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Opportunities and barriers for biodiesel and bioethanol in Germany, the United Kingdom and Luxembourg

Country studies and recommendations for policy makers

Christian Bomb

Supervisors

Tomas Kåberger

Bengt Lindner

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Published in 2004 by IIIEE, Lund University, P.O. Box 196, S-221 00 LUND, Sweden,
Tel: +46 – 46 222 02 00, Fax: +46 – 46 222 02 10, e-mail: iiiee@iiiee.lu.se.

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Abstract

Substitution of fossil transport fuels with biodiesel and bioethanol can lower greenhouse gas emissions, reduce dependency on oil and strengthen agriculture. This thesis describes, compares and analyses market penetration of biodiesel and bioethanol, as well as the socio-political context for biofuels, in Germany and the United Kingdom. General conclusions for policy makers wanting to design or change their biofuels policy are derived from the country studies. Specific recommendations on how to implement the European Biofuels Directive in Luxembourg are also given. In particular, it is argued that an obligatory biofuel quota scheme is most suitable for promoting biofuel use in Luxembourg.

Executive Summary

The use of biodiesel and bioethanol, the only transport biofuels that can currently be mass-produced, is growing in the European Union. Their current market share (2005) is around 1.2% of the diesel and petrol market, up from 0.45% in 2002. Member States have, through the "Biofuels Directive", set themselves the ambitious indicative target of a 5.75% market share, by energy content, in 2010. The substitution of fossil fuels with biofuels is considered to reduce greenhouse gas emissions, reduce dependency on oil and strengthen the agricultural sector. For biofuels to play a significant role in future, a number of conditions must be met, the following being the most important ones: sufficient amounts must be supplied at prices that are competitive with fossil fuels; the biofuels as well as compatible vehicles must be easily available to consumers. The first goal of this thesis is to find out to what extent these conditions were successfully met in two of Europe's largest fuel markets, Germany and the United Kingdom. I will not only address the national situtations, but also the European regulatory framework, that has a strong influence on developments in the Member States. From this comparative analysis a number of general conclusions for policy making will be derived. In the final section, specific recommendations on how to implement the Biofuels Directive in Luxembourg will be given. The following are my main findings:

The European regulatory framework

The Biofuels Directive has stimulated biofuel production since its adoption in 2003. 14 Member States have so far taken advantage of the provisions of the Energy Taxation Directive that allows them to (partially) exempt biofuels from excise duty. Since 2004 and 1999 the diesel and petrol quality standards allow the blending of up to 5% (vol.) biodiesel into diesel or ethanol into petrol. This has opened up large markets for biofuels as all vehicles must be compatible with such blends, which can be distributed via the existing fossil fuel infrastructure at little extra cost. On the other hand, the 5.75% target cannot be met through low percentage blends alone. The standards also set a summer vapour pressure limit for petrol that requires oil companies to adapt their refining and distribution practices for ethanol-petrol blends. A new biodiesel standard (2004) ensures fuel quality but, since it is based on the properties of rapeseed and sunflower biodiesel, complicates the use of other feedstocks. Stricter tailpipe emission requirements have led car manufacturers to offer fewer vehicles that can run on pure biodiesel or to charge a premium for an extra biodiesel sensor. While biodiesel and its feedstocks, similarly to crude oil, petrol and diesel, can be imported at low or zero import duties, high import duties reduce the price-competitiveness of undenatured bioethanol, produced at low cost in countries such as Brazil. Depending on the national biofuels legislation it may, however, be possible to avoid this tariff by importing ethanol as a denatured or chemical product.

Biodiesel and bioethanol in Germany

Germany is the biggest biofuel producer and consumer in Europe. Biodiesel produced from rapeseed oil is by far the dominant biofuel, bioethanol only appeared on the market in 2004 and still plays a marginal role. Biodiesel production and consumption have been steadily growing since the 1990s and are still showing strong growth today. In 2004 1.2 million tonnes of biodiesel were sold (25% in blends, 75% as neat biodiesel) and biodiesel had a market share of 2% of the road transport fuels market. Since the early nineties, when a farmers' association was set up to promote biodiesel, pure biodiesel has benefited from a large *de facto* tax subsidy (0.55€/l in 2005), making it price competitive with diesel. Increasing numbers of independent station operators have been willing to supply the fuel and manufacturers, in particular Volkswagen, have provided vehicles that could run on biodiesel as well as normal diesel at no

extra cost. Since 2004 the tax subsidy also applies to biodiesel and bioethanol in blends, and this led to further growth of the biodiesel sector and stimulated investment into bioethanol plants. The oil industry has accepted and taken up the blending of biodiesel, but rejects nation-wide introduction of ethanol-petrol blends, for logistic and financial reasons (even though bioethanol benefits from a tax rebate of 0.75€/l). The government is strongly supporting the use of biofuels, the domestic production of which is considered a key future industry and a means of reducing dependency on oil and supporting domestic farmers. Considerable amounts of public money have been invested into biofuels RDD. If current trends continue, Germany is likely to meet the EU indicative target of 5.75% market share by 2010.

