matters related to mobile energy use. Firstly, OED is continually considering the possibilities of increasing domestic use of natural gas. One possible application is natural gas in the transport sector. And secondly, OED, as all other ministries, use each year a considerable amount of money on supporting and initiating various research projects. Projects related to mobile energy use receive support from OED from time to time. Lately, OED has contributed with financial assistance to the development of the electrical car CityBee.

Ministry of agriculture

The Ministry of Agriculture is responsible for planning and implementing the Government's agricultural policy. It is to a great extent engaged in work on stationary biomass energy use. The Ministry of Agriculture is not, however, engaged in activities related to liquid fuels and alternative liquid fuels. However, some of the regional departments of the Ministry of Agriculture have contributed with financial assistance to a biodiesel project that the company Habiol is running. The goal of the project is to establish a production system for biodiesel in Norway.

If biodiesel production based on Norwegian agricultural products is to take place in the future, the Ministry of Agriculture will have a role to play in planning and implementing the national fuel policy.

3.1.4. National policies on liquid fuels

National policies on fuels (included biodiesel) influence the likeliness of biodiesel deployment in heavy-duty vehicles. The present chapter gives a brief overview of the Norwegian policies on fuels. The presentation is divided into three parts: First, the most important *principles* in Norwegian policies on fuels are presented. For example, which factors ought to determine the level of fuel taxes, according to the opinions of the Government? In the second part of the chapter, some aspects of current fuel policies are presented. This part will concentrate on describing the actual level of taxes on the different types of fuel in Norway today. Finally, an analysis of whether national climate change policy can create an opportunity for increased biodiesel use in Norway is included.

Principles in Norwegian policies on fuels

The Government is of the opinion that taxes imposed on fuels are to reflect the real socio-economic costs of their use. The fuel taxes are to be related to 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. 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 the equal for all fuels, included alternative fuels (Finansdepartementet, 1998a).

The tax component related to environmental costs ought to vary according to the environmental properties of the different fuels. Fuels with fewer effects on local environment due to lower emissions of for example sulphur and NO_X, are to have a lower environmental tax than fuels with a higher impact on the local environment. Similar, fuels with less impact on the global environment (emissions of greenhouse gases), ought to have a lower tax level than fuels with higher impacts on the global environment. For example, biodiesel can in principle be exempted from the carbon dioxide tax, when the net emissions of CO_2 from biodiesel use is considered to be zero.

A differentiation of the environmental fuel tax component for 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.

The Government is willing to subsidise research projects on alternative fuels and sometimes also the first period of commercial use. However, they are not in favour of long-term subsidising of alternative fuel use. In the long run alternative fuels have to be competitive to traditional fuel. The taxes imposed on fuels are to reflect the real socio-economic costs of their use. Alternative fuels will have taxes at a lower level than traditional fuel, provided that the fuels are more friendly to the environment (Miljøverndepartementet, 1998).

Current fuel policies: Taxes on petrol and mineral diesel, and possible changes

The fuel taxes on mineral diesel are lower than the fuel taxes on petrol. This is not in accordance with the general principles described in the previous section. Mineral diesel use cause as many accidents and as much road wear as petrol use. According to the principles, mineral diesel use and petrol use should be imposed with the same tax per kilometre driven. Since the consumption of mineral diesel per kilometre in general is lower than the corresponding petrol consumption, the tax level per litre mineral diesel ought in fact to be higher than the tax level per litre petrol (Finansdepartementet, 1998a).

The reason why mineral diesel has a lower tax level per litre than petrol, is that the Government wants to reduce the costs for industry and trade. Most other Western countries also have a lower tax level on mineral diesel than on petrol, exactly for the same reason.

The tax level on petrol and mineral diesel in Norway for the years 1995-1998, is presented in Table 1 and Table 2 below.

Table 1 *Taxes on non-leaded petrol, 1st January (NOK per litre)*

Petrol	1995	1996	1997	1998
Petrol tax	3,57	3,64	4,02	4,11
CO_2-tax	0,83	0,85	0,87	0,89
Sum Petrol	4,40	4,49	4,89	5,00

a) Only marginal amounts of leaded petrol is sold in Norway today.
Source: NPI (1998)

Table 2 *Taxes on mineral diesel, 1st January (NOK per litre)*

Mineral diesel	1995	1996	1997	1998
Auto diesel tax	2,87	2,93	3,35	3,43
CO_2-tax	0,42	0,43	0,44	0,45
Sulphur tax (≥ 0,05 % S)	0,07	0,07	0,07	0,07
Sum mineral diesel (< 0,05 % S)	3,28	3,36	3,79	3,88
Sum mineral diesel (≥0,05 % S)	3,36	3,43	3,86	3,95

Source: NPI (1998)

Today the difference between the petrol tax and the auto diesel tax is 0,68 NOK per litre. In addition the CO_2 tax imposed on mineral diesel is only half of the CO_2 tax imposed on petrol.

Recently an inter-ministerial committee has 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.[1] However, the committee also emphasises that the uncertainty regarding these estimates is considerable. The Ministry of Finance is in the near future to consider an equalisation of the petrol- and auto diesel taxes. The Government will return to this issue when putting forward the state budget proposal for the fiscal year 1999 (Finansdepartementet, 1998a).

The CO_2 tax imposed on petrol and mineral diesel has increased somewhat in the last years (see Table 1 and Table 2). However, the increase is marginal and is done only in order to adjust for the inflation. The Government has recently suggested that these taxes are kept on the same level as today in the next years to come (i.e., only adjusting for inflation) (Finansdepartementet, 1998a).

The Government has instead given priority to extending the basis for the CO_2-taxation. Today about 60 percent of the CO_2-emissions in Norway is being CO_2-taxed. The Government has suggested that CO_2-emissions not being CO_2-taxed today, is to be imposed with a CO_2-tax of 100 NOK per ton. In comparison the CO_2-tax imposed on petrol and mineral diesel is equivalent to 384 NOK and 190 NOK per ton CO_2 , respectively. The Government stresses that it is important to have a cost-effective climate change policy. A fully cost-effective climate change policy implies that all CO_2 emissions are imposed with an equal CO_2 tax. The Governments strategy is therefore to extend the basis for CO_2-taxation, and not to increase the tax level on petrol and mineral diesel. The next step thereafter for the Government is to consider the possibility of introducing climate change related taxes on greenhouse gas emissions other than CO_2 (Finansdepartementet, 1998a). Such emissions are not being “CO_2-taxed” today. And finally, the Government will consider buying CO_2-quotas internationally as well as obtaining CO_2-credits through Joint implementation projects. If these measures are not sufficient or if buying CO_2-quotas is too expensive, the Government will consider to further increase the level of the CO_2-taxes. Hence, a substantial increase in the CO_2-tax imposed on petrol and mineral diesel is not very likely in the near future.

[1] 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.

Current Fuel Policies: The tax-exemption for busses in public transport

The auto diesel tax was introduced in 1993. It replaced the tax per kilometre driven that all mineral diesel vehicles in Norway previously had to pay. Busses in public transport were, however, exempted from the auto diesel tax. In practical terms this was arranged by having to types of mineral diesel - the blank mineral diesel which is fully taxed, and the coloured mineral diesel which is tax-exempted. Hence, busses in public transport has since 1993 consumed mineral diesel that is considerable cheaper than what other mineral diesel vehicles are allowed to use. In 1998 bus companies pays about 2,10 NOK per litre mineral diesel while the taxed diesel costs about 6,40 NOK per litre[2].

However, the Government has recently suggested removing the tax-exemption for buses. If the proposal is passed by the Parliament, it is to take effect from January 1st 1999. The transport companies are to be fully compensated for the increased costs the first two years. After two years, it will be up to the county authorities to decide whether the bus companies should continue to be compensated or not. The reason why the Government put forward the proposal of removing the tax-exemption for busses is to create an incentive for decreasing the fuel consumption in bus companies. An other reason for the proposal, is to remove the discriminating effect of this tax exemption on the competitiveness of other modes of transport such as maxi-taxis compared to busses (Finansdepatementet, 1998a).

The former Government (Labour-government) did also put forward similar proposals. Each time it was turned down by the Parliament. If the Labour party stick to its previous positions in this matter, there is a majority in the Parliament supporting the tax proposal. The Parliament is to vote on this matter at the end of the present year (1998). Discussions within the Committee of Finance indicate that the proposal will pass the Parliament. However, it is likely that the companies will be fully compensated for the increased costs in indefinite time, and not only for the first two years as the Government has proposed (Transportforum, 1998).

[2] These prices include 23 % V.A.T.

Current Fuel Policies: Alternative fuels

The most important governmental activity in the area of alternative fuels is the fund on alternative fuels and environmental friendly technology within the transport sector. This fund is, as previously mentioned, administrated by the Norwegian Directorate of Public Roads. It started in 1991 and is to continue in the years ahead. The fund policy is in accordance with the principal that the Government is willing to subsidise research projects on alternative fuels.

Several alternative fuels are more or less tax-exempted today. Use of gas (LPG, LNG and CNG) as a fuel in vehicles is fully tax-exempted today (Finansdepartementet, 1998a). However, only a few vehicles use gas as a fuel in Norway today. Most of these vehicles are combined petrol- and gas driven. In addition a few gas busses are running in the cities of Trondheim and Haugesund. These busses are part of two research projects. The tax exemption for 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 former Government (the Labour Government) has, however, previously proposed to introduce a gas tax internalising the external costs related to accidents and road wear. In addition the former Government proposed to introduce a CO_2-tax for gas. The emissions of CO_2 from gas are at about the same level as the CO_2 emissions from petrol use and mineral diesel use. These proposals did not, however, receive a majority vote in the Parliament. The present Government is not willing to consider an introduction of a gas tax or a CO_2 tax for gas until a decision regarding the future level of the petrol tax and the auto diesel tax is made. If the number of vehicles using gas is increasing substantially, it is more likely that the Government will propose such taxes (Finansdepartementet, 1998a). Otherwise, the revenues from fuel taxes will be reduced. This is also in accordance with the principal that the Government is not in favour of long-term subsidising regular alternative fuel use.

Use of electric cars is not imposed to fuel taxes due to the fact that electricity is the energy source. The external environmental costs for this type of vehicle are low. 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).[3] However, the number of electric cars in Norway is only marginal. The Government is not willing to consider introducing fuel taxes for electric cars until the number of such vehicles has risen 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.

Biodiesel is fully tax exempted (except VAT[4]) today. The Parliament decided in 1992 that biodiesel is to be exempted for the auto diesel tax. The Ministry of Finance is to consider whether the tax exemption is to continue in the years to come (Finansdepartementet 1998a). The use of biodiesel 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 biodiesel. Biodiesel is 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 biodiesel use is often considered to be zero. According to the fuel principles of the Government, biodiesel is therefore to be exempted for the CO_2-tax. As previously seen, this is also the case.

Is there a national goal in the area of alternative fuels?

The Government has not formulated any goal in the area of alternative fuels. Furthermore, the interviews clarified that no new actions to promote use of alternative fuels are planned by the Government. The representative from the Ministry of Environment expressed, however, a wish to work out a strategy for future use of alternative fuels in Norway and where one decides which alternative fuels to promote. The Ministry of Agriculture has so far not had any activities in the field of biodiesel, and it has no plan for such activities in the future either. However, each year the Ministry of Agriculture gives some financial support to various projects, and biodiesel project proposals will be given the same consideration as other project proposals. As mentioned previously, the agricultural authorities have in the recent past supported a biodiesel project at Habiol.

[3] 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.
[4] All alternative fuels are taxed with V.A.T.

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 are no specific inter-ministerial committees on the area of fuels. However, there are at least two inter-ministerial committees where issues related to fuels could be discussed - one committee where the national climate change policy is discussed, 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 will look at a specific problem. However, so far no such committee has had as an objective to evaluate the policy of fuels and alternative fuels.

The representative from the Norwegian Pollution Control Authority (SFT) emphasises that there is a substantial potential to improve the co-ordination between SFT and the Norwegian Directorate of Public Roads. Therefore, SFT has taken an initiative to a closer co-operation between the two governmental agencies. In addition, SFT wishes a closer co-operation with the Directorate of Customs and Taxes. A similar closer co-operation between the Ministries above the three directorates mentioned would then be necessary, according to the representative from SFT.

3.1.5. Biodiesel and climate change policy

One main reason for introducing biodiesel as a fuel is to reduce the emissions of carbon dioxide from the transport sector. In the present section a short presentation is given on the Norwegian climate change policy. This will be done in order to consider whether climate change policy might promote an introduction of biodiesel in Norway or not.

In December 1997 binding international climate change commitments were agreed upon in Kyoto, Japan. According to the Kyoto protocol, the industrialised countries have to reduce their emissions of climate change gases with at least 5 percent by the period 2008-2012 compared to the 1990-level. The Kyoto commitments are differentiated between the industrialised countries (Miljøverndepartementet, 1998).

Norway is allowed to increase its emissions of climate change gases with 1 percent in 2008-2012, compared to 1990. If no new measures against climate change are adopted by the Parliament, the emissions of these gases are expected to increase with 23 percent in the described period. In April 1998, the Government presented a plan on how to fulfil the Kyoto commitments. If the plan is adopted by the Parliament, the expected growth in emissions will be reduced from 23 percent to about 14-17 percent. Although if all proposed actions are implemented, there will still be a large gap between the national Kyoto commitment and the expected emissions of greenhouse gases in 2010. However, the Government emphasises that it later on will propose further actions in order to fulfil the Kyoto agreement (Miljøverndepartementet, 1998).

The Government emphasises that 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 of 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. It is planned that the disagreements regarding the carbon trading regulations are to be settled at the fourth Conference of the Parties (COP4) in Buenos Aires, in November 1998. Until these regulations are in place, accurate estimates of the price per ton CO_2 is difficult to make. However, the Government considers it to be likely that the costs will be lower than most other domestic climate change actions. Hence, the Government is of the opinion that parts of the Kyoto commitments can be fulfilled abroad.

The Government has in the climate change plan briefly discussed alternative fuels, biodiesel included. However, measures related to alternative fuels in order to fulfil the Kyoto target are not seriously considered. The interviews with representatives from national authorities, revealed that biodiesel use is not seen as a cost-effective measure against climate change. Hence, a whole range of other climate change measures is considered to give CO_2 reductions at a much lower cost than a substitution of mineral diesel use with biodiesel.

The result of the Kyoto agreement is that the industrialised countries, Norway included, have to substantially increase their efforts to curb the emissions of greenhouse gases. CO_2-emissions from biodiesel use is considered to be zero. A strengthened national climate change policy could therefore imply a promotion of biodiesel use in Norway. As previously seen, however, biodiesel use as a measure against climate change is not considered by the Government. The Government emphasises cost-effectiveness in its climate change policy. It is therefore likely that a considerable proportion of the national obligation is going to be fulfilled abroad. Furthermore, the domestic climate change measures, which are the Government's priority in a short term, are: 1) an extension of the CO_2-tax to include all CO_2-emissions, and 2) to introduce further actions/taxes towards the emissions of other greenhouse gases than CO_2. Climate change related actions towards fuels or alternative fuels will not be considered in a short term, according to the Government.

3.1.6. The role of three interest organisations

The Government, the Parliament and the governmental agencies are not planning and implementing policies totally on their own. To some extent the views of actors such as interest organisations are taken into consideration when planning policies.

In this chapter a short presentation is given of the three interest organisations interviewed in this study: 1) Habiol, 2) the Norwegian Petroleum Association and 3) the Norwegian Federation of Transport Companies. Habiol is the only importer of biodiesel in Norway today. One of its goals is to produce biodiesel in Norway, based on Norwegian raw materials. Habiol can therefore be said to advocate the interests of the *biodiesel producers*. The Norwegian Petroleum Association (NPI) is the interest organisation for the oil companies in Norway. NPI can therefore be said to advocate the interests of the *fossil fuel producers*. And finally, the Norwegian Federation of Transport Companies can be said to advocate the interests of the (heavy vehicle) *fuel consumers*.