Biodiesel and bioethanol in the United Kingdom

At the moment, the UK is only a minor player in the biofuels arena. In 2004 0.012 million t of biodiesel – 1% of the amount sold in Germany in the same year - and no bioethanol were sold; biodiesel had a market share of 0.03%. Since 2005, bioethanol is also used in Britain. The biofuels are only used for blending, there is no B100 market. Some biodiesel is produced domestically in small plants, from waste vegetable oil, animal tallow and imported soya and palm oil. The sector is, however, growing fast. Several larger biodiesel plants are under construction or have gone on stream in 2005, but no bioethanol plants have been developed beyond the planning stage. Tax incentives of 0.34€/l biodiesel or bioethanol have only been introduced in 2002 and 2005. Lower than in Germany, they have so far mainly stimulated the production of biodiesel from low-cost feedstocks and imports of Brazilian bioethanol. Most major oil companies have not taken up blending of biodiesel or bioethanol. Government sees biofuels as an expensive option to reduce greenhouse gas emissions and is hesitant to give them the additional support that is necessary to meet the EU target. It is expected to clarify its position in autumn 2005 and possibly introduce an obligatory biofuel quota. Without additional support Britain is unlikely to achieve a biofuels market share of 5.75% by 2010.

Implementing the Biofuels Directive in Luxembourg

I believe that the best way to promote the sales of biofuels in Luxembourg is through the introduction of an obligatory biofuel quota, as has been done in Austria and is being considered in the UK and Sweden. Such a scheme would require fuel suppliers to demonstrate that a minimum percentage of their yearly aggregate sales was biofuels. The quota would gradually increase to reach 5.75% in 2010. The scheme can be kept simple, with each supplier having to supply the same share of biofuels or allow the trading of certificates, providing greater flexibility but increasing the administrative burden. Extra costs incurred by fuel suppliers can be compensated by allowing them to be passed on to the end-consumers via the Luxembourg fuel price mechanism or by reducing excise duty on biofuels. An obligatory biofuel quota scheme allows suppliers greater flexibility and lower costs than the proposed Belgian scheme, the adoption of which is also being considered by government. A quota scheme provides a better guarantee than a tax exemption that the indicative target will be met. Furthermore, due to the low fuel excise duties in Luxembourg and tax competition with neighbouring countries, a full duty exemption is likely to be insufficient to stimulate biofuel sales. The quota scheme could also be designed to favour those biofuels that deliver the best CO_2 savings and are produced in a sustainable way. UK Government is expected to publish the results of a feasibility study on this issue later in 2005. Furthermore, clear government commitment is necessary to allow economic actors to plan ahead and the use of neat biofuels and high-percentage blends should be encouraged to meet the target. I also recommend to design policy in a way that allows low-cost bioethanol from non-EU countries to be imported without facing the high import tariff for undenatured ethanol.

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1 Introduction

1.1 Background: Transport biofuels in the European Union

In recent years, biomass derived transport fuels, such as bioethanol or biodiesel, have gained political support in the European Union. The use of automotive biofuels[1], as substitutes for fossil petrol and diesel, is considered to have three main benefits (International Energy Agency – Bioenergy, 2004):

- reduced emissions of greenhouse gases and air pollutants;
- reduced dependency on oil imports and increased security of fuel supply;
- creation of local and regional economic development opportunities, especially in rural areas by strengthening the agriculture and forestry sectors.

European Directive 2003/30/EC of 8 May 2003 (the "Biofuels Directive") recognises biofuels as a means of achieving the above targets and sets "indicative" targets for their market share. The target for 2005 is a market share of 2% of all transport petrol and diesel, based on energy content. The target for 2010 is 5.75%.

The consumption of biofuels in the EU is increasing (see Figure 1). While in 2002 biofuels only accounted for about 0.45% of total road transport fuel consumption in the EU-15 (European Environment Agency, 2004), it is expected to reach 1.2% in 2005 (Hodson - European Commission, Directorate-General Energy and Transport, 4 July 2005).

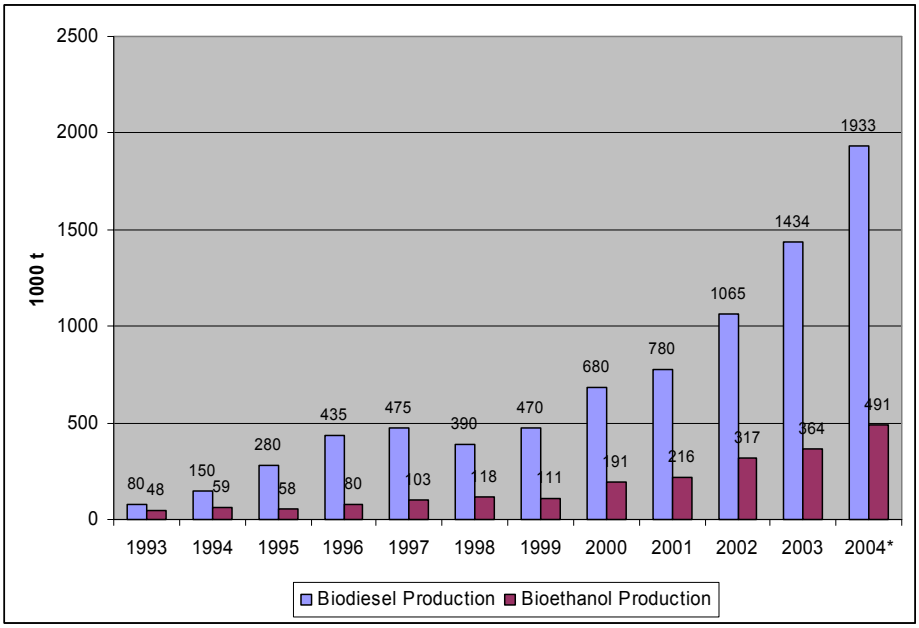

Figure 1: Production of biodiesel and bioethanol - the two most important transport biofuels - in the EU

(*): 2004 data include production in the 10 new Member States

Source: EurObserv'ER, June 2005

[1] In this paper I will use the terms "automotive biofuels", "transport biofuels" and, simply, "biofuels" interchangeably. Only road transport fuels, as opposed maritime or air transport fuels fuels, will be addressed.

The favourable political climate and the growing market for biofuels open up business opportunities for producers, importers and distributors of transport biofuels. In the short term, the only biofuels that can be supplied in significantly large quantities are "first-generation" biofuels biodiesel and bioethanol. Biogas (methane) is used to some extent as a transport fuel in Sweden, but is seen to have only a narrow potential for the moment. Other biofuels, such as biomethanol, bio-dimethylether, synthetic biofuels and bio-hydrogen are still under development and only produced in insignificant quantities. In 2004 79.5% of the total production (by mass) of biofuels in the EU was biodiesel, while 20.5% was bioethanol (EurObserv'ER, June 2005). This thesis addresses opportunities and barriers for the biodiesel and bioethanol sectors.

1.2 Purpose and research questions

The first purpose of this thesis is to describe, compare and understand the market penetration of biodiesel and bioethanol and the socio-political context for biofuel use in Germany and the United Kingdom. It aims to:

- describe the market penetration of biodiesel and bioethanol and the national context in which this "technological system" evolves (e.g. regulation, public opinion, behaviour of key actors);
- identify drivers and blocking mechanisms affecting the market penetration of biofuels;
- compare the different countries and see if the different national trends can be explained by differences in the national context.

The following research questions have guided my research:

- *What is the market situation and evolution (sales, production, import/export) for biodiesel and bioethanol in Germany and the UK?*
- *How does the regulatory framework promote or hinder the use of biodiesel and bioethanol?*
- *What is the view of opinion leaders (government/politicians, environmental organisations, the media) on biodiesel and bioethanol?*
- *How do key actors influence the development of the market situation for biodiesel and bioethanol?*
- *How do the market situations in the two countries differ and can these differences be explained by differences in the national context?*

The second purpose of the thesis is then to derive general conclusions from the two country studies that are helpful to policy makers in designing or adapting their national biofuels policy. Specific recommendations will be given to policy makers in Luxembourg, one of several Member States which have not yet implemented the Biofuels Directive. The corresponding research questions are:

- *What lessons can policy makers in Europe learn from the German and British biofuels experience?*
- *How should Luxembourg implement the Biofuels Directive?*

1.3 Justification of the research

This piece of research adds to the knowledge about how an alternative fuel can be introduced to a market and what barriers it faces. It is of particular interest to those who want to shape or participate in the development of a transport biofuels sector in the EU:

- It helps biofuel producers or suppliers to gain an overview of the opportunities and barriers they face if they want to bring biofuels to two of Europe's largest fuel markets.

- It allows policy makers to learn from the German and British cases, identify the obstacles that need to be overcome and the policy measures capable of stimulating the use of biofuels.

1.4 Methodology

This thesis is a case (or country) study, it examines and compares the cases of Germany and the UK. From these cases general recommendations as well as specific ones for a third country, Luxembourg, are derived. The unit of analysis are the products "biodiesel and bioethanol as road transport fuels", which are part of a technological system. I have chosen a number of variables (components) that characterise this technological system, such as biofuel producers, users, regulation, vehicle manufacturers and oil companies (see Section 3.2). I have gathered both quantitative (statistics from reports and databases) and qualitative data (e.g. descriptions, opinions) as observations on the variables. The following were my main data gathering methods:

1. Interviews: they were semi-structured interviews, based on a questionnaire which I had sent my informants in advance. Most of them were held over the phone, some face to face and some via email. Interviewees in the different countries were:

    a. Government officials responsible for implementing the Biofuels Directive

    b. Biofuels experts

    c. Trade association representatives of biofuel producers, oil industry, car manufacturers

2. Document review: I reviewed documents published by the key actors, such as legal documents (e.g. directives, laws, regulations, customs code), strategic policy documents, press releases and position papers, studies and reports, technical standards.