In addition to give a short presentation of the three interest organisations and their work on alternative fuels, a brief description of the overriding alternative fuel policy of these organisations is given. The content of this chapter is solely based on the conducted interviews. The barriers against biodiesel use, as seen by these actors, are presented in Chapter 3.1.7.

Habiol

Habiol is a stock holding company established in 1992. Agricultural companies own most of the stocks. Habiol is localised in Jaren, Hadeland. The main activities of Habiol are to produce and import various biological oil products from biological raw materials. In the area of biodiesel, Habiol is continually evaluating the possibilities of producing biodiesel in Norway based on Norwegian raw materials. Until date, Habiol has produced only small quantities of biodiesel (laboratory scale production). Estimates done by Habiol indicate that the production cost for biodiesel, based on Norwegian rape or turnip rape, is too high to be a commercial option. Therefore, Habiol is evaluating the possibilities of producing biodiesel from other sources than rape and turnip rape. Today, all biodiesel distributed by Habiol is imported, mainly from Germany and Belgium.

When Habiol emerged as a company in 1992, some governmental agencies and the oil companies looked upon the biofuel initiative as something obscure. In 1993 both the Norwegian Directorate of Public Roads and the oil company Statoil produced critical reports about biodiesel which Habiol strongly reacted on. But in the last years, no oil company or governmental agency has worked against biodiesel, according to Habiol.

In 1993 Habiol and the Norwegian Bioenergy organisation (NoBio) tried to influence the Committee of Finance in the Norwegian Parliament to take a stand on taxes on biofuels. They succeeded as the Minister of Finance himself, then Sigbjørn Johnsen, argued for a full tax exemption on biofuels. It passed the Parliament without any thorough consideration in the bureaucracy in advance, according to Habiol.

Habiol has the intention to use the existing distribution system for fossil fuels in Norway. Therefore, in 1992 they contacted several oil companies in Norway to check out if there was any interest to co-operate with Habiol in this field. All companies were more or less interested. Hydro and Hydro Texaco were the most interested, and Habiol decided to co-operate with them. As a result of this co-operation, Hydro and Hydro Texaco are companies promoting the use of biodiesel in Norway today, according to Habiol. Late summer 1997 the first commercial biodiesel filling pump in Norway was opened. Recently Statoil started to distribute biodiesel in

Stockholm. Therefore, in the opinion of Habiol, the oil companies are getting more and more involved with biodiesel issues.

Norwegian Petroleum Association (NPI)

The Norwegian Petroleum Association is the interest organisation for the oil companies operating in Norway. It is working “downstream”, i.e., working with issues ranging from the refineries to the filling pump station. It does not work with the oil production itself (“upstream” issues). NPI is working a lot with the Auto/Oil Program of the European Union. In that regard it is often in contact with especially the Ministry of Environment and the Norwegian Pollution Control Authority, but also the Ministry of Oil and Energy, Ministry of Trade and Industry, Ministry of Finance and Ministry of Transport and Communications.

NPI is very little involved in issues related to alternative fuels. It has not contributed to any research projects on alternative fuels. NPI studies from time to time the socio-economic impacts of various alternative fuels, and it has worked out a policy on this field. According to NPI, environmental policy has to be based on cost-effectiveness. All fuels, including alternative fuels, have to be taxed according to the same principles. For example, the tax reflecting the cost of road wear must be the same for all fuels. A car driving on biodiesel contributes to the same amount of road wear as a car driving on traditional fuel. NPI has no plan to increase their effort in the field of alternative fuels, but they will continue to be updated on the development in this area.

Federation of Transport Companies (TL)

The Federation of Transport Companies is the interest organisation for the bus companies at the national level. Its job is to create a better understanding of the interests of bus companies among national decision-makers. In addition, it is an employers’ organisation. Important parts of the decision-making regarding public transport in Norway is, however, decentralised to the regional level. There is a regional TL department in most of the 19 counties (“fylker”) in Norway, and it is the regional TL department that works towards the regional authorities.

The environmental aspects of bus transport is only one of many issues TL works with. It is of the opinion that the authorities are underestimating the positive environmental effects of bus transport in Norway, especially in comparison to how the authorities look upon the environmental effects of passenger transport by railway. Bus companies do not, however, compete with railways for passengers, in fact they are not allowed to. They compete with the railway for resources from the national budget. In the last years, TL therefore has spent money on research projects on environmental issues, including alternative fuels, to document that bus transport in cities is much more environmental friendly that its reputation. In addition TL tries to influence the national policy in their field by having regular meetings with the committee of transport and communication in the Parliament. They do this through lobbying work in relation to the political parties and by having contact with relevant Ministries, especially the Ministry of Transport and Communications, the Ministry of Finance and the Ministry of Trade and Industry.

TL as an organisation has no plan to increase their involvement in projects related to alternative fuels. If, however, the Government decides to have a more clear strategy regarding alternative fuels, then TL is prepared to respond to such signals, but only if they are supported by financial incentives.

3.1.7. The most important barriers against biodiesel use identified by the different institutions

In the interview study the representatives from the different institutions was asked to name the most important barriers towards biodiesel use in Norway, in their opinions. This was done in order to improve the understanding of how these institutions view biodiesel use in Norway. However, as emphasised at the outset of this report, it was strictly speaking not the institutions themselves that was interviewed. Therefore, the barriers described below reflect the opinions of the representatives working in the different governmental agencies. The exceptions are Habiol, NPI and TL - here representatives for the management were interviewed. Their answers can therefore be considered to be the opinions of these institutions.

Price/Production costs

The barrier seen as the most important one by the different institutions, is the price of biodiesel compared to fossil fuel. Both the environmental authorities, the transport authorities and the Ministry of Finance, emphasise that the price of a fuel must reflect its socio-economic costs. Although alternative fuels in general will have a lower tax level due to better environmental characteristics, they could still be too expensive and therefore should not be introduced. The Norwegian Petroleum Association agrees that the price of a fuel has to reflect its socio-economic costs. It emphasises that vehicles driving on alternative fuels are exposing the road for as much wear as other vehicles and are as often involved in accidents as vehicles running on traditional fuel. The part of fuel taxes that reflect these types of socio-economic costs should therefore be at the same level for all fuels, according to NPI.

The idea to increase the taxes on ordinary fuel substantially in order to make some alternative fuels more attractive, is not conceived as a realistic scenario among the national authorities interviewed. Habiol argues that the taxes on fuel today are too low and that they do not internalise the external effects. The green taxes imposed on fuels ought to be increased substantially. It is the carbon tax in particular that has to be risen, according to Habiol. NPI, on the other hand, emphasises that the taxes imposed on petrol more than internalise the external costs of its use. It is fiscal reasons for having high taxes on petrol in Norway, according to NPI. NPI is of the opinion that the taxes on mineral diesel seem to be in accordance with the external costs of its use. It is also important that the fuel taxes not differ too much from the most important trading partners, according to NPI.

Some of the alternative fuels (such as CNG and electricity) require special vehicles constructed for that purpose. The Ministry of Environment points to the fact that Norway has no vehicle production and therefore the government cannot influence the development of such vehicles. NPI is also in favour of subsidising research projects on alternative fuels, but when it comes to regular use of a specific alternative fuel, NPI is sceptical to subsidisation. The taxes on LPG in Sweden in the 1970s were low in order to motivate the use of it. It triggered substantial investments in LPG infrastructure, and soon after that the use of LPG levelled off. Subsequently when the government increased the taxes on LPG to cover the loss of fiscal income due to the transition from ordinary fuel to LPG, the result was that the use of LPG dropped. To avoid such useless investments it is necessary that governments have a long-term policy when promoting new fuels, according to the NPI.

Habiol and the Norwegian Federation of Transport Companies point to the low price of fossil diesel for bus companies as a barrier to introduction of biodiesel to these vehicles. The price of coloured fossil diesel is less than 2,50 NOK per litre for the bus companies, compared to nearly 7 NOK per litre for other vehicles. None of these organisations are in favour of a removal of the tax exemption for bus companies, but they both argue that bus companies which decide to use biodiesel have to be compensated for their increased costs in one way or another.

Emissions

Several governmental agencies are of the opinion that biodiesel leads to higher emissions of NO_X compared to re-formulated diesel and alternative fuels such as CNG and electricity. The Norwegian Pollution Control Authority therefore is a bit sceptical to use of biodiesel in urban areas. Although biodiesel has lower emissions of sulphur dioxide compared to traditional diesel, SFT stresses that the relevant comparison is with re-formulated diesel, and thereby it is not obvious that biodiesel has lower emissions of SO_2. The Ministry of Transport and Communications claims that it is debatable how environmentally friendly this fuel is compared with the alternatives. Habiol, on the other hand, is of the opinion that it is possible to reduce the emissions of NO_X and other local pollutants from biodiesel use by modifying the diesel engines and developing a new catalyst. According to the Norwegian Federation of Transport Companies, the largest environmental effect would be accomplished if biodiesel is used on old buses. TL claims that new busses with CRT-filters installed have very low emissions. TL is of the opinion that a conversion to biodiesel on such busses will not result in substantial reductions in emissions.

SFT has a positive attitude to biodiesel because of the low emissions of carbon dioxide from this fuel. The CO_2 effect would probably be larger than the negative effect of increased NO_X emissions, according to SFT. Before substantial increase in the use of biodiesel is to occur in Norway, it is necessary to demonstrate that the total environmental effects are improved in comparison with re-formulated diesel. A life cycle approach must be used in such studies. Introduction of biodiesel could be one of many measures to combat climate change. However, the strategy of the government is to implement the most cost-effective measures, and in this respect SFT believes that biodiesel could be one of the more expensive measures. The Norwegian Petroleum Association has estimated that biodiesel as a climate change measure would have a cost of 1000 NOK per ton CO_2 reduced, which is substantially higher than the level of the carbon tax in Norway today.

The Ministry of Petroleum and Energy said that emissions from biodiesel illustrate a general problem: alternative fuels do not always have only positive environmental effects. Although some emissions are reduced, others again often rise compared to fossil fuels. An introduction of biodiesel in Norway implies an evaluation of the global environmental effects against the local environmental effects, according to OED.

Land consumption/ Production Volume Limitations

The majority of the interviewed institutions mention the requirement of large land consumption for biodiesel production as an important barrier. Due to the high area requirement, the amount of biodiesel possible to produce is limited. The Ministry of Environment emphasises the importance of a stable supply of fuel, which could be a problem in the case of biodiesel. Today one is too dependent of the level of agricultural production within the European Union, according to the MD. The Ministry of Agriculture informs that the agricultural area in Norway is small when compared to countries in the European Union, and that there is no set-aside land policy in Norway. In fact, the situation is the opposite - the policy is to protect agricultural land against alternative use. According to Habiol, production of biodiesel in Norway has to be based on several raw materials, not only rape and turnip rape. Otherwise, the amount of biodiesel possible to produce in Norway would be too small. The Federation of Transport Companies is of the opinion that it is unrealistic to use large areas for biodiesel production in Norway. Therefore they see only two, possible three solutions to obtain biodiesel of some amount in Norway; 1) import it from Europe or 2) biodiesel production based on used cooking oils. A third possible solution, according to TL, is to use other raw materials than rape and turnip rape. The Ministry of Environment is more positive to biodiesel production based on used cooking oils than biodiesel production based on rape or turnip rape. In addition, the Ministry of Environment emphasises that it could represent an ethical problem to use agricultural land to produce non-food products.

The Ministry of Finance is not necessarily against using large land areas for biodiesel production in Norway. It presupposes, however, that the biodiesel production is more profitable than alternative use of the land.

Winter Properties

The Ministry of Environment and the Ministry of Transport and Communications believe that problems with biodiesel use in cold temperatures could represent a barrier. The drivers are very quality conscious when it comes to the performance of their vehicles, according to the SD. If there is a problem associated with driving on biodiesel during winter times, the drivers would be reluctant to use biodiesel. MD emphasises that using diesel always includes how to deal with cold starting problems. It is therefore strategically important that for example bus companies in the beginning create a market for biodiesel use, so that not each single lorry driver has to decide whether to use biodiesel or not. One has a similar pedagogical problem in the area of winter tyres in Norway (with or without spikes), according to the MD. Also the Federation of Transport Companies conceives the winter properties of biodiesel as a barrier.

Technology

None of the institutions indicate any major technological problems regarding the use of biodiesel. Only minor adjustments have to be done with the engine system to be able to drive on biodiesel. In fact, biodiesel has an advantage in that ordinary diesel vehicles can use it. Other types of alternative fuels, such as CNG and electricity, demand special vehicles which today is expensive to produce, and in addition, substantial investments are necessary to establish the right infrastructure. Biodiesel, on the other hand, can be distributed in the same way and with the same infrastructure as traditional fuel. Habiol claims, however, that there still is a potential for improvements on the engine side. Especially a catalyst to decrease the NO_X emissions from biodiesel has to be developed.

3.2. Strategies for TL

Almost all public transport companies in Norway are members of TL. This implies that TL has the possibility to impact and influence both central and local authorities. TL thereby has the potential to participate in solving some of the identified barriers.

It is important in this respect that TL develop their own strategy in the area of alternative fuels. Today TL expresses the opinion that it is the responsibility of the authorities to encourage increased use of alternative fuels. The authorities on their side, express the opinion that market mechanisms will do this. To break out of this "vicious circle", it is necessary that TL change their strategy into becoming more proactive in this area.

The actual development work on a strategy in the area of alternative fuels should be the responsibility of the environmental department in TL. This work should include a priority of what type of alternative fuels TL prefers that the member companies use. The conclusion might be that different geographical regions of Norway require different alternative fuels. In what part of Norway should for example use of biodiesel be encouraged (cities or rural areas, coast or inland?). Today, the environmental focus in TL is too vague and mainly in the following two areas: (1) to document that TL have a serious approach to environmental concerns, and (2) to give the bus transportation mode an improved environmental image, and thereby increasing the financial support from the authorities. TL has shown little willingness to implement specific actions as follow-up of earlier studies. In the area of alternative fuels, this can be done by developing specific strategies for fuel use. In this work it is relevant for TL to draw attention from and utilise the existing experience in its member companies.

When this strategy is developed, TL should enter a dialogue with the central authorities in this area. Specifically it will be important to get a clarification on the future situation for the tax-exemption on biodiesel. The tax-exemption must be maintained even if the use of biodiesel will increase significantly. Furthermore will TL's new proactive role in the area of alternative fuels have a lobbying effect in moving in this direction.

This could result in new measures and policies from the authorities encouraging the use of alternative fuels such as biodiesel. In this regard it could be useful for TL to influence the authorities to consider the use of biodiesel as a measure to reduce CO_2 –emissions.

Regarding the price of biodiesel, this has to be the same or preferably lower then the price of fossil diesel today. Biodiesel is as mentioned exempted from taxes today. Only VAT applies. It is not to be expected that the authorities are willing to subsidise the price of this fuel. In order to reduce the price difference between biodiesel and fossil diesel, the price of fossil diesel has to increase. One of the most important strategies in TL's lobbying activities with the authorities has been to secure that the tax-exemption on fossil diesel for public transport is maintained. This is a point-of-view which contradicts the harmonising of the price of biodiesel and fossil diesel. It will be difficult to encourage TL to change this point-of-view. The fuel price is very important in the total cost situation for a bus company. Even so, perhaps TL can be encouraged to propose their main point-of-view; that the mineral tax is introduced, but a full compensation is given in the future. It is however a realistic possibility that the Parliament will vote for introduction of mineral tax in public transport in 1999.