3. Media survey: I searched "Google News"[2] for articles containing the keywords "biofuel(s), bio-fuels, bioethanol, bio-ethanol, biodiesel, bio-diesel" and published by a German or British source on a daily basis from 1 June to 6 August 2005. The author's view on biodiesel and –ethanol was classified as "positive", "mainly positive, some negative aspects mentioned", "neutral", "mainly negative, some positive aspects mentioned" and "negative". "Positive" articles were those that gave the reader the impression that biofuels were something desirable, either because they are considered environmentally friendly, to reduce dependency on oil, to support the (rural) economy, to improve engine performance or a promising technology. Typical "negative" views considered the cost of producing biofuels and the necessary subsidies excessive, or

[2] news.google.com

highlighted negative impacts on the environment or engine performance due to biofuel production and use.

Data collection was pursued with "triangulation" at three different levels. Firstly, different informants with different functions were interviewed (government official vs. expert vs. biofuel producers vs. oil industry vs. car manufacturer). Secondly, three different data collection methods were used (interviews, document review, media survey). And thirdly data were collected for two different national contexts.

To present and analyse the data in a structured way and facilitate cross-country comparison I used an analytical framework based on work by Jacobsson et al. (e.g. Jacobsson [2005], Bergek et al. [2005], Jacobsson and Johnson [2000]). This framework will be presented in Section 3.

To get a wider overview of the biofuel situation in the EU I also collected on information on EU countries other than Germany and Britain, in particular Sweden, Belgium, France and Austria. However, these countries will only be touched upon in the thesis. Furthermore, I interviewed two representatives of the European Commission, responsible for preparing the Biofuels Directive and overseeing its implementation.

1.5 Justification of the methodology

Germany and UK were chosen because they are two of the largest EU Member States with large fuel markets. Their success or failure in promoting biofuels will have an important impact on the EU average. The two countries are interesting to compare because they have stark differences in national context: while Germany has been fostering a biofuels industry since the early nineties and has a government that is strongly pro biofuels, Britain's use of biofuels is much more recent, still at a low level and its government is ambiguous in its support for biofuels. I did not compare more countries to be able to gain a more detailed understanding of the two I decided to focus on. The trade-off was one of depth versus breadth. The reason why I chose to propose specific policy recommendations for Luxembourg was out of personal interest, familiarity with the national context and the fact the Ministry of the Economy expressed an interest in the study results.

Informants were chosen because of the following reasons: government officials play a key role in shaping biofuels policy, whereas biofuel producers, oil industry and automobile industry are key actors whose business decisions are crucial to the success and failure of these policies. Biofuel producers and importers supply the fuels, the oil industry controls most of the distribution infrastructure and the automobile industry provides the complementary product that is essential for their use, i.e. vehicles. I interviewed trade associations to avoid having to contact many individual companies to get an "average" opinion from the industry. "Independent" biofuel experts were interviewed to verify statements made by the lobbyists.

I chose to use semi-structured interviews as my main means of information gathering. The growth of European biofuels production and use is a very recent development and the sector and the corresponding policies are evolving very fast. Information from insiders taking part in this development was crucial to gather up-to-date information. Interviews with a limited number of key informants allowed me to gain a deeper understanding of the field than a quantitative survey with more respondents would have. By doing the interviews in a semi-structured way I could pursue new trajectories of questioning if new or unexpected information was given in the answers to the pre-defined questions.

The document review allowed me to verify statements made by the informants and to discover the finer details of the legislation, some of which I found out to have a large influence on the market for biofuels.

I carried out a small media survey to get an impression of public opinion on biofuels. The survey's goal is based on the assumption that media and public opinion are linked: media influence what the public thinks, and at the same time often try to be "in tune" with their audience, providing it with views they expect it to share. I used a rather crude method, only surveying information available on the world-wide-web and identified by "Google News", without making any attempt to establish the reach of the different news sources. I believe, however, that this simple, quick and cheap method was adequate to get a good first impression and confirm what my interviewees had told me, especially given the clear results.

Jacobsson's analytical framework was used because it was described in sufficient detail in the literature, had already been used for assessing the development of renewable energy technologies (e.g. photovoltaics in Germany) and was helpful to categorise information I gathered and facilitate comparison.

1.6 Scope and limitations

While I also looked at other countries, such as Sweden, Belgium, France and Austria, I only studied two countries, Germany and the UK in a systematic way. Looking systematically at more countries would have provided a broader set of data from which conclusions and policy recommendations could have been derived.