In relation to its member companies, TL can function as a knowledge-provider in the area of biodiesel (and alternative fuels in general). If TL centrally has an active and positive attitude towards increased use of alternative fuels, this might increase the possibility that more of the member companies start using biodiesel. Interested companies can get the handbook in biodiesel use, which is produced in this ALTENER-project. If enough member companies are interested in using biodiesel, then TL can be used in the dialogue with the vehicle manufacturers. There is not much indication that the vehicle manufacturers will guarantee for biodiesel use in single bus companies. If, however TL takes part and applies pressure in such negotiations, the possibilities of vehicle approvals are increased.

4. Company strategies for biodiesel

In this chapter an organisational framework for understanding barriers to introduction of biodiesel in bus companies is presented. Subsequently the company strategies for introduction of biodiesel are presented. This is in the form of a handbook that has been written (in Norwegian) for the bus companies and the branch organisation. The handbook serves as a strategic planning tool for both the individual bus companies and their national branch organisation.

4.1. An organisational framework for understanding barriers

In order to identify barriers to increased use of biodiesel in bus companies it is important to have an understanding of the organisational functioning of bus companies. A framework for improving the understanding of the societal barriers within an organisation has been developed in the project.

This chapter presents some key theoretical concepts for analysing non-technological barriers to introduction of new technology. These concepts works like linguistic microscopes which facilitate access and assessment of the empirical relations within this ALTENER project, which study implementation of the alternative fuel biodiesel. Alternative fuel can be conceived of as being one form of new technology.

4.1.1. Organisation and environment

This chapter concerns organisations as scientific objects. An organisation is understood as an entity that acts within stable social patterns. These social patterns or relations, in which an organisation acts, as well as being acted upon, are described as an environment. It is important to be aware of the social character of this term as it is applied in this article. In other areas the term environment describes physical or biological relations, while in this chapter the *social* features of the environment are of primary interest.

The distinction between organisation and environment is based upon an understanding of the organisation as an *open*, *natural* system that interacts with its environment. This environment consists in its turn of other organisations. A satisfactory decomposition of the organisation on one hand and the environment on the other is needed. A theoretical assessment of organisations based on Thompson (1967) is followed, which suggests that different parts of an organisation interacts with different elements in the environment, and that the form of this interaction varies with organisational structure and features of the environment. The interaction between an organisation and its environment is one of mutual influence. This suggests a perspective which understand the organisation as an *open* system.

The *natural* system perspective conceives the behaviour of an organisation as based on urges, inclinations or instincts. In this perspective behaviour is an effect of reaction rather than action, the organisation is adapting more than interacting with its environment and outcomes are rational if they are functional to the survival of the organisation. This perspective is in opposition to the rational system where effects are explained by the intentions of the organisation as an unitary actor.

Each part of an organisation has an exchange relation with the organisation as a whole and with the environment. These relations are generated and managed by spontaneous and instinctive actions rather than by rational and calculated ones, and the overall goal for the organisation is survival (Thompson 1967). The organisation might be viewed as an organism consisting of many different parts, which acts without consideration of the organism as a whole. The consequence is that an organisation as a natural system is one which is "..a product of forces which are beyond internal management by the system" (Bukve, 1993).

In this chapter an organisation is conceived as basically a natural and open system which strives to generate rational behaviour (Scott, 1981). Rational behaviour means actions that maximise organisational survival and persistence. For an organisation operating in a market, profitability is a primary goal. A complex causal process linking organisational parts to each other and to parts of the environment determines the total outcome of organisational behaviour. The role of science is to describe the causal mechanisms that operate in each unique process. In this project the starting point must therefore be a decomposition of the organisations participating in the project and their environment.

4.1.2. Organisation: A compounded entity

An organisation is composed of the following elements (Bukve, 1993):

- social structure
- participants or actors
- goals
- technology

A description of these elements in more detail now follows.

4.1.3. Social structure

A structure can be conceived as a permanent pattern of behaviour, a process of differentiation and co-ordination of internal relations between different parts of an organisation. By *social* structure of an organisation is understood the relations between different individual actors of which the organisation consists. These individuals are grouped in different levels of an organisation, and following Thompson (1967, based on a distinction originally made by Parsons), a differentiation between three different *levels* of an organisation has been done:

1) The technical level, also described as the technical core of an organisation where production of goods and services are taking place
2) The institutional level, the level of the organisation serving the organisations environment
3) The administrative level, with a primary task of mediating between the other to levels. This includes procuring inputs, obtain access to financial contributors and securing a market for products.

What follows is an identification of the different levels in the organisations that participated in this ALTENER-project. These are the two transport companies Sogn Billag based in Sogndal and Firda Billag based in Førde. Both places are situated in the western part of southern Norway. It is assumed that the technological level consists of the company’s workshop, where busses are maintained and prepared for services for the clients. It is further assumed that the institutional level consists of the bus drivers, who are the actual suppliers of the service. The administrative level is the management level of the organisation.

It is expected that different levels of these organisations have a potentially different response to changes in the environment. Application of biological fuel can be analysed as an introduction of new technology. In theory, different levels of the organisation can differently appreciate introduction of new technology.

It is further expected different involvement among different actors in applying the new technology. More specifically, the workshop is expected to have the least involvement and more objections to new technology, since this will cause more work and increase uncertainty for this organisational level. The administrative level is expected to show most involvement and least objections, since their job is the handling of the supply side and generate more transport demand by increasing the «green» profile of the organisation.

The analysis also focus on whether information on the new technology is shared through different levels of the organisation, and whether introduction of new technology is discussed in councils or boards where the different levels are represented (i.e. “arbeidsmiljøutvalg”, a council established to monitor the general working conditions of the whole organisations).

4.1.4. Organisation and technology

The technology of an organisation comprises educational level and individual competence in addition to machines and technical tools. Competence is a capacity to act according to some general rules while knowledge is *about* some particular things.

Thompson (1967) distinguishes between three different types of technology. His first category is the serial technology, of which the assembly line is the prime example. The dominating problem for organisations using this technology is to seal off the technological core from the environment.

Thompson’s second category is the mediating technology, where the prime task is to establish a link between independent clients and the organisation as the supplier of the service in question.

The third technological category is the intensive technology, where several different techniques are applied in order to manipulate an external object. Access to and co-ordination of the different techniques included in the diversity is the dominating problem of organisations belonging to this category.

The analysis of the public transport companies in the ALTENER-project confirms that they use mediating technology. Organisations with this technology try to develop rules and standardised measures to handle a large amount of different clients spread out in a geographical and social space. Their ability to influence the clients and customers is very restricted, and the organisations therefore strive to offset their dependency of customers by influencing actors on the supply side. For public transport companies in Norway the political institutions, as financial contributors and fiscal regulators, are of special interest in the hypothesis building. National institutions determine the level of tax on different fuel types while regional institutions allocate subsidies to each transport company. In addition, regional political institutions are significant purchasers of the services supplied by the transport companies, especially in connection with transporting school kids.

There is a rather interesting situation concerning the identity and differences between the two transport companies participating in the project. They are quite similar in size and identical in structure. Their environment is quite similar, they need access to the same suppliers on the financial side. They face the same type of general public, and they are *not* competitors since public transport is a regulated business in Norway.

From this, it can be expected that the companies’ behaviour and response to new technology is approximately identical. When this is not the case, one could ask why, and the answers would probably illuminate some significant non-technological barriers.

4.1.5. *Environment*

The social environment is probably the key factor for this study of non-technical barriers. Thompson (1967) characterises the environment of an organisation in the following way:

- suppliers
- customers or clients
- competitors
- political actors, including the government, trade organisations, unions and legislative bodies preparing legal arrangements
-

According to Thompson, the environment can also be categorised in two dimensions, described by the concept pairs homogenous/heterogeneous and stable/variable. This is understood as the question of whether the challenges from the environment on the organisation is univocal or ambiguous, and whether these demands are stable or whether they change over time. For the purpose of this project the question is then: Is the environmental requirements from the organisational environment increasing, and are these requirements evenly or unevenly distributed through this environment? Are these demands coming from customers, suppliers or political actors?

4.1.6. *Suppliers*

With focus on this research context, one can separate the supply-side into four parts: One is the distribution and price of fuel, another is the supplier of production means (buses), and the third part is the supplier of financial means. The fourth part is the farmers cultivating the land on which raw material for biodiesel is produced.

The organisations in this study are transport companies. They are financed partly by customers purchasing their services, and partly by public means. Public transport in Norway is subsidised in order to maintain a level of transport supply which would not be realised when left alone to customers willingness to pay.

Ordinary diesel fuel (“non-coloured diesel”) is taxed in Norway. But the public transport companies use a special type of diesel fuel (“coloured diesel”) for passenger transport purposes. This type is exempted from taxation, and this exemption is a form of subsidy. The *national* public level is a supplier of financial means for the two transport companies. The Ministry of Finance («Finansdepartementet») and the Ministry of Transport and Communications («Samferdselsdepartementet») are the most important national actors for transport companies in Norway. In addition to tax exemption, the transport companies receive direct subsidies. These are allocated from the national to the regional public level as a lump sum determined by criteria such as population size, proportion of population living in sparsely populated areas and total area in square km. The regional public level in its turn allocates subsidies to the individual transport company which operates within the region based on political deliberations. An analysis of the regional public administration level as a central *customer* for the companies is then conducted.

The purchase and distribution of fuel is a crucial factor in the environment of the transport companies. This factor probably constitutes the most significant feature of the non-technical barriers. The price of the subsidised fuel is today approx. NOK 2,10 pr litre. Diesel fuel used for transporting goods is not subsidised, and the price difference between these two fuel types is consequently a measure of the subsidy element. This is worth around NOK 4 pr litre for the public transport companies. Converting to biodiesel would at present prices cost the companies around 5 NOK more pr litre, including value-added tax. This is an increase of more than 200 %. It is inconceivable that the transport companies should carry this burden alone, only for the purpose of prestige or heightened environment status. It is also hard to imagine the customers (passengers) being motivated for such a price increase. The most credible strategy is therefore to obtain some subsidy for biodiesel in order to minimise the cost difference relative to traditional fuel. Alternatively, one could argue for an inclusion of external costs in the price of coloured fuel that would increase its price to at least the level of biodiesel. This latter national strategy would dramatically increase the price of public transport for the passengers, thereby influencing the substitution of public with private transport.

Distribution of biodiesel is also a significant problem. Currently, this fuel has to be ordered through special channels, and it has to be stored separately from other fuels. This means additional costs in handling biodiesel. Who should pay for these costs? The transport companies? The political authorities through some reimbursement of investment costs?

The next supplier to be considered in this context is the producer of busses and its local sales representatives. What are their views on introducing biodiesel? Do they consider it as a threat or as a challenge? What are their reactions and attitudes to environmental-friendly demands made upon the transport companies? Do they share these demands? Do they foresee a relative competitive advantage?

The last supplier included in the analysis is the agricultural sector which provide land for cultivating raw material for alternative fuel. The problem for *society as a whole* is that this cultivating of raw material should take place at fallow land so that the total production of food is not reduced. The problem for the individual *farmers* is that the price of raw material for biodiesel is less than the price of the alternative products that can be cultivated on the same land. The challenge for policy makers is to find incentives for the farmers both to take fallow land in use *and* to apply it to cultivating raw material for alternative fuels.

4.1.7. Customers

The public authority is a significant customer. School busses run by transport companies are purchased by regional public authorities. Accordingly, one can regard the public system both as a supplier of financial means and as a customer. For 1996 the regional public level purchased about 8,5 mill km from the two transport companies. The local public administration level is the single most significant customer for the companies.

It is necessary to add at this point that the regional authority in question is a political one, it is the political assembly at the regional level which provides the management of this authority. Consequently, the political preferences on the regional level can differ from the national ones. Goals formulated at the national level may not be appreciated at the regional level, and the opposite may also be true. It is necessary to conduct an empirical investigation to answer the question of whether the transport companies are experiencing conflicting demands from different political levels, or whether there is a consensus in demands made upon transport organisations.

The general public is also a customer, though it is hard to conceive this public as a unitary actor. Rather it is a diversity of actors, attitudes and demands. One can assume that the general public plays a limited role in this study. It is of course interesting to know whether the attention on emissions from climate gases is increasing among the general public, and whether «green values» are gaining ground as a political important subject. One may ask specifically whether the regional and national levels are front-runners or laggards compared to the attention and significance given to «green values» by the general public, as measured in opinion polls and election behaviour.

4.1.8. Competitors

The two transport companies are not competitors, since public transport in Norway is a regulated business. The companies do not bid for the same routes, and they do not compete for the same passengers.

It is therefore necessary to look for competitors in alternative modes of transport. It is only the private car that can offer competition. Alternative public modes of transport such as railway is not available in this part of Norway. The relative competitive strength between public transport and private cars is dependent on several factors. One is price, another is the public’s conception of environmental impacts of the different transport modes, what can be called the distribution of environmental legitimacy between transport modes. Heightened awareness on external effects of the private car on the environment should favour the competitive strength of the public transport.

This relative advantage of public transport should be further strengthened by introduction of new technology such as biodiesel. It is therefore to be expected that transport companies are interested in such projects because their environmental profile and legitimacy should be strengthened relative to the private car. This again may influence the public’s willingness to use public transport and their willingness to pay extra for reducing the global emissions of greenhouse gases.

4.1.9. Political actors

Political actors are responsible for fiscal arrangements as already mentioned. In addition political actors are responsible for designing a coherent policy for the transport companies. By policy one refer to a set of means which are connected through a strategy which aims at attaining some specific goals. Among other things this strategy determines who gets what and why, i.e. the criteria for subsidising transport companies. The policy should also include quality control of alternative fuels and an authorisation of producers. This could increase the attractiveness of alternative fuels both to producers of raw material and to distributors.

4.2. The strategic handbook

A main result of this ALTENER-project is the development of a handbook for biodiesel use. The handbook is published separately from this report (Lundli, 1998) and is written in Norwegian language in order to be more user-friendly for the bus companies in Norway.

The handbook is written as a strategic document to be used both for bus companies and the national branch organisation. Its main focus is on identifying barriers related to using biodiesel as a fuel in heavy-duty vehicles in Norway.

As a background for the use of biodiesel, the handbook includes a review of the national policies on fuels in Norway. This comprise of both general fuel policy principles, present fuel policies, possible changes in fuel policies, and the connection between biodiesel and climate change politics.

The national barriers are presented in the handbook by incorporating the results from the study of the national policies and structuring them into five groups:

1. Price
2. Emissions
3. Land-use requirement
4. Winter properties
5. Technology

A separate chapter in the handbook covers the branch organisation TL and barriers associated with this organisation. The material in this chapter of the handbook in structured into five sections:

1. General information on TL
2. The lobbying activities with national authorities
3. TL's environmental policy
4. TL's view on the fossil fuel tax
5. Barriers within TL

There is also in the handbook included a presentation of the main strategies that TL can use in order to solve some of the barriers against biodiesel use.

A separate chapter in the handbook deals with the barriers that are identified through the vehicle fleet tests in this ALTENER -project. This includes a thorough description of the tests and the results in the two bus companies Sogn Billag and Firda Billag. The barriers identified at the three different company-levels; 1) management, 2) driver, and 3) workshop are presented in this chapter.

The different strategies that the bus companies can use in order to solve some of the barriers against biodiesel use are also included in the handbook. This includes both barriers at the different company-levels, environmental barriers and specific barriers related to biodiesel use in cold ambient temperatures.

As an appendix to the handbook it is added a list of technical aspects to be considered when using biodiesel in heavy duty vehicles.

5. Field experiments

In this chapter a summary of the results of the field experiments with biodiesel in the two bus companies is presented. A more comprehensive description of this study is published in a separate report (Lundli and Simonsen, 1998).

Test driving with biodiesel was conducted in the two transport companies Sogn Billag and Firda Billag during March 1997 (phase I) and January-February 1998 (phase II). In March 1997 two busses in Sogn Billag and one bus in Firda Billag were driving on biodiesel for one week each. 1000 litre biodiesel was consumed in total during phase I. The purpose of phase I was to prepare the ground for a longer test driving period the following winter.

During the winter of 1998, a 2-month test-driving period with biodiesel was conducted with busses from Sogn Billag and Firda Billag. The same busses as in phase I were involved in the test driving. A total of 11.000 litre of biodiesel was consumed and 25.000 km driven during phase II. The lowest temperature recorded during the experiment period was minus 11°C.

The test driving in Sogndal included the airport route as well as the city service route. The airport route drives from the centre of Sogndal (at sea level) to the airport at Haukåsen, approximately 500 meter above sea level. Parts of the route are very steep. In contradiction to the airport route, the city service route drives a line almost without hills. In both cases, a MAN bus was used (produced in 1996 and 1993, respectively).

The fleet experiment in Førde was carried out with the popular city service route. In 1997 a total of 217.000 passengers were transported by the city service route. Similar to the airport route in Sogndal, the city service route in Førde drives a very steep route. The bus involved was a Scania, produced in 1995.

No major problems occurred during the test periods. The engine yield was somewhat reduced, especially noticeably when driving up steep hills. The fuel consumption increased with 10-20 percent compared to mineral diesel driving. Very few passengers responded negatively to the characteristic smell of the biodiesel exhaust. The most severe incident during the test period occurred during the last day of biodiesel test driving in Førde. The diesel filter was then blocked twice with a 4-hour interval.

6. Special barriers in winter: Additives

A separate literature study of biodiesel additives has been carried out in the project. This was done to be able to illuminate possible barriers related to the use of different fuel blends and/or additives. It has also been important to evaluate to what extent problems with driving in low ambient temperatures can be overcome. Through this separate study it was also a goal to obtain knowledge as to what other technical, environmental and health problems might be connected to biodiesel fuel blends and additives usage.

This chapter is a summary of some aspects of additive uses in connection with biodiesel. The focus has been on additives used to obtain improved winter properties ("cold flow additives") of biodiesel made from rape seed (rape seed methyl ester, RME), but other additive types are also included. The goal has been to obtain an overview of the usage of different types of additives applicable for biodiesel. This knowledge overview is a starting point for evaluating environmental, health and safety aspects of additive usage. This will provide an aid in the identification of barriers to implementation of biodiesel. Some indications of such environmental aspects are included in the chapter. This presentation is by no means a complete overview of different additives in use today. A major problem in this regard is the proprietary information of many additive compositions, only available to the additive producers. The chapter is however an introduction to the barriers associated with biodiesel additives.

6.1. Additive usage in biodiesel

Most additives marketed for use in biodiesel are originally developed for improving the properties of mineral diesel. Additive products marketed are almost always mixtures of different compounds blended together into additive packages to provide a number of functions simultaneously. Substantial research is conducted in improving the properties of fuels by finding combinations of different types of additives (Wilson, 1997). This implies that the environmental effects of additive usage are not limited to the effects of individual compounds. The possibility for synergistic effects of each individual compound must also be taken into account when assessing the effect of additives on health and environment. This consideration must be done both for combustion products, emissions and physical contact.

The US environmental protection agency (EPA) suggests that the possible environmental problems from emissions of biodiesel additives primarly consists of nitrogen oxides and aldehydes (Sopata, 1997).

Most additives in the US are recommended used in concentrations up to 2000 PPM (2 %), which means that 20 gram of the active ingredient can be added to 1 litre of the fuel. The Austrian standard for biodiesel has an upper limit of 1 % for additives.

There are at least four different reasons for using additives in biodiesel:

1) At temperatures below -5 ^{0}C it is necessary to improve the flow properties of biodiesel to avoid plugging of fuel lines and filter. Two different terms are being used to describe the cold flow properties. CCFPP is an abbreviation both for *critical cold filling pouring point* and for *critical cold filter plugging point*. With a CCFPP of -20 ^{0}C the fuel is suitable for use at temperatures down to -20 ^{0}C. Additives which increase the cold flow properties, by lowering the CCFPP, are termed *pour point depressors* (PPD).

2) The use of biodiesel can cause the formation of deposits in the engines, mainly on intake valve shafts and injection systems. Additives used to reduce this deposit-forming tendency are named *dispersant supplements*.

3) RME has a high content of unsaturated fatty acid methyl esters (FAME). The double bonds are vulnerable to oxidation. Contact with metal can also result in oxidation that reduces the stability of the fuel. A wide range of antioxidants and metal-passivators (increasing the metal compatibility) are being used to extend the shelf-life of biodiesel.

4) The different fatty acids that are esterified to form biodiesel possess different ignition properties. The ignition properties are described in terms of *cetane numbers*. Including additives can improve the ignition properties of biodiesel by reducing the time delay between the

injection and the ignition. This will increase the cetane number of the fuel.

The winter-biodiesel used by Firda Billag and Sogn Billag in the ALTENER-project contains 1 % of the following additive:

> "Polymer chains of middle molecular weight, alkyl ester copolymers and similar substances of anti-crystalline effect, solved in long chain alcohols and fatty acid esters"

The producer (Exxon) further states in the material data safety sheet regarding the environmental hazards of this additive product:

> "Negligible hazard and minimal toxicity. Flash point is considerably above 100 ^{o}C. Solvent-like, readily degradable, slightly hazardous for water and adverse effects to aquatic organisms is possible."

6.2. Pour point depressors

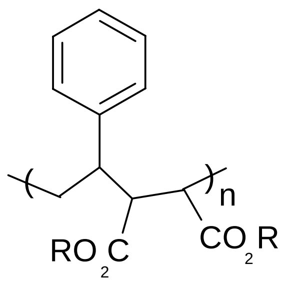
Substantial research on cold flow additives has been conducted at Northern Agricultural Energy Centre and National Centre for Agricultural Utilisation Research (NCAUR) in Peoria, Illinois. Their studies have emphasised soy fatty acid esters, but the physical chemistry involved in additive treatment is analogous for RME.

Nearly all of the additives tested by NCAUR were developed and marketed for treatment of conventional diesel fuel (petroleum middle distillates). Most of these additives have active compounds such as ethylene vinyl acetate copolymers, alkenyl succinic amides, high molecular weight long-chain polyacrylates, fumarate-vinyl acetate copolymers and copolymers of linear alpha-olefins with acrylic, vinylic and maleic compounds. Additive products also typically contain a petroleum-based solvent or vehicle such as aromatic naphtha. Naphtha can cause cancer with skin contact, airway irritations with breathing problems, and coma with high air concentration. Chronic exposure can cause headache, reduced appetite, dizziness, sleeplessness, indigestion and nausea (Lewis, 1996).

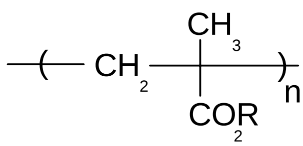
Experiments have also been performed aiming at mixing in medium-long alcohols and methanol (Dunn and Bagby, 1994; Knothe, Dunn and Bagby, 1994; Knothe, Bagby, Weisleder and Peterson, 1994; Knothe and Bagby, 1994). The conclusions from this research are that none of the additives will lower the CCFPP better than by mixing in kerosene (paraffin, "no. 1 diesel"), the same way it is done for mineral diesel. Similar conclusions are reached at the research group at Department of Biological and Agricultural Engineering at University of Idaho. The mixing in of paraffin in cold weather in addition to additive usage, is a common practice. The disadvantage of this blending is however that it can lower the cetane number of the fuel, thereby requiring an additive to improve the cetane number again.

Lubrizol International Laboratories is marketing PPD-additives based on the following three main structures:

I. Melan-styrene esters:

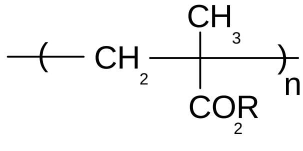


II. Polymethacrylate:



When R=CH_3 this is polymethylmethacrylate, also known as the material "liquid Plexiglas", a suspected carcinogen (Lewis, 1996).

III. Ethylene vinylacetate:



Ethylenevinylacetate copolymer, will upon combustion degrade into a large number of different straight chain hydrocarbons, and add to air pollution in the same way as other volatile organic compounds (McGrattan, 1994). The combustion gas from this additive is in addition characterised as sharp, bitter and irritating (Lewis, 1996).

At the Belgian research institute VITO (Vlaamse Instelling voor Technologisch Onderzoek) the C8-C10 fraction (the lightest fraction) of cocos-methyl-ester (CME) has been used to overcome the cold temperature problems associated with biodiesel use. By using a 20 % blend of CME in biodiesel a lowering of CCFPP down to -15 ^{0}C was achieved in tests (Kinoo et. al., 1996). Fina Oleochemicals in Belgium produced the CME. The problem with smell form the exhaust was however increased when this mixture was used. VITO did not continue with these investigations, partly due to the barrier in the form of the long transport of the cocos oil from the tropics to usage in cold weather regions (Demoulin, 1997).

6.3. Dispersant supplements

Formation and build/up of deposits in the fuel injector equipment, and especially in the injectors, can cause injector fouling. Excessive fouling increases fuel consumption and particulate emissions. Detergents are used to avoid deposits to build up on metal surfaces like combustion chambers, intake valves and fuel injectors. Periodically clean-up of the deposits by using detergents that remove the deposits after they are formed is also a method to reduce the injector fouling. These compounds are called “deposit control additives” and have a prime position in the diesel additive packages.

6.4. Antioxidants/metal-passivators

Tert-butyl hydroquinone (TBHQ) has shown promise as an antioxidant for biodiesel. This antioxidant is however not suitable in blends of biodiesel and mineral diesel because it has limited solubility in petroleum middle distillate fuels and may precipitate out of blends (Dunn, 1997).

TBHQ is moderately toxic by ingestion. It is also suspected to be a carcinogen (Lewis, 1996).

The common antioxidants like butylated xylenols and/with/or butylated hydroxy toluene (BHT), are also suitable for use in biodiesel (Laird, 1997). BHT is a poison, a teratogen, and a skin and eye irritant (Lewis, 1996). Another antioxidant suitable for biodiesel is tocopherol, a natural antioxidant (vitamin E) found in most oil seeds. Phenylenediamine has been determined to be the most effective antioxidant in a study by the International Society for Stability and Handling of Liquid Fuels (ICSHLF, 1994). Both the o-, p-, and m-isomers of phenylenediamine are however suspected human carcinogens with mutagen and teratogen activities (Lewis, 1996). They all emit NO_x when combusted. O-phenylenediamine is in addition a confirmed animal carcinogen. P-phenylenediamine is on the list of hazardous air pollutants (HAP) on the U.S. EPA Clean Air Act amendments. The production of the chemicals on this list is likely to emit HAP.

6.5. Ignition improvers

The cetane number is an important indicator of biodiesel fuel quality. It is an indicator of the time delay between the injection and the spontaneous ignition of the fuel in the combustion chamber. Although mechanistically different, the cetane number is conceptually similar to the octane number used for gasoline. Generally the shorter the ignition delay time, the higher the cetane number. The cetane scale uses two standard compounds, the one is cetane (n-hexadecane) defined as 100, and the other is heptanonylnonane defined as 15. The Austrian biodiesel standard for minimum cetane number is 48. Most mineral diesel fuels do not perform well with fuels of cetane numbers below 40. In cold weather, the difficulty of starting a cold engine increases as both the cetane numbers of the fuel and the temperature decreases. Chemical cetane improvers are compounds that readily decompose to form free radicals, which promote the chain initiation, and thereby accelerate combustion. Chemicals selected from alkyl nitrates, some peroxides, tetraazoles, and thioaldehydes can be used as cetane improvers. Because of their low cost, alkyl nitrates have played the most significant role in commercial use (Coughenour et. al, 1997). 2-Ethylhexyl nitrate has been used as a commercial cetane improver for many years and currently is the predominant cetane-improving additive on the market. Some ignition promotors for diesel and their associated environmental effects are listed in Table 3.

Table 3 *Ignition promotors and some associated environmental effects*

ID	Compound	Environmental effect
1	1,1-di-(t-butylperoxy)-3,3,5-trimethylcyclohexane	Toxic, irritation, explosive
2	2,5-dimethyl-2,5-di-(t-butylperoxy)-hexane	Toxic, irritation, explosive
3	di-t-butyl peroxide	Toxic, irritation, explosive
4	2-ethylhexyl nitrate	NOx emission
5	n-butyl-4,4-bis(t-butylperoxy)-valerate	Toxic, irritation, explosive
6	O,O-t-butyl-O-(2-ethylhexyl)-monoperoxy-carbonate	Toxic, irritation, explosive
7	t-butyl perbenzoate	Toxic, irritant, potential carcinogen

Source: Clothier et. al. (1993)

Di-t-butyl peroxide (DTBP) is an effective cetane improver also in biodiesel (Liotta, 1997). Cetane improvers also have the potential to *reduce* the CO, particulate and NOx emissions from the combustion of diesel fuels. This is the case for DTBP, which has been found to reduce both particulate and NO_x emissions when added to biodiesel (Ibid.). The organic nitrates (In Table 3 exemplified by 2-ethylhexyl nitrate) will however release NOx into the atmosphere through the combustion process because it contains nitrogen. A US patent for the use as cetane improver also exists on melamine cyanurate (Dorsey, 1996). This is a synonym for 2,4,6-Triamino-s-Triazine compounded with S-Triazine-Triol (CAS: 37640-57-6), and is an eye irritant and is mildly toxic by skin contact (Lewis, 1996). In addition it is toxic by ingestion, inhalation, and intraperitoneal routes. This compound also emits some NOx itself when combusted.

Various polyaromatic nitrates, e.g. 3-nitro-benzanthrone are also being investigated as potential ignition improvers. Most of these compounds are highly carcinogenic (Pritchard, 1998).

Most of the organic peroxides (as ID 1, 2, 3, 5, 6,7 in Table 3 are examples of) are highly toxic and irritating to the skin, eyes and mucous membranes (Lewis et. al, 1996). There is also substantial fire and explosive hazard associated with these compounds when exposed to reducing agents or heat. Tert-butyl perbenzoate is in addition classified as a potentially carcinogen with reported mutagenic effects.

Nitro alkanes and nitro carbamates can also function as ignition improvers (Robbins et. al, 1950). Many carbamates are poisons and some are carcinogenic, teratogenic or mutagenic. Several nitro carbamates produce cancer in animals even at small doses (Lewis, 1996).

Another example of an additive product with ignition-improving properties is “Bycosin” sold under the name “Fuelsaver” by Ing. Holme & Sandbakken AS in Oslo. According to the material data sheet this product is a metal-organic carboxylate dissolved in petroleum-naphtha. The health, safety and environmental effects of this additive are shown in Table 4.

Table 4 ***Health, safety and environmental aspects of Bycosin***

Area effected	Effect
Breathing	Can cause health problems when repeated air exposure by breathing
Skin contact	Can give permanent health effects, including eczema, from repeated or long term exposure
Eye contact	Splashing in the eyes can cause strong irritation/pain. In high concentrated vapour cause irritations.
Digesting	Can cause diarrhea and vomiting, thereby the product might enter the lungs and cause chemical pneumonia.
Environmental effect	Dangerous for living organisms in water. Can cause damage and long-time effects in aquatic environments. Not easy biodegradable. Potentially bioaccumulating in aquatic life due to low water solubility.
Fire- and explosion hazard	The gas from the product is heavier than air and diffuses along floors, where it can ignite unwanted. The product can in addition, by being heated up, give off combustible gases that can cause explosions when mixed with air.