Furthermore, the field of biofuels is evolving rapidly and the information presented in the thesis risks being out of date rather quickly. For example, the UK government may announce a radically new biofuels policy in autumn 2005 and the German car industry association has made a complete U-turn in its stance on bioethanol over the last year.

Interviewing trade association representatives has allowed me to learn an "average" view, while that of the different members may spread over a wide spectrum. Readers should also bear in mind when reading about the positions of different actors and their associations that they have vested interests and may hide some of their motives: for example, while it seems plausible to me that there are indeed logistic problems associated with handling ethanol-petrol blends, these may well be over-exaggerated by oil companies who do not want to take up ethanol blending for other reasons. Uncovering the truth on such issues is difficult and some speculation remains.

Many of the numbers I quote in the thesis are based on estimates, averages and simplifying assumptions. They should be read with caution. They are inform about orders of magnitude and how variables compare (e.g. production costs of biodiesel and fossil diesel). Examples of such data are production costs, greenhouse gas balances, future fuel consumption, tax losses and crop yields. Biofuel crop yields are European averages derived from the literature; I did not check to what extent soil and climate conditions allow the different kinds of crops to be grown in Germany, Britain and Luxembourg.

1.7 Outline of the thesis

Section 2 will introduce the reader to automotive biofuels in general, and first generation biofuels biodiesel and bioethanol in particular. Their technical properties, advantages and disadvantages, "well-to-wheel" environmental performance and cost as an option to reduce

greenhouse gas emissions will be discussed. Section 3 presents the analytical framework I have used to identify driving and blocking mechanisms to the development of biodiesel and bioethanol use in the countries I studied. Before addressing the biodiesel and bioethanol sectors from a national perspective I will discuss the relevant EU regulatory framework in Section 4. This supranational framework creates important drivers and barriers for biofuels and has a strong influence on the developments in the Union's Member States. Sections 5 and 6 are devoted to the situation for biodiesel and bioethanol in Germany and the UK. I will first describe the evolution of the market situtation for the biofuels, then address the technological system's institutional components "regulatory framework" and "public opinion". Next, I will describe how the system's key actors "biofuel industry", "oil industry" and "automobile industry" are influencing the market situation for bioethanol and biodiesel. Having addressed the components of the system, I will then look at the strength of its functions to identify the main driving and blocking factors (see Section 3 for a discussion of the concepts *institutions*, *actors* and *functions*). In Section 7 the German and British cases are compared and it is discussed how the differing market situations for biofuels can be explained by differences in the national context. General recommendations for policy makers that can be learned from the German and British cases will be given in Section 8. In the remaining Section, the national fuel context of Luxembourg is described and assessed and recommendations on how to implement the Biofuels Directive are given.

2 Automotive biofuels: an overview

2.1 What are automotive biofuels?

Automotive biofuels are automotive fuels that have been produced from biomass. Biomass is plant or animal matter, such as wood, straw, vegetable oil, dung or animal fat. The energy it contains has been captured from solar energy through photosynthesis. Thus, transport biofuels are made from renewable sources. Globally, the only biofuels used in significant quantities are ethanol and biodiesel. There are also other biofuels, as well as different feedstocks and conversion processes to make them. The most important biofuels, feedstocks and conversion routes are shown in Figure 2 and discussed below.