6.6. Alternatives to additive usage

In addition to using additives, there has been developed other methods to improve the winter properties of biodiesel. Terms like “winterizing” and “de-clouding” are used for a process where the high-melting fatty acid methyl esters (FAME) are being removed from the biodiesel. This is done by slowly cooling down the biodiesel to a critical temperature where the high molecular FAME are precipitated out of solution and settles at the bottom. The sediment is removed and used in the summer as a fuel with a higher CCFPP. A special winter biodiesel with a CCFPP of –38 ^{o}C can be obtained using this method of physical separation. This is however only possible in combination with 1 % additive (Rathbauer, 1995). The process of physical separation requires much energy input, and the separation also requires carefully controlled conditions. The fatty acid composition in this winter-RME and native biodiesel is shown in Table 5. It shows that especially the proportion of the saturated FAME of $C_{16:0}$ is reduced.

Another aspect of biodiesel that can be improved is the deposit-forming tendency due to polymerisation of the fuel. This property is partially determined by the degree of unsaturation in the fatty acids. The polymerisation tendency of the fuel goes down if the number of unsaturations is reduced. Low volatility of the polymerised fuel causes it to be washed down along the cylinder walls and end up in the engine oil, which thereby is being diluted. To reduce this problem, new hybrids of the rape plant are being developed by breeding and genetic engineering. For example, a "high oleic rape seed oil", with iodine number of 100, as opposed to 118 for normal rape, is currently commercially available (Landels, 1995). As shown in Table 5 this rape seed oil contains 72 % oleic acid ($C_{18:1}$) and less of the polyunsaturated fatty acids $C_{18:2}$ and $C_{18:3}$.

Table 5 *Main fatty acid composition in native RME, special winter–RME and "high oleic rape seed oil"*

Fatty acid	% mass					
	Native RME		Winter-RME		HORO	
$C_{16:0}$	4		1		4	
$C_{18:0}$	1		-		2	
$C_{18:1}$	60		61		72	
$C_{18:2}$	22		25		15	
$C_{18:3}$	10		11		2	
$C_{20:0}$	-		-		1	
$C_{20:1}$	1		2		-	
$C_{20:2}$	-		1		1	

The chemical manufacturing companies are currently doing a major lobbying effort in terms of promoting genetically engineered rape plants as raw materials for production of biodiesel with improved properties.

Ciba-Geigy is one of the main actors in this regard. This currently happens both in Germany and France.

The development of new plant properties by the use of genetic engineering can however represent a conflict with the *precautionary principle*, as it is impossible to guarantee that no unpredicted negative environmental effects of this technology will appear in the future. The precautionary principle states that if there is such uncertainty for irreversible effects on the environment, the lack of full scientific proof is not a good enough argument for not implementing actions to reduce the effects.

7. Barriers in the production of biodiesel

7.1. Main issues

In this part the main barriers in the production of RME is identified. The main issues are:

1. What are the main barriers to replace a substantial quantity of mineral diesel with RME (produced in Norway) in heavy-duty vehicles in Norway in year 2005 within:

- An organic agricultural system
- A traditional agricultural system
- A high technology and intensive agricultural system

2. To realise the potential of oil seed production, to what extent are there important environmental impacts related to the different agriculture systems?

The barriers discussed in this chapter, are limited to those concerning the agricultural sector, in order to replace a substantial quantity of mineral diesel with biodiesel produced in Norway. Today there is no RME-production in Norway. With a substantial quantity one understand a biodiesel-share of 5 % or more of the diesel for heavy vehicles. The European Commission has defined 5 % as goal for the production of renewable biofuels within year 2005 (Xenakis, 1996). In the project plan 5 % is a realistic goal for biodiesel production in Norway in year 2005.

7.2. Expected results

Our hypothesis is that RME production in Norway is strongly limited by the potential of oil seed cultivation. The agricultural land is limited in Norway and the climate only allows cultivating rape seed in certain parts of the country. The limitations are also given by rotation limitation.

Rapeseed can not be cultivated every year on the same land because of problems with plant diseases and pests.

7.3. Literature study

In this part some of the results of other studies of biodiesel which are relevant to the issues are summarised.

7.3.1. Biodiesel - LCA, Figenbaum

Figenbaum (1995) has conducted a Life-Cycle Analysis (LCA) on biodiesel in a Norwegian context. The study does not identify barriers, but comments on use or none-use of the by-products (rape seed meal and glycerol) as very important for the results in the LCA. Production of biodiesel implies a use of fossil energy which is only 20 % of the use in the production of mineral diesel, and only 40 % of the CO_2-emission, when the use of by-products are included. Without by-products, the study shows that these two figures are 55 % and 75 %.

The estimate of N_2O –emissions has strong influence on the result of the study. Figenbaum uses a Global Warming Potential (GWP) –factor of 270 for N_2O. Since the study by Figenbaum was conducted, the United Nations International Panel for Climate Change has decided to use a GWP-factor of 310 for N_2O.The estimate on N_2O –emissions is based on an average value of 1 % of nitrogen in fertiliser, as recommended by the Norwegian Pollution Control Authority.

Figenbaum concludes that the production and use of biodiesel would lead to an increase of 20-30 % in NOx emission, compared with mineral diesel. The LCA study did not include land use, but Figenbaum refers to estimates from Erik Eid Hole, the manager of “Energigården”, a demonstration farm for bioenergy in Norway. This estimate is that cultivating rape and turnip rape in Norway is possible on 50.000 hectares yearly, which can result in about 46 million litres biodiesel. This can replace 2-3 % of mineral diesel used in Norway today.

7.3.2. *Energy balance, ecological impact and economics of BIODIESEL production in Europe*

This study was conducted by Gesellschaft für Entwicklungstechnologie (GET) and Institut National de la Recherche Agronomique (INRA) as a part of the ALTENER Programme (Scharmer & Gosse, 1996). It compares 24 different LCAs to get an overview of the most probable total energy and CO_2 balances of biodiesel compared with mineral diesel.

There are large variations in input energy and CO_2 -emissions in the 24 studies. The differences of energy input are mainly due to differences in the agricultural production of rape and the energy consumption in the oil mills. The variations of CO_2 –eq. emissions depends on different estimates on other greenhouse gases than CO_2, for example N_2O from agriculture, and in converting these gases to CO_2 –eq.

Nevertheless the report concludes that the major part of the LCA-studies gives a positive picture for use of the biodiesel on the fossil energy use and greenhouse effect. The study concludes that the input of fossil energy in RME is 36 % compared with using mineral diesel, and 32 % CO_2 emissions compared with mineral diesel. The credit from by-products, glycerol and rape seed meal, is included. Without by-products the result is 106 % and 74 % respectively.

The study presents its own evaluations on available land for rape seed cultivation. In general the global land availability cannot be considered as a limiting factor for the extension of a new crop today. It concludes that within the EU there are no climatic limitations to extend rape cultivation for RME proposes in the *grain production areas.* Improved farm economy when cultivating other crops is an important barrier for increasing rape seed production. Sugar beet is more profitable in these areas. And sugar beet is, as rape, a problem in the plant rotation cycle. It can not be cultivated more than once every 5-6 years.

Today Germany, France, UK/Irland and Denmark have 99 % of all rape seed cultivation in the EU. Water would be a limitation if the cultivation area of rape seed was to be expanded to the central plains of Spain. The average yield in Spain is 0,8 tons/hectare compared with 2,6 tons/hectare in France.

The present limitation is the available water in Southern Europe, and farm economy and phytosanitary conditions (plant rotation) in the central Europe. There are also important *institutional barriers* as the Blair-House agreement in GATT which only allows EU to produce 1 mill tons of oil seeds for technical use on set aside land.

The actual biodiesel production potential is 800.000 tons/year in the EU. This can replace less than 1 % of the mineral diesel used in the transport sector in EU-15. The total physical potential in year 2010 of RME production is 2,2 million tons/year in the EU (GET/INRA, 1996).

7.3.3. Non technical barriers to the development of liquid biofuels in Europe

The study "Non technical barriers to the development of liquid biofuels in Europe" identifies barriers on several different levels; agricultural, economical and financial, industrial, legislation, market, environmental and public (Xenakis, 1995). The conclusions are reported below.

<u>Agricultural barriers:</u>

- The Blair-House-Agreement limits the quantity of oleaginous seeds produced in the European Union on set aside surfaces. There are no guarantees of land availability; the set-aside land are limited by the new European Common Agricultural Policy (CAP), and the remaining land is mostly dedicated to food crops.

- Lack of contracts between industry and agriculture. Both sides are reluctant to engage themselves.

- Lack of awareness from farmers, resistance to transition into cultivating new crops for energy purposes, (by maintaining the crops for food purposes).

<u>Economic and financial barriers:</u>

- The raw material prices are too high.
- Logistics and transportation of raw material is too expensive.
- Too low price for non-food purposes in comparison to food purposes (lower income for the farmers, which has reduced the interest).

Environmental issues are to date not driving forces for farmers and industries.
- Too low price of fossil fuels making biodiesel non-competitive.

Industry:

- Lack of standardisation and specification of liquid biofuels.
- No guarantee for raw material supply.
- Too much risk for investors.
- Lack of coordination, no strong system (from farmers to producers and to users).

Legislation:

- Lack of a satisfactory dialogue between all the EU members on taxation.

Market:

- No measures stabilising the market.
- No concept of long-term marketing.
- No common strategy between farmers, producers and users.
- No large market.
- No general awareness of the new specificity of the products (biofuels must not be considered as a substitute of fossil fuels but as a new product with different advantages like renewability and lubricity).

Environmental impacts:

- Lack of a list of advantages of biofuels.
- Too much controversy of emissions in particular, mainly due to the non-conformity of the protocols and to the influence of the lobbies.
- Risk of decreasing the biodiversity (energy crops on fallow lands).
- No acknowledged general description of the environmental impacts is available.
- Energy and environmental balance. These are hard to compare because of varying data and differing methods due to the lack of standardised and approved rules for assessing the environmental

effects (for example, N_2O emissions are rather poorly described in literature).

Public:

- Lack of information in terms of environmental effects.
- Lack of information dedicated to politicians.

Many of these barriers are related to the production chain, which is the topic here. These include agricultural barriers, economical and financial aspects, industrial and some of the environmental impacts. Land availability as a limiting factor is one important barrier. There is no guarantee for land availability; the set aside land is limited by the new CAP regulations and the other agriculture land are mostly dedicated to food crops.

"The existing instruments of set-aside land in the EU is not appropriate to increase the biofuels production. The Blair-House Agreement in GATT is a main barrier to develop biofuels in EU. When accepting this limit, biodiesel would only cover 0,2 % of EU's diesel fuel demand. The restriction in the Blair-House Agreements should be removed as soon as possible", is the conclusion of the report from Ademe (Xenakis,1995).

7.4. An overview on the oil seed cultivation in Norway

The total agricultural land in Norway is at present (1998) 1,04 million hectare. One third of this, 0,33 million hectare, is used for grains, mainly barley, oats and wheat. For the last three years, oil seed has been cultivated on approx. 7600 hectare. This is less than 1 % of the agricultural land. In 1991 the oil seed cultivation reached a maximum of 11.400 hectare. The agricultural land use[5] is shown in Figure 1.

[5] Source: Statistics Norway (1998a)

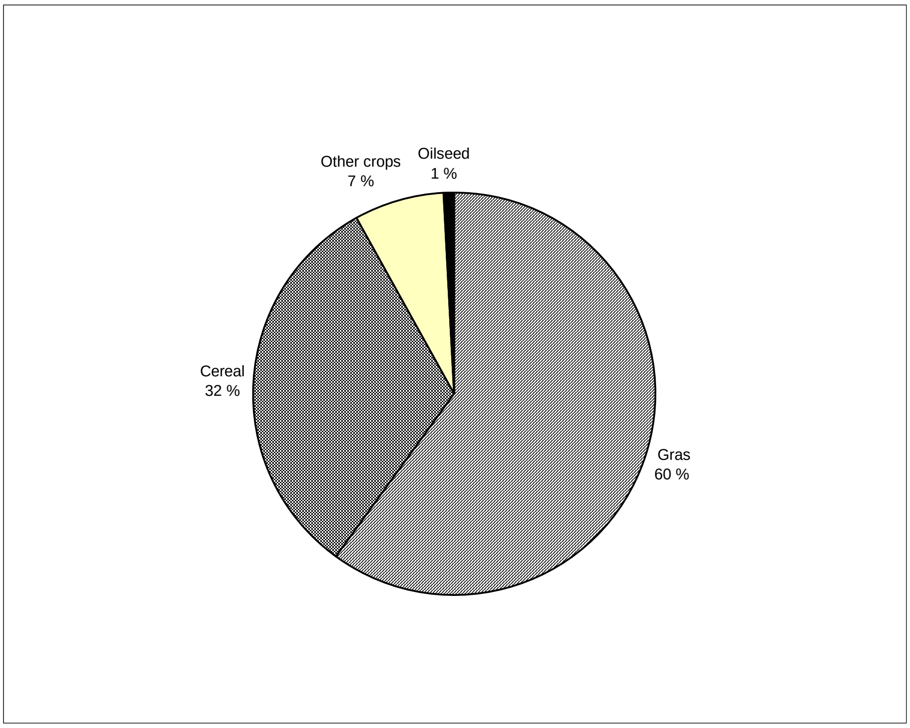


Figure 1 *Agricultural land use in Norway in 1997*

The grain production in Norway is very concentrated to the south eastern part of the country. There is also some grain production in the middle part of Norway, Trøndelag. In other parts, west, south and north, there is very limited grain cultivation. These are the grass and livestock agricultural areas. The oil seed cultivation is even more concentrated than grain, and is located in the best agricultural areas. During the last 15 years the the oil seed cultivation has decreased in the interior parts of eastern Norway, and increased in the best climatic areas around the Oslofjord (Uhlen, 1998a). Figure 2 shows the grain and the rape seed cultivation from 1964 until today[6] (rape seed in the very bottom of the figure).

[6] Source: Statistics Norway, 1998b & 1998c

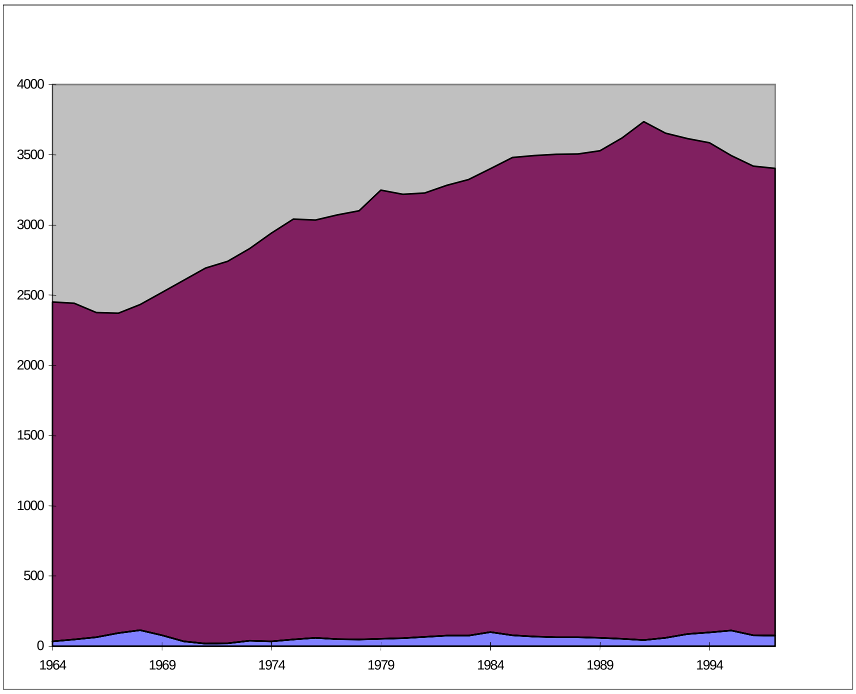


Figure 2 *Grain and rape seed cultivation in Norway in1964-1997 (in 100 hectare)*

The yield has not increased in the period of 1976-97. The average yield of all oil seed cultivation in Norway in the same period is 1,6 tons/hectare (Statistics Norway, 1998d & 1998e). This is shown in Figure 3.