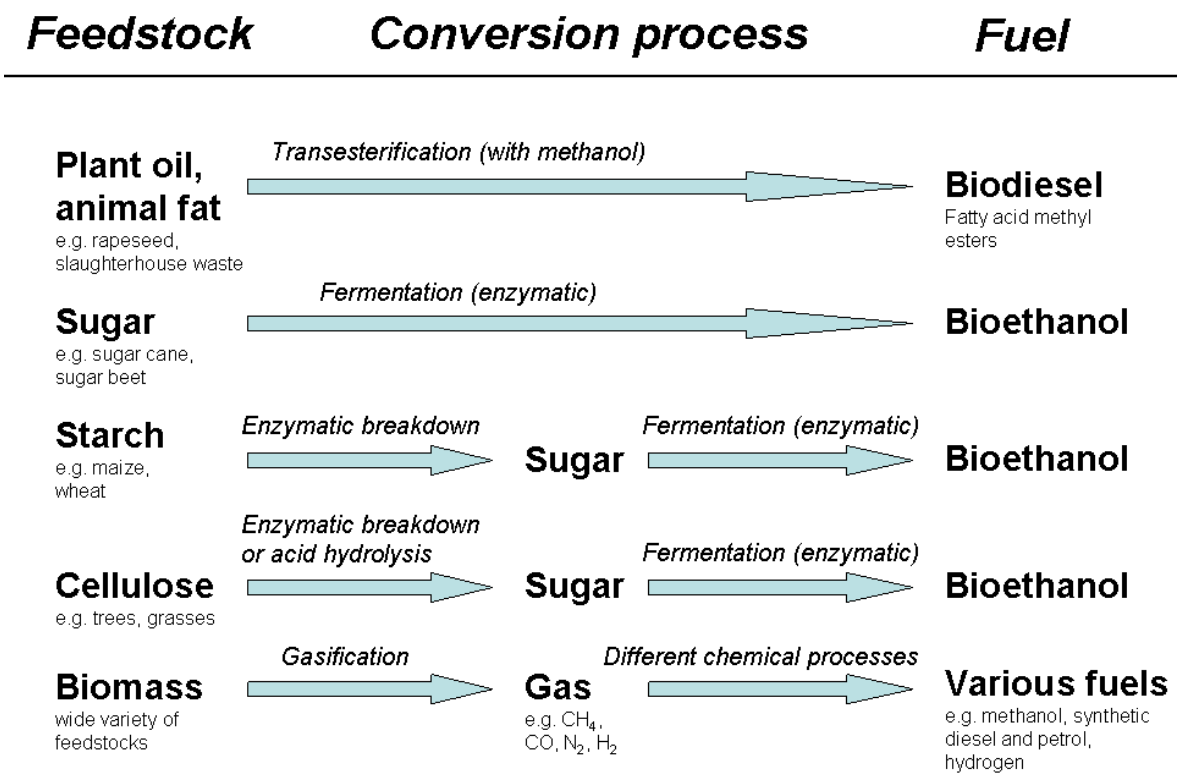

Figure 2: Main feedstocks and conversion processes to make automotive biofuels

2.1.1 Biodiesel from plant oil or animal fat

"Biodiesel" consists of fatty acid methyl esters (FAME) that are produced by reacting a feedstock oil or fat with methanol. This reaction is called transesterification. The most widely used feedstock is vegetable oil extracted from e.g. rapeseed, sunflower or soya, but other plant oils, used frying oil and animal fat are also used. Currently, researchers are experimenting with using bioethanol as a substitute for (typically fossil) methanol in the esterification process. The resulting biodiesel would be Fatty Acid Ethyl Ester, a 100% renewable product (Kyriakos Maniatis, DG TREN, 4 July 2005). If fossil methanol is used, FAME has a biogenic content

of around 94-96% (own calculation based on Kritchvesky, Encyclopedia of Life Sciences, 2001).

2.1.2 Ethanol from sugar or starch

Sugar can be extracted from sugar-rich plants, such as sugar cane and sugar beet, and fermented into ethanol. Enzymes from yeasts catalyse this biological process. After fermentation the ethanol is separated by distillation.

Starch is a polymer made up of sugars. Before the sugars can be fermented into ethanol, the starch first needs to be broken down into its sugar components. This is also achieved through enzymatic action. Maize (corn) and cereals, such as wheat, are typical starch-rich feedstocks.

2.1.3 Ethanol from cellulose

Similarly to starch, cellulose and hemicellulose can also be broken down into sugars, although with greater difficulty. This process can be done through acid or enzymatic hydrolysis, with the first route being rather inefficient and the second technologically immature (Faaij, 2005). The sugars are then fermented to ethanol in the usual way. Should the problems with enzymatic hydrolysis be overcome, it promises to be a highly efficient process capable of producing ethanol at low costs.

A wide variety of potential cellulose-rich feedstocks exist: crops, such as trees or grasses, but also agricultural wastes (e.g. straw or maize stalks that cannot be used in the conventional starch-to-ethanol process), forestry residues, the organic fraction of municipal solid waste, pulp and paper process waste.

2.1.4 Biomass gasification and related pathways

It is also possibly to gasify biomass and convert the gas into a number of biofuels. Examples are liquid fuels, such as methanol, ethanol, synthetic diesel and petrol (using the so-called "Fischer-Tropsch process"), dimethyl ether (DME) and gaseous fuels such as hydrogen and methane. The simplest way to gasify biomass is anaerobic microbial digestion, yielding methane. More advanced techniques that are currently being developed use heat and/or chemicals and little or no microbial action. Depending on the process, different gases are produced, including methane, carbon monoxide, nitrogen and hydrogen. These are then further converted into the biofuels mentioned above. Other advanced processes that do not involve gasification are hydrothermal upgrading (HTU) and fast pyrolysis.

All these technologies are still immature and expensive (IEA, 2004). However, they are promising as they can be used with a large variety of feedstocks and make use of the entire plant, rather than just its oil, sugar or starch content.

2.2 First generation biofuels: technical and environmental issues

2.2.1 Overcoming the "chicken and egg" problem with biodiesel and bioethanol

Biodiesel and bioethanol, the so-called "first generation biofuels" have an important advantage over other alternative transport fuels, such as gases methane, DME or hydrogen: they can be used in conventional diesel and petrol engines, either as neat fuels or blended with diesel and petrol. Biodiesel can be used in diesel engines, and be blended with diesel fuel. The

same is true for bioethanol and petrol. As will be discussed in Section 4.4, the European standards for diesel and petrol allow a biodiesel, respectively bioethanol content of up to 5% (vol.), which means that every engine must be compatible with B5 or E5. In the US new petrol vehicles must be compatible with E10, and in Brazil petrol typically contains 22-26% bioethanol (IEA, 2004).

According to the International Energy Agency (2004), biodiesel can be used in pure form (B100) and any blend ratio in conventional diesel engines. This contrasts with a study by Novem/Ecofys (2003) stating that pure biodiesel cannot be used in conventional diesel engines. It is, however, generally agreed that only minor technical changes are necessary to make a conventional diesel engine compatible with biodiesel. However, more stringent tailpipe air emission standards that came into force in the EU in 2005 can only be met with B100 if the engine is equipped with the necessary technology, such as a biodiesel sensor.

Regarding bioethanol, it is generally accepted that all recent-model conventional petrol vehicles, produced for the international market, are compatible with 10% ethanol / 90% petrol blends, by volume, known as E10 (IEA, 2004). Using E10 in new cars is thought not to require any vehicle or engine modifications (European Parliament – Directorate General for Research, 2001) and many manufacturers' liabilities cover its use (Novem/Ecofys, 2003). As many manufacturers improved ethanol compatibility of their vehicles over the 1990s there is concern regarding older vehicles (IEA, 2004). For blend levels above E10 some engine modifications may be necessary, even though limited, short-term research has shown no compatibility problems with blends as high as E30 in colder climates, such as that of Minnesota, US (Minnesota State University - Minnesota Center for Automotive Research, 1999). For blends up to 85% ethanol flexible fuel vehicles (FFVs) are used. These are equipped with a sensor system that detects the ethanol/petrol blend currently used and automatically adjusts the engine. Manufacturer's incremental costs for making a normal vehicle fuel flexible are estimated to be 100-200$ (IEA, 2004). FFV models have been available in the US for some years and, more recently, have been introduced to Sweden and Germany with no or only a small price premium, compared to the standard version. Pure, hydrous ethanol (96% ethanol, 4% water) can only be used in dedicated vehicles. It is also feasible to use ethanol in low and high level blends in diesel engines, but further research is needed in this area and no diesel-ethanol mixes are publicly dispensed at the moment (IEA, 2004).

It is also technically feasible to distribute and store niodiesel and bioethanol using conventional diesel and petrol infrastructure. Biodiesel is the easiest of the two to distribute and can use the same transport, storage and retail infrastructure as conventional diesel, even in its neat form. However, if stored over longer periods, biodiesel tends to degrade. Distribution logistics have to be adapted to prevent this from happening. Ethanol, having a chemical nature different to that of petrol, faces more difficulties. There have been few reported problems with low percentage blends, such as E5, but higher concentrations have a tendency to degrade certain materials commonly used in conventional infrastructure (e.g. pipelines, storage tanks, retail pumps). These have to be modified or replaced. But even with E5 some additional care has to be taken, due to its water absorbing nature. Often, there are small quantities of water in the petrol distribution structure and there is a risk that the ethanol separates out of the E5 mix and into the water phase. It must thus be ensured that the infrastructure is kept water free.

To avoid the problems caused by the water affinity (and vapour pressure – see Section 4.4) of ethanol, it can first be converted to an ether, commonly Ethyl-Tertiary-Butyl-Ether (ETBE),

and then added to petrol. ETBE is an anti-knock additive[3] that increases the octane number of petrol and presents none of the technical difficulties of ethanol. It is made from ethanol and fossil isobutylene, and only has a "bio" content of 47%, according to the Biofuels Directive.

Blended with diesel and petrol, biodiesel, bioethanol (and ETBE) can be brought to the market without facing the "chicken and egg problem" which arises when fuel retailers do not want to market a fuel and install extra tanks and pumps because there are no vehicles that can run on it and manufacturers do not want to market compatible vehicles because there are no service stations where buyers could fill up. For B100 and E85 additional retail pumps do need to be installed, but conventional engines can easily be made compatible with both normal diesel or petrol and these biofuels.

2.2.2 Energy content of biofuels

While transport fuels are typically marketed and taxed in litres, national consumption statistics given in tonnes (at least in the EU) the Biofuels Directive sets the target for biofuels "of 5.75 %, *calculated on the basis of energy content*, of all petrol and diesel for transport purposes placed on their markets by 31 December 2010".

Both biodiesel and bioethanol have a lower volumetric energy density than diesel and petrol. This would mean that more than a litre of biofuel is necessary to substitute one litre of fossil fuel. However, both biofuels are also reported to have a better combustion efficiency, at least partly making up for the lower energy density. There are some conflicting study results regarding the distance that can be driven on a litre of biofuel compared to fossil fuel, as discussed, for example in a report by Novem/Ecofys (2003). In this thesis I have taken a conservative approach and calculated diesel-biodiesel and petrol-ethanol equivalency on the basis of energy content.