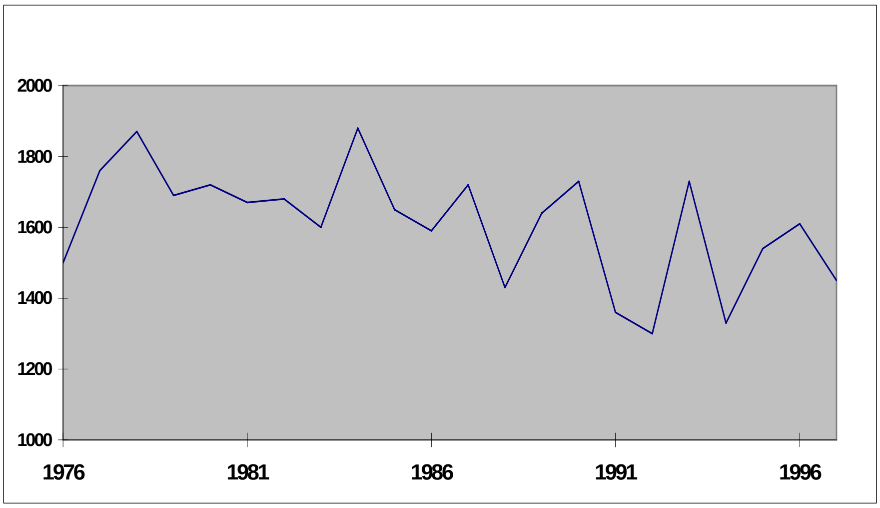


Figure 3 *Rape seed yield (mainly spring turnip rape) in Norway in 1976-1997 (kilogram/hectare)*

About 85 % of all oil seed in Norway are spring turnip rape, the least profitable rape seed. Winter rape represents only 5 % and spring rape 10 % of all oil seed production. The yield is closely linked to the properties of the cultivar. The winter rape cultivar used in Sweden or Finland is only possible to cultivate in the very best agricultural areas in Norway, which is near the Oslofjord.

The average yield on the farms in "Driftsgranskingane" by Norwegian Agricultural Economics Research Institute was 1,8 tons in the best districts in eastern Norway and 1,65 tons in other districts in eastern Norway in the period 1980-97 (NILF, 1998). This research on agricultural practices ("Driftsgranskningene") often contains the best run farms.

7.5. Description of the three agricultural systems

It is necessary to identify the barriers related to the three different agricultural systems with the aim to reach a substantial use of biodiesel. In this chapter a definition of the three systems with the necessary assumptions is given. The conditions are summarised in Table 6.

7.5.1. Available land

Most of the land used for grains in Norway today can be used for rape seed cultivation (Uhlen, 1998b). Some areas with high rainfall and wind in autumn is not suitable. The available land for rape seed growing has therefore been to 300.000 hectare in the traditional and intensive systems. In these systems the present regional specialised production structure with concentrated growing of grains in the east parts is continued.

In the organic system this is different. It needs more grass and animal in the east to maintain the nutrient balance. So the main difference in land use in this system is the need for more grass and thereby less land available for grain and oil seed cultivation. An increase of grain and oil seed cultivation in the southern parts can not replace the decrease in the eastern parts of the country. A model work at the Agriculture University of Norway has predicted the grain land in an organic agriculture system in Norway to 276.000 hectare (Aanestad, 1989). The rain- and windy area is included in this estimate. The available land in the organic system is therefore reduced to 250.000 hectare.

7.5.2. Oilseed cultivar

There is no oil seed breeding to get improved cultivars for Norwegian growing conditions in Norway today, but this can start up if there is a substantial increase in demand of oil seed. With an oil seed cultivation on 50.000 hectare of land, it is realistic to assume that oil seed breeding will start up (Gullor, 1998). It is assumed oil seed breeding in Norway in all the agricultural systems.

With an own oil seed breeding it is more probable to get cultivars suitable for the Norwegian climate (Åssveen, 1998). This will give an increase in yield from the cultivar used today. In the best agriculture districts around the Oslofjord some farmers get 4 tons a hectare with winter rape during the best years. Spring turnip rape can give up to 2,7 tons a hectare under the same conditions (Lindemark, 1998). This is not an average estimate, but shows the potential with winter cultivars of oil seed. The average yield with winter rape seed in Sweden is 2,55 tons a hectare and 1,65 tons for spring rape seed the last ten years (Jonsson, 1989, Wallenhammar, 1989).

It is not realistic to expect that winter rape will be grown on all oil seed land in Norway. In Sweden the rape seed cultivation contain 1/3 winter rape, 1/3 spring rape and 1/3 spring turnip rape. With own oil seed breeding one could expect the same in Norway in the year 2005. It is assumed the same composition of cultivars in year 2005 as in Sweden today.

It is also possible to increase the yield with new hybrid cultivars. This can give an increase of 20 % in yield (Gullor, 1998 and Jonsson, 1998). Some organic farmers do not like to use, or do not use, hybrid cultivar because it is not fertile. But according to the regulation on organic agriculture it is not forbidden to use hybrid cultivars (Debio, 1998). It is assumed that hybrid cultivars are used in the three agricultural systems.

The breeding companies are also working to develop transgenic plant with resistance against fungus and pest (insects). This is expected to reduce the use of pesticides (Jonsson, 1998). Herbicides resistance from genetic changes is already developed. It is assumed that transgenic plants with resistance against herbicides, fungus and pests are used in the intensive system.

7.5.3. Assumptions about rotation

In the scientific literature it is recommended not to cultivate rape seed more than once during a period of five to six years (Sogn, 1984, Uhlen 1998a). This is necessary to avoid club root (of cabbage) which can give a substantial decrease in yield. The club root can also be spread with Brassica-weed. It is important to avoid this weed during the whole rotation. On the *arable land* in Norway the Club root is a more serios limitation than the climate (Uhlen, 1998b).

The growth of club root is stopped on pH 7,5. With a substantial supply of lime in the soil it is possible to increase the pH-value to this level and reduce the club root problem. This is done in the intensive cabbage-cultivation areas in Lier in eastern Norway. This can also be done in the oil seed cultivation (Uhlen, 1998b). But such systems can not be called sustainable. Other kinds of diseases and pests will increase because of the intensive rotation (Hermansen, 1998).

It is also possible to develop cultivars with resistance against club root. This is being done with traditional breeding methods. A development work is going on and the result on rotation problems is not yet given. The resistance function is uncertain. Nevertheless resistance cultivars will give a better protection against Club root than the present cultivar, and will make it possible to cultivate rape seed more intensively than today. It is assumed that resistance cultivars are used in all the three agricultural systems.

On land without club root it is possible to cultivate rape seed every fourth year in a traditional agriculture system, without using resistant cultivar (Uhlen, 1998b). This has also been done in practical farming in Norway, but on very small areas (Lindmark, 1998). It has mostly been combined with an active weed control with the use of herbicides. Still there can be a risk to get club root. The experience from similar large scale oil seed cultivation in Skåne, Sweden, are not good. There they got big problems with plant diseases and pests, and they had to reduce the cultivation (Wallenhammer, 1998). This is also the experience from intensive monoculture grain cropping in Norway (Uhlen, 1998b)

On the background of these assessments it is assumed oil seed cultivation every fifth year in the traditional system, and every sixth year in the organic system trying, to avoid rotation problems.

In the intensive system it is more difficult to predict a more frequent rotation. The result of the transgenic work to give resistant cultivar is uncertain. It is assumes rape seed cultivation every third year in the intensive system.

7.5.4. Fertiliser use

Yield also depends of the use of fertiliser. The recommendations in Sweden in a traditional cultivation system is 140 kilo N/hectare to winter rape, depending on the rape seed price (Wallenhammer, 1998). Norwegian tests shows profit with increasing N up to 140 kilo a hectare to spring rape seed (Sogn, 1984). In practical cultivation farmers in Østfold use 180 kilo N/ha to winter rape, 160 kilo N/ha to spring rape and 140 kilo N/ha to spring turnip rape (Lindmark, 1998). This is also the amount of fertiliser that gives the best economical result (Lindmark, 1998).

Protein content increases with increasing use of fertiliser, and it is a negative relationship between protein- and oil content. Therefore much N-fertiliser gives a decrease in oil yield.

Others characterise such amounts as a very intense use of fertiliser. Fertiliser gives response up too 120 kilo/ha (Enge, 1998). In the national average estimate, in the intensive and the traditional system, it is used:

- 170 kilo N/ha to winter rape
- 150 kilo N/ha to spring rape
- 130 kilo N/ha to spring turnip rape.

It is not possible to describe the organic system in a similar way. The use of fertiliser depends more on the whole rotation and the soil fertility. Taking this into account a normal recommendation in Sweden is 110 kilo N/hectare. In this study the following amounts of fertiliser (livestock slurry) are used for calculations on the organic system:

- 110 kilo N/ha to winter rape
- 95 kilo N/ha to spring rape
- 80 kilo N/ha to spring turnip rape.

It is very difficult to change the genetic characteristics for yield with genetic engineering. Yield depends on many genes in the plant (Gullor, 1998). The possible increase in yield by genetic changes has not been.

7.5.5. Seed yield

The average seed yield in Norway is about 1,7 tons hectare with spring turnip rape. In Sweden the average yield today from winter rape is 2,55 tons/hectare and from spring rape 1,65 t/hectare (Wallenhammar, 1998). The yield of winter rape in Norway in year 2005 is assumed to be 3 tons, spring rape at 2,5 tons and spring turnip rape at 2 tons a hectare both in the intensive and the traditional system. This gives an average yield on 2,5 tons a hectare with one third of each cultivar in these systems.

There is no organic cultivation of rape seed in Norway today. In Sweden the cultivation is in a very beginning. There are large variations from one year to another and between farmers: 500-3000 kilo/hectare (Bjørnberg, 1998). An estimate average yield today is 1 tons a hectare (Bjørnberg, 1998). It is assumed that the average yield in year 2005 is 1,5 tons a hectare.

These yield estimates are very optimistic in all three systems.

7.5.6. Oil content

The oil content in rape and turnip rape cultivated in Norway today is about 42 %. This gives an oilyield in the traditional system today of 670-760 kg a hectare. There is an oil seed cultivar (Express) today with oil content of 47 % (Jonsson, 1998). But cultivar with high oil content is often linked with medium or small seed yield and opposite, cultivar with a high seed yield often have a medium oil content.

It is possible to increase the oil content both with traditional breeding methods and with genetic engineering. The breeding company Svalöf Weibull in Sweden expects a 20 % increase in oil content with genetic engineering from the present cultivars (Jonsson, 1998). This will give an oil content of 55-60 %. It is very optimistic to expect these results already in year 2005. It is more realistic to achieve this by year 2010.

It is not sure that Svalöf Weibull is in a position to develop genetic modified oil seed (Jonsson, 1998). This depends on three aspects:

1) Licence. The company needs a licence to use patented genes.
2) Acceptance –formal: There is an opposition against genetic engineering in EU. The company is depended on decisions in EU.
3) Acceptance-public: In Sweden the company is depended on public acceptance.

Genetic engineering is not allowed in organic farming. The scepticism is also very high in the traditional agriculture and in the public opinion. No use of genetic engineering is assumed in the traditional system. In the intensive system a 55 % increase in the oil content of the seeds from the use of genetic engineering is assumed.

7.5.7. Overview of the assumptions made for the agricultural systems

The assumptions for each agricultural system are summarised in Table 6. These assumptions are optimistic, especially the available land, the yield and the genetic engineering.

It is only possible to reach the replacement percentages in these systems with a very active policies to develop biodiesel. Today there are no such policies.

Table 6 *The assumptions made in the agriculture systems*

Agricultural system	Available land (hectare)	Oil seed cultivation frequency (year)	Annual land use (hectare)	Ave-rage yield (tons/ha)	Oil content (%)
Organic	250.000	6	42.000	1,5	45
Traditional	300.000	5	60.000	2,5	45
Intensive	300.000	3	100.000	2,5	55

7.6. The replacement potential

The use of autodiesel in Norway was 1,3 mill m^3 in 1991 and 1,8 mill m^3 in 1997. This is an increase of 36 % between 1991 till 1997. In 1994 the use of autodiesel in heavy vehicles was 664.000 tons. This was approximately 50 % of the total autodiesel consume in 1994 (OFV, 1998).

Ministry of Transport and Communications has given an estimate on transport of people and goods from 1995 till 2005 (Ministry of Transport and Communications, 1997). As shown in Table 7 the increase is expected to be lower in this period than in the past.

Table 7 *Increase in people and goods traffic 1980-95, and expected increase 1995-2005 (percent/year)*

	People	Goods
1980-95	2,0	2,6
1995-05	1,2	1,9

Taking into account the more energy-efficient engines in 2005, one can estimate the total consume of autodiesel in year 2005 to be approximately 1,7 mill tons, and approximately 900.000 tons in heavy duty vehicles. The result of the analysis is shown in Table 8.

Table 8 *The replacement potential with three different agriculture systems in year 2005 (tons and percent)*

	Autodiesel consumption in heavy duty vehicles	Intensive agriculture	Traditional agriculture	Organic agriculture
Tons	900.000	156.240	76.680	32.220
%	100	17,4	8,5	3,6

The intensive agricultural systems could reach a substantial replacement of mineral diesel with RME, at approximately 17 %. The most important uncertainity in this system is the available land for rape seed production. This depends on the rotation plan and the amount of total available land. The intensive system represents a very large change in the Norwegian agriculture and land use today.

The traditional system could, to some extent, reach a substantial replacement of mineral diesel with RME, at approximately 8 %. This system is closest to the agriculture practice in Norway today. A very active policy for biodiesel use and production is needed to reach this potential. The main factor to explain the different replacement potentials from the intensive system is the available land due to the rotation plan. The traditional system has only 60 % of the land used in the intensive system, available every year.

The organic system can only replace about 3 % of the mineral diesel. The main factor is less available land for rape seed cultivation every year, both from less intensive rotation and less available land totally in this system.

7.6.1. Sensibility analysis

Many of the assumptions in the agricultural systems are optimistic. In this chapter the results from a sensibility analysis, which also will give information on barriers, is presented. The analysis examine the following changes:

- 100.000 hectare reduction of available land in all systems. This gives rape seed on 67.000 hectare every year in the intensive system, 40.000 hectare in the traditional, and 25.000 hectare a year in the organic system.

- Reduction in yield: No winter rape and more spring turnip rape: 1/3 spring rape and 2/3 spring turnip rape. This represents about 12 % reduction in yield.

- Change in rotation:

1) Rape seed every fourth year in the intensive system and every sixth year in the traditional system. No changes in the organic system.

2) Rape seed every second year in the intensive system, every fourth year in the traditional system and every fifth year in the organic system.

- No genetic engineering. Oil content at 45 % in all systems. This only gives changes in the intensive system.

The results of the sensibility analysis are summarised in Table 9.

Table 9 *Sensibility analysis. Mineral diesel replaced with biodiesel (Potential in %)*

Changes	Replacement potential in the 3 agricultural systems		
	Intensive	Traditional	Organic
No changes (Table 8)	17,4	8,5	3,5
Land reduction	11,6	5,7	2,1
Less intensive rotation	13,0	7,1	3,5
No winter rape	15,3	7,5	3,1
Oil content at 45 %	14,2	8,5	3,5
Oil content at 55 %	17,4	10,4	3,5
More intensive rotation	26,0	10,1	4,3

The analysis demonstrates clearly that major changes in all agriculture systems have small or moderate influence on the replacement potential. The changes (presented as percent-unit changes) in the replacement potentials can be summarised as follows:

- use of winter rape gives 0,4-2 % change in replacement potential
- increased oil content from transgenic plants (with oil 55 % oil content) gives 1,9 % (traditional system)
- less intensive rotation gives 1,4 - 4,4 % change
- reduction in available land gives 0,65-5,8 % change

These changes have the largest effects in the intensive system due to the larger scale in land use from the intensive rotation. More intensive rotation, with rape seed every second year in the intensive system, gives a substantial change in replacement potential, an increase to about 26 %.

A more intensive rotation, to every second and fourth year in the intensive and traditional system, respectively, will however increase the problems with diseases, pests and weed control.

The land use, both the available land and the rotation plan, are the main factors explaining the difference in replacement potential in the three systems. Changes in available land and rotation have larger effects in an intensive system than in a more extensive system. The uncertainty of the replacement potential is therefore larger in this system.

The analysis shows the strong limitations in agricultural production of RME. The scale in possible agricultural RME production is quite different from the diesel consumption in the transport sector today.

7.7. Barriers to reach a substantial use of biodiesel

The assumptions of land use and yield are optimistic in all systems. Also the oil content and the rotation cycle in the intensive system are optimistic assumptions. The replacement potential is limited to 8-9 % in the traditional system and to 17 % in the intensive system. It is more realistic to reach this in year 2010 than in 2005. In any case, an active policy to develop RME production is needed.

The analysis identifies two main barriers to increase the replacement potential above this level: available land and climate. In the best agricultural areas the land is limited to 330.000 hectare. In the other parts of Norway the climate is too cold or wet for oil seed cultivation.

Table 10 *Barriers at various RME replacement levels*

Replace-ment	Intensive		Traditional		Organic	
(%)	Reached?	Main barrier	Reached?	Main barrier	Reached?	Main barrier
5	Yes	Agricultural Policy	Yes	Farmer & economy	No	Land & rotation
15	Yes	Land & rotation	No	Land & climate	No	Land & climate
30	No	Land & climate	No	Land	No	Land

As shown in Table 10 it is possible to reach 5 % replacement both in the intensive and in the traditional system. The main barrier in the intensive system on this level is not physical, but political and institutional. Environmental aims and principles are important in the agricultural policies in Norway (Ministry of Agriculture, 1992). The intensive system is not sustainable due to the rotation plan of rape seed cultivation every third year. The environmental impacts will make it difficult to obtain public and political acceptance for such an agricultural system.

To reach a replacement of 15 %, which is possible in the intensive system, the most insecure factors are available land (300.000 hectare for rape seed) and the rotation assumption of rape seed cultivation every third year. To reach 30 % replacement, the main barriers are land and climate. If rape seed could be cultivated on all agricultural land in Norway it would however be possible to reach this replacement percentage in the intensive system.

In the traditional system the main barriers to reach a 5 % replacement is linked to the farmers. Rape seed is more difficult to cultivate than grains, and more efforts from the farmers are needed. The grain cultivation in Norway has become less profitable the last five years. More farmers have switched to full time work outside the farm, and the cultivation has become less important for the farmers.

The ratio between oil seed and corn price has decreased the last years. In these context it is difficult to increase the oil seed cultivation in Norway (Fjærestad, 1998).

The County Agricultural Consulting in Østfold (in south-eastern Norway) is working to increase the oil seed cultivation. They have identified barriers in a survey of farmers. The study identified these barriers: unsuitable storage and drying facilities, lack of machinery to harvest the seed, and perform other necessary steps in the cultivation process. According to the consulting experience, Lindmark (1998) has concluded that these are not the main barriers, but more what the farmers prefer to express. The consulting conclusion is that the real barriers are lack of knowledge. The farmers need motivation and information (Lindmark, 1998).

From this one can summarise the main barriers to reach 5 % replacement in the traditional system to be:

- Farmer attitudes and interests
- Knowledge among farmers
- Farm economy

To reach the whole replacement potential of 8-9 % in the traditional system, the most uncertain factor is available land. All land suitable for rape seed cultivation has to be used. A replacement of 15 % or higher is not possible to reach in the traditional system. Available land and climate are the main limitations. If it was possible to cultivate rape seed on all agricultural land in Norway, it could be possible to reach 15 % replacement.

In the organic system it is not possible to reach a substantial replacement of mineral diesel with biodiesel. The main barriers are available land and climate. A more intensive rotation of rape seed cultivation every fifth year would increase the replacement potential to 4,3 %.

7.8. Effects on emissions of greenhouse gases

Emissions of di-nitrogen-oxide (N_2O) from rape seed cultivation have large effects on the total CO_2 -balance in RME production and usage (Figenbaum, 1995). In this chapter, the effect on the CO_2 -balance of using updated estimates on N_2O-emission, based on new data from Statistics Norway, are presented.

The two largest by-products from RME-production are glycerol and rape seed meal. The calculation of the environmental effects of RME-use is to a large degree dependent of whether the use of these products are considered or not (Figenbaum, 1995; Scharmer & Gosse, 1996). In this chapter the use of rape seed meal is considered in detail.

7.8.1. N_2O -emissions

The N_2O -emissions are not only an impact from cultivating rape seed, but from all agricultural cultivation. These are the most important factors for N_2O -emissions from agriculture:

- Industrial production of fertiliser
- Use of mineral fertiliser and manure
- Runoff/leakage from mineral fertiliser and manure
- Decomposition of plant-material (plant-rests).
- Nitrogen-fixation by bacteria

- Livestock on pasture

In the estimates of N_2O the three first factors are included. Table 11 shows the percentage of nitrogen in fertiliser and runoff that ends up as nitrogen in N_2O.

Table 11 *N_2O -factors from production, use and runoff of fertiliser*

Source	Factors
Production of fertiliser	0,54 % N in fertiliser as N in N_2O
Use of fertiliser/slurry	1,25 % N in fertiliser as N in N_2O
Runoff/leakage	2,5 % of N in runoff as N in N_2O

Source: Rypdal (1998) and Jevne (1998)

In this study, the same amount of N-runoff per hectare in the organic system as in the intensive and traditional system is used. This is however probably associated with some errors. One can however expect much less runoff from the organic system (Gabrielsen, 1990). On the other hand, the N_2O -emissions from N-fixation and livestock on pasture, factors which should have been included in the organic system, is not included.

The results from the N_2O calculations from rape seed cultivation with the three factors from Table 11 are shown in Table 12.

Table 12 *N_2O -emissions from rape seed cultivation (Kilogram N_2O/hectare)*

	Intensive/Traditional agricultural system	Organic system
	Mineral	Manure
Fertiliser	150	95
Production of fertiliser	1,27	0
Fertiliser usage	2,95	1,87
Runoff/leakage	1,12	1,12
Total	5,34	2,99

The intensive and the traditional system will result in emissions of 0,0214 kilogram N_2O per kilogram rape seed produced. The corresponding figure for the organic system will be 0,0199 kilogram. On a land area basis, the emissions of CO_2 will be 1655 kilogram per hectare for the intensive and the traditional system, and 925 kilogram per hectare for the organic system.

The errors in the N_2O factors (Table 11) are however significant. The uncertainly is +/- 50 % (Rypdal, 1998). Taking these errors into account the results will change significantly (Table 13).

Table 13 *The degree of uncertainty in connection with N_2O -emissions from the intensive and traditional system*

	Baseline	+50 %	-50 %
Kilogram N_2O/ kilogram rape	0,0214	0,0320	0,0107
Kilogram CO_2eq/ hectare	1655	2483	828

Source: New estimates used on data from Figenbaum (1995).

The results from the study by Figenbaum (1995) indicate a reduction of 1,90 kg fossil CO_2 emissions per kilo RME used (by-products included). These reductions represent 60 % of the total CO_2 -emissions from mineral diesel use. Using the data from Figenbaum (1995), with the new estimates on N_2O -emissions, one can get the results shown in Table 14.

Table 14 *Effects from N2O –emissions on reductions of greenhouse gases*

	N_2O – emissions of CO_2 –eq. (hg/hectare)	Net reduction (kilogram CO_2 / kilogram RME)	Net reduction (percent)
Figenbaum (1995)	636	1,90	60
This study	1655	0,55	17
Uncertainty – 50 %	828	1,60	50
Uncertainty + 50 %	2482	-0,50	+ 15

The lowest estimate in the calculations (-50 %) reduces the CO_2 – emissions to the same level as in Figenbaum (1995). But the middle estimate results decreases the CO_2 -emissions from RME use to only 17 % compared with mineral diesel. The “highest” estimate (+50 %, Table 15) actually gives a 15 % *increase* in CO_2 emissions with RME compared with the use of fossil diesel.

If the new estimates of N_2O emissions are correct, then the positive environmental effects from the use of RME are small and uncertain. More research is however needed to conclude whether N_2O -emissions eliminate the positive effects on greenhouse gas emissions connected to the use of RME.

7.8.2. Rapeseed meal

Here a study of the effects from rape seed meal as a by- product from RME production is presented. If the rape seed meal can replace other raw materials in protein concentrate, this will give positive effects on the CO_2-balance.

The amounts of possible rape seed meal production in the three agricultural systems are shown in Table 15.

Table 15 *Rapeseed meal from RME production (tons/year)*

	Intensive	Traditional	Organic
Rape meal	112.500	82.500	34.650

From 1985 to 1990 the use of soybean-, rape seed- and guar meal amounted to approximately 180.000 tons in Norway. Rapeseed meal can replace other proteins such as soybean, herring and meat and bone meal (Sterten, 1998). It is however not possible to replace the total amount of these protein sources with rape seed meal due to of the strong taste of rape seed (Tørvi, 1998).

The amounts of protein concentrate use in Norway from 1985 to 1995 are shown in Table 16.

Table 16 *Use of protein concentrate in Norway 1985-1994 (1000 tons) (Import data in parenthesis)*

	1994	1992	1990	1988	1985
Rape-seed meal	29 (29)	41 (41)	77 (77)	88 (88)	79 (79)
Soybean meal	43 (43)	67 (67)	82 (82)	104 (104)	81 (81)
Guar meal	4 (4)	18 (18)	32 (32)	27 (27)	27 (27)
Maize gluten meal	16 (16)	-	-	-	-
Rape-seed	12 (-)	12 (7)	15 (8)	17 (9)	22 (3)
Other proteins	275 (63)	252 (81)	206 (34)	-	-

Source: Statistics Norway

The industries manufacturing protein concentrates use different upper limits of rape seed in the protein meal, but all in the range of 3-8 % (Tørvi 1998; Sterten, 1998). Rape meal and rape seed constitute 7 %, in weight, of the total protein concentrate in 1997. The potential rape meal use in the total concentrate production in Norway is tabulated in Table 17.

Table 17 *Potential rape meal in total concentrate in Norway (1000 tons)*

	1994-97	2005
Total concentrate	2.000	2.100
7 % rape meal	140	147
Intensive system		112

7.8.3. Conclusion

The analysis shows that all the rape meal produced in all the agricultural systems could be used in the concentrate industry. The positive CO_2 -effect from rape seed meal could therefore be added in the CO_2 -balance for RME.

7.9. Other environmental impacts

The main issue in this chapter is to analyse to what extent there are other important environmental impacts related to the three different agricultural systems. The changes in environmental impacts from the three systems, according to the agricultural practice today, is described. The impact from the oil seed cultivation, in the three systems, compared to the present agricultural system is analysed.

The analysis includes the following topics:

- The use of transgenic plants
- The use of pesticides and herbicides
- Landscape values and erosion
- The use of fertilisers

7.9.1. Transgenic plants

Transgenic plants are used in the intensive system to increase the oil content of the seeds, and to obtain resistance to the pesticide Glyphosate, and resistance to fungus- and insects. The use of fungicides and insecticides are expected (by the producers of the plants) to be reduced when using genetic resistant plants.

But other effects are also reported. Destruction of all of the rape plant after the harvest, in order to prevent resistant genes to spread, might result in a shift to the use of more harmful herbicides (Scharmer & Gosse, 1996). The result could also be that weeds, insects and fungus adjust to the new transgenic plant. In traditional agriculture, with monoculture and intensive cropping, problems with weeds, pests and plant disease when pesticides are used are common.

Another main uncertainty with transgenic plants is the scattering of genes and other substances to other plants and organisms. Such scattering might imply the following:

- Resistant gene scatter to other crops and wild plants
- Resistant genes scatter to weed in the field
- DNA can transfer in the soil and into soil microorganisms
- Substance made by genetic engineering, e.g. insects poison, scatter to other plants and organisms
- Unknown effects

Several examples of these effects have already been discovered. In Niedersachsen in Germany, herbicide resistant rape has been tested. The resistant gene is found in normal rape plants 200 metre from the test field (Forbrukerrapporten, 1998).

Unknown effects from the transgenic maize made by Novartois are also discovered. The poison made by genetic engineering in maize to kill harmful insects, also kills other more friendly insects (Nationen, 1998).

Transgenic seeds or plants spread to an organic farm can imply dramatic consequences for the farm economy. Organic products are marketed with the quality “without any genetic engineering”. The demand for the farmers products will probably decrease when genetic pollution is known to the consumers. This could also have a general effect on all organic farming because the consumer can not know if the products contain modified genes or not.

Possible negative environmental effects from the use of transgenic rape seeds include:

- Reduction in plant biodiversity in the field and the surroundings
- Reduction in biodiversity of other organism in the environment
- Increase in the use of herbicides, fungicides and insecticides
- Unknown effects

7.9.2. Pesticides and herbicides

In the intensive and the traditional system pesticides and herbicides are used. Pesticides used in oil seed cultivation in Norway are listed in Table 18.

Table 18 *Pesticides used in oil seed cultivation in Norway*

Herbicides	Insecticides	Fungicides
Propachlor *	Alfacypermentrin	Metalaksyl *
Chlopyralid	Deltamentrin	Iprodion
Pyridate[7]	Esfenvalerate	Vinklozolin *
Propaquizafop	Lambdacyhalotrin	
Sethoxydim	Diazinon *	
Cycloxydim		
Triallate		
Glyphosate *		
Glufosinate		

Source: Norwegian Crop Research Institute (1997).

* In the monitoring program on pesticides (JOVÅ-program) these protectants, among 30 others, have been traced in water (groundwater, wells, drain-systems and surface water) by Centre for Soil and Environmental Research.

In the traditional system Glyphosate can be used before and after the growing period. In the intensive system transgenic rape seed with Glyphosate-resistance makes it possible to use this protectant in the growing period.

[7] Not in colza

In the JOVÅ program they it was found pesticides in 10 of 11 tested grains and also in small rivers. In 75 % of the tests pesticides was detected. 14 different pesticides were found. In most cases the concentrations measured were below the known harmful level. The following substances were found in 1995 and 1996:

- 2,4 D - H
- bentazon - H
- dichlorprop - H
- *dimetoat* - I
- fenpropimorf - H
- *linuron* - H
- *mankozeb (ETU)* - F
- metalaksyl - F
- MCPA - H
- mekoprop - H
- *metribuzin* - U
- *metamintron*
- *propaklor* - H
- propikonazol - F
- simazin - H
  - H= Herbicides
  - F= Fungicides
  - I= Insecticides

In 6 of 11 test places findings of levels harmful for water organisms were found. Six different substances are included on the list of compounds harmful for water organisms, according to the European Plant Protection Organisation (EPPO) risk index. These substances are marked (written in *cursive* letters) above. In 1997 the following additional substances were found:

- Aklonifen
- Chlorfenvinfos
- Glyphosate.

Most findings were in areas with potato- and vegetable cultivation. Only a few findings were in areas with mainly grain cropping. Centre for Soil and Environmental Research at Ås has the following comments to the program:

- Little knowledge exists on the combined effect of the substances, and on the more chronic effects of low concentrations.

- The test program clearly shows that some pesticides use considerable more time to disintegrate than expected from the product data supplied by the manufacturers. An explanation could be low soil temperature and much humus in Norwegian soil.

- The tests show that pesticide residues can penetrate into deep groundwater wells.

Pesticides in the environment

The JOVÅ program demonstrated that plant protectants do not disintegrate as fast as expected. The “non-possible effect”, as stated by the producers and also the plant protectant authorities in Norway, has occurred. Residues exceeding the limit of safe levels, of the six pesticides marked above, are found in ground water and surface water.

The concentrations of Glyphosate measured did not exceed the limit for safe levels. But the producer states that the substance disintegrate very fast in the soil. This has been marketed as an environmental advantage. The findings however show that this is not correct. In this study this is important in relation to the use of herbicide-resistance transgenic rape seed in the intensive system.

One should also take into account that the harmful level is determined from today’s knowledge of effects. The effects from many substances are not tested and are not known. Using the precautionary principle, as stated in the report: “Our Common future” by the UN World Commission on Environment and Development (Bruntland et.al.,1987), there are good reasons for being critical to the use pesticides in general.

Our general conclusions are therefore:

- Pesticides used in oil seed cultivation are found in surface water in agricultural areas in an amount that could be harmful for organisms in the water.
- Pesticides have, taking into account the known effects, negative properties and environmental impacts.

Pesticide use in the different systems

More intensive oil seed cultivation than every fifth or sixth year gives increasing problems with fungus, weeds and insects. There is scientific consensus that this is the case (Wallenhammar, 1998; Uhlen, 1998b). The problems are demonstrated in practical farming in Skåne, Sweden, were oil seed every fourth year on large areas was normal earlier. The problems from pests, disease and weed control are among the reasons why the oil seed cropping in this area has decreased (Wallenhammer, 1998).

An intensive rotation, as conducted in the cabbage cultivation in Lier, Norway, is also assessed to be not sustainable (Hermansen, 1998). The intensive system in this study is closely linked to this kind of agriculture. It is well stated that rape seed every third year (as in the intensive system), will give large problems with fungus, insects and weed control and thereby an increase in the need for pesticide use.

In theory, the fungus- and insect problems could be solved with genetic engineering, which again will reduce the need for pesticides. The experience from traditional breeding is however that resistance gives less effect after some years. The fungus and insects adjust to the new properties of the plants, especially in intensive cropping systems. The effects on pesticide use are therefore very uncertain.

The largest amounts of pesticides use are the use of herbicides in weed control. This use will probably not decrease with the introduction of more transgenic plants. Glyphosate resistance (and other kinds of pesticide resistance) would probably result in an increase in the use of herbicides. The less harmful effect of Glyphosate compared to other pesticides is not documented. The JOVÅ –program has shown that Glyphosate does not degrade as fast as expected. In account to this, the farmers have to use other herbicides to kill all rape after harvest, before next growing period.

The total effects of genetic resistance could probable be an increase in the use of pesticides in the intensive agriculture system.

In the traditional system, with rape seed every fifth year, the increase in biodiversity normally results in less problems with plant diseases and pests, compared with a traditional grain crop rotation (wheat, oat and barley). Insects more easily attack oil seeds than grains, and insecticides are needed. Oil seed also make it possible to use herbicides that are not permitted in barley, oats and wheat, thereby improving the weed control. This will probably increase the use of herbicides. In the traditional system one should expect an increase (or use at the same level) of pesticides as without oil seed cultivation.

If one intensify the traditional system to cultivate rape seed every fourth year one could expect a substantial increase in problems with fungus, insects and weed, and increasing use of chemicals (plant protectant) trying to avoid these problems.

In organic farming the use of chemical protectants is not permitted. Rotation is the main method to avoid problems from weed, fungus and insects. In addition is weed control by harrowing much used.

7.9.3. Landscape values and erosion

The esthetic values of agricultural landscapes differ with the rotation plan. Compared with only grain cropping, oil seed in the intensive and the traditional system will increase the landscape values.

Also in the organic system, will oil seed increase the landscape values, but with less extent than in the traditional system, due to the diversity of the organic system also without oil seed cultivation.

The intensive and the traditional system represent a continuation in the specialised farming in central eastern Norway. This causes more erosion than diverse cultivation with grass, grain and oil seed as in the organic system. More winter crop such as winter rape seed could however reduce these problems. The change to more spring ploughing has also given reduction in erosion, but the use of grass in the rotation will give even better effects.

In the organic system will oil seed cultivation replace other arable crops such as barley, oats and wheat. It will therefore not have any major influence on the erosion.

7.9.4. Fertiliser and N-leaching

Nitrogen-leaching from agricultural fields are results of many factors and a complex connection between the factors. Use of fertiliser is just one of these factors. There is a relationship between the amount of N-fertiliser used and N-leaching. There is a degree of uncertainty associated with how strong this relationship is (Vedeld et.al.,1992).

Factors influencing N-leaching from agricultural land are:

- type of soil (class)
- natural drainage conditions
- organic matter in soil
- precipitation during the year
- temperature during the year
- yield
- chemical conditions and biological activity in the soil

Factors influencing N-leaching from the cultivation methods are (Vedeld, op.cit.):

- type of crop
- drainage conditions
- cultivation methods
- fertiliser amount
- fertiliser technique
- yield

The total supply of N for agriculture in Norway is much higher than the N content in the yield. A national nitrogen budget for Norwegian agriculture is given in Table 19.

Table 19 *Accounts of nitrogen in Norwegian agriculture (N in 1000 tons)*

Supply		Products for sale		Rest (losses)	
Industrial fertiliser	110 N	Animal	15,5 N	Manure	22 N
Biological N	8 N	Plant	3,5 N	Chemicals	3 N
Fall-out	5 N			Denitrification	20 N
Livestock in field	7 N			N-leaching	50 N
Concentrate(flour)	22 N			Rest	38 N
Others	3 N				
Total	155 N	Total	19 N	Total	136 N

Source:Kiland, 1996.

The rape seed cultivation in the traditional and the intensive system will not imply losses at these levels. In these systems the use of manure and concentrate (flour) is less than the national average. But the supply of N is still substantially higher than the demand. The yield of 2,5 tons per hectare contains 100-125 kilo N (Uhlen, 1998a). Only the supply of fertiliser (150 N) gives a substantial surplus of N.

In the scientific literature it is a well-known statement that increasing use of fertiliser over a certain level gives less increase in yield. Most of the Norwegian agricultural practice is above this level. Use of 150 N per hectare for rape seed cultivation is above this level.

The conclusion is that rape seed in the intensive and traditional system will give nitrogen losses on the same high level as in the present agricultural system.

7.9.5. Summary of important environmental impacts

In Table 20 is presented a summary of the environmental impact assessed above.

Table 20 *Important environmental impacts from rape seed cultivation in the three difference agriculture systems (Point of reference: the present agricultural system in Norway)*

	Intensive agriculture	Traditional agriculture	Organic agriculture
Modified genes & other substance scattered	Yes	No	No
Chemicals in Environment	Probably more use of pesticides	More or at same level	No
Agricultural landscape values	Higher value	Higher value	Higher value
N-leaching	Still on high level	Still on high level	Lower level
Erosion	Still on high level	Still on high level	Lower level

The system properties are described by comparing the system to the agriculture in Norway today.

In the intensive system it could be possible (in the best case) to reduce the amount of pesticides used due to less problems with fungus and insects (transgenic plants resistance). But other environmental problems from the transgenic plants arise. It may be possible to solve some problems, but others will be generated. In the worst case, the problems from genetic engineering will occur in addition to the problems from pesticides use. The intensive system is therefore not sustainable.

8. Final conclusions

Conclusions on national policies on biodiesel

National policies on fuels are strongly influencing the likelihood of increased biodiesel use in Norway. The governmental bodies that are considered to be the most important in planning and implementing national fuel policies have been identified. The activities of the respective ministries and agencies in this regard are described. Most of the information was gathered through interviews with representatives working in the different governmental bodies.

National authorities are however not planning and implementing policies totally on their own. To some extent the views of actors such as interest organisations are taken into consideration when planning policies. Therefore, interviews with 3 interest organisations/companies conceived to be important actors in influencing national policies on biodiesel were conducted. The 3 interest organisations/companies can be said to advocate the interests of the *biodiesel producers* (Habiol), the *fossil fuel producers* (NPI) and the *fuel consumers* (TL).

The Government is willing to subsidise research projects on alternative fuels and sometimes also the first period of commercial use. However, they are not in favour of long-term subsidising of alternative fuel use. The most important governmental activity in the area of alternative fuels is the funds on alternative fuels and environmental friendly technology within the transport sector. The interviews have revealed that the authorities have no intention to further increase its efforts in the area of alternative fuels in the years ahead. There is no national goal regarding future use of alternative fuels in Norway. The authorities have no particular opinion regarding which alternative fuels to promote. It is up to the market to decide which alternative fuels that is to increase in use the next years. In an introduction phase of an alternative fuel, the Government is willing to subsidise the use of it. However, in the long run it has to be competitive to petrol and mineral diesel.

According to the Government, the taxes imposed on fuels are to reflect the real socio-economic costs of their use. In the opinion of the

Government, it is only the tax component related to environmental effects that ought to vary. For biodiesel this means that it only ought to be exempted for the CO_2-tax. The production costs of biodiesel are, however, several times higher than the production costs of fossil fuels. If biodiesel is to be exempted only for the CO_2-tax, it is not likely that a marked for biodiesel use in Norway will be created. Today biodiesel in Norway is exempted for also the auto diesel tax. However, as pointed on in this report, if the use of biodiesel in Norway rise substantially, it is likely that the auto diesel tax exemption will be removed.

The Norwegian Petroleum Association dislikes such a policy. In its opinion, it is meaningless to subsidise alternative fuels in an introduction phase if the alternative fuels cannot be competitive with fossil fuels in the long run. If the Government wants to phase in a new type of fuel, it has to create stable and long-lasting framework conditions for the new fuel, in order to avoid useless investments. NPI is also of the opinion that the taxes on fuels anyway ought to reflect the socio-economic costs of their use.

Habiol is satisfied with the Government’s policy on biodiesel. The auto diesel tax-exemption has created an opportunity for Habiol to introduce biodiesel as a fuel in Norway. However, Habiol is not satisfied with the level of the CO_2-tax on mineral diesel and petrol in Norway. In the opinion of Habiol, the CO_2-tax has to be risen substantially in order to internalise the external costs related to the climate change effects of fossil fuel use. It is also a necessity for Habiol that biodiesel continues to be exempted for the auto diesel tax.

The interest organisation for the bus companies, TL, wants the Government to have a more clear strategy in the area of alternative fuels. TL is always interested in improving the environmental image of buses. It is therefore prepared to respond to any governmental strategy in this area. However, the bus companies have to be supported by financial incentives if alternative fuels, biodiesel included, is to be used to a larger extent than today.

This study has also identified the barriers that the different institutions consider as the most important in relation to increased use of biodiesel. The institutions had similar opinions in this regard. The price of biodiesel was seen as the dominant barrier. This is especially the case for buses, since busses use mineral diesel that is exempted for the auto diesel tax. However, the presentation of national fuel policies in this report, also showed that it is likely that the tax-exemption for busses will be removed from the year 1999. The limited amount of biodiesel possible to produce was also seen as a barrier. Most of the institutions questioned the environmental friendliness of the fuel. Especially the increased emissions of NO_X were seen as problematic.

Company strategies

The bus companies face the following important barriers related to implementing strategies for biodiesel use:

1) The price on biodiesel is higher than mineral diesel. This might change if the tax-exemption of mineral diesel is removed for public transport.

2) Access to biodiesel, the lack of a well-established distribution network

Measures for reducing the price disadvantage for alternative fuel is up to national authorities to implement. This concerns central parts of national fiscal policy such as the general level of taxes and charges and the differentiation of this level among different fuel types and transport modes.

The establishment of a distribution network for alternative fuels is more up to the transport companies as a general trade. One should expect that transport trade organisations could take part in such an activity, either in co-operation with national authorities or with the oil companies which currently run the distribution network for traditional fuel. For the oil companies to take part in such activity, one should expect strengthened environmental demands upon them from national authorities or from the general public.

Barriers related to the operation of biodiesel in winter

Biodiesel does not work as well as mineral diesel in cold winter temperatures. Due to this, special precautions must be taken when operating in cold weather. The use of special additives in winter-biodiesel represents potential environmental and health-related problems. Several of the most common winter-additives in use today are carcinogenic and exhibit potential pollution threats in the case of spillage and accidents.

Issues related to biodiesel production

In an intensive agriculture system, it is possible to replace a substantial quantity of mineral diesel with biodiesel in heavy duty vehicles in year 2005 (up to 17 % replacement). The main barriers to reach a replacement of 5-10 % in this system are:

- Agriculture policy (environmental concerns)
- Environmental impacts: Spreading of modified genes and other substances and probably more pesticide use.

In addition to these barriers a replacement on about 15 % will face barriers such as:

- Available land (all 300.000 hectare suitable for rape seed cultivation have to be used)
- Rotation plan (rape seed every third year on available land)

A replacement above this level (15 %) will face a climate barrier in the form of limitation of available land (2/3 of all agriculture land in Norway is not suitable for rape seed cultivation because of the climate).

In a traditional agriculture system it is possible to reach a 8-9 % replacement of mineral diesel with biodiesel in heavy duty vehicles in year 2005. The main barriers to reach a replacement at 5 % in this system is:

- Farmers attitudes
- Farmers knowledge
- Farm economy

In addition to this, main barriers to reach a replacement at 8-9 % is:

- Available land (all 300.000 hectare is suitable for rape seed cultivation have to be used)

- Climate (2/3 of all agriculture land is not suitable for rape seed cultivation due to the climate)

In an organic agriculture system it is not possible to reach a substantial quantity of mineral diesel with biodiesel in heavy-duty vehicles. The main barriers are:

- Available land every year according to rotation plan
- Available land according to possible land to rape seed cultivation (climate limitation)

It is possible to replace 3-4 % of mineral diesel with biodiesel in an organic agriculture system in heavy vehicles in year 2005 in Norway.

There are strong limitations in agricultural production of RME in Norway. The scale of possible agricultural RME production is quite different from the scale of diesel consumption in transport sector.

As shown in the intensive system it is possible to reach a substantial replacement of mineral diesel with biodiesel at 17 %. This can increase to 26 % with a more intensive rotation. The problem with the intensive system is that other environmental problems arise. A policy to produce RME by more intensive agriculture will give new and increasing environmental problems from agriculture.

This issue is also possible to show in the traditional system. If genetic plants with higher oil content is used in the traditional system the replacement increase with approximately 2 %. The environmental effect from this increase in replacement potential has to be compared with the environmental impact from use of transgenic plants.

Rape seed cultivation in the traditional and organic system, as previously defined, will increase the agricultural landscape values. An increase in rape seed cultivation in these systems will, according to present agriculture practises, cause environmental benefits.

Our estimates on N_2O -emissions from agricultural activities indicate a weakening of the argument that a transition into use of biodiesel has a very positive effect on reducing greenhouse gas emissions. This result is independent of the type of agriculture system if one use the factor N_2O /

kilogram RME. The organic system gives less N_2O per hectare, but also less amount RME per hectare.

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