As can be seen in Appendix 1, there is some variation in the literature regarding the volumetric and energy density of transport fuels. This is due to the fact that petrol, diesel and biodiesel are not chemically homogenuous liquids but made up of a mix of compounds whose proportions may vary. Table 1 lists the average energy and volumetric densities that I used in the thesis, calculated from literature data. Using these conversion factors, the 5.75% target, on an energy basis, corresponds to 6.24% (biodiesel) and 8.57% (bioethanol) on a volume basis.

Table 1: Energy content and density of transport fuels

	Energy content (MJ/kg)	**Energy content (MJ/l)**	**Density (kg/l)**	**1 l Diesel/Petrol energy equivalency**
Diesel	42.314	35.501	0.839	100%
Petrol	42.210	31.546	0.747	100%
Biodiesel	36.728	32.728	0.892	92.19%
Bioethanol	26.710	21.164	0.792	67.09%

Sources: German national report on the implementation of the Biofuels Directive (2005); Austrian ordinance on transport fuels (2004); Valbiom (2003)

[3] Anti-knock agents improve engine performance by preventing uncontrolled self-ignition of petrol during the combustion process.

2.2.3 Environmental performance of first generation biofuels

2.2.3.1 Tailpipe emissions of pollutants

Tailpipe emissions from (blends of) biodiesel and bioethanol are generally considered to be less polluting than those of petrol or diesel. Emissions of some pollutants have been found to increase, such as Volatile Organic Compounds from ethanol-petrol blends or NO_X from biodiesel, but these can be effectively reduced using standard emission control equipment (IEA, 2004).

2.2.3.2 Well-to-wheels greenhouse gas balance

The "well-to-wheels" (WTW) greenhouse gas balance of biofuels depends largely on the way feedstocks are produced, processed into fuels and distributed. For example, the use of fossil energy to process biofuels or N_2O emissions from fertiliser use reduces net greenhouse gas savings. A vast array of studies exist and most scientists agree that on a WTW basis biodiesel and bioethanol have lower net greenhouse gas emissions than diesel and petrol. There are, however, some studies that report higher net emissions (e.g. Pimentel and Patzek, 2005). A joint study by the EU's Joint Research Centre, European refiners' association CONCAWE and European car manufacturers' association EUCAR (2004) came to the following WTW results for biofuels produced in Europe: the use of biodiesel instead of diesel, produced from rape seed or sunflower oil, allows to avoid 40-60% of greenhouse gas emissions; the use ethanol as a petrol substitute, produced from sugar beet or wheat, reduces greenhouse gas emissions by 15-70%. Ethanol WTW emissions are lower if produced from sugar beet.

The greenhouse gas balance of bioethanol produced from sugarcane in Brazil currently outperforms that of all other first generation biofuels. Macedo et al. (Government of the State of Sao Paulo, 2004) estimate WTW net greenhouse gas savings to be higher than 90%. Due to the warm, moist climate and fertile soils Brazilian sugarcane production requires little fertiliser input. The crushed cane remains, after sugar extraction, are not only used to generate process heat but also electricity in modern plants (IEA, 2004); "fossil" greenhouse gas emissions are thus not only avoided by substituting fossil fuels in the transport sector, but also for heat and electricity production.

2.2.3.3 Land consumption

Another important environmental impact of biofuels is "land consumption". If the EU is to meet its target significant areas need to be used for feedstock production.

Table 2 lists European and Brazilian yield averages for biodiesel and bioethanol mentioned in the literature. The data show that, even when taking the lower energy density of bioethanol into account, ethanol yields are higher than biodiesel yields. Again, due to the more favourable climate and the characteristics of the sugarcane crop, bioethanol yields in Brazil are higher than in Europe. The European Commission estimates that for the EU-15 to meet its biofuel market share target of 5.75% with domestic feedstock production, some 9% of the total arable land are needed (European Commission / Biomass Technology Group, 2004).

Land used on which biofuel crops are grown is no longer available for other uses, such as food production or wildlife conservation. The World Wildlife Fund UK (WWF) warns that there have been a number of cases where farmers in South-East Asia have cleared rainforest to grow oil palms, the oil of which is also used for biodiesel production (WWF, 7 June 2005).

Table 2: Biodiesel and bioethanol yields in the EU and Brazil

Biodiesel – from rapeseed oil (l/ha x y)	**Bioethanol (l/ha x y)**	**Source**
1300	2500 (cereals)	Fachagentur Nachwachsende Rohstoffe [German Agency of Renewable Resources] (2005)
1500	3100 (wheat) 6000 (sugarbeet)	Valbiom (2003)
1200	2500 (wheat) 5500 (sugarbeet) 6500 (sugarcane in Brazil)	IEA (2004)
1333 (average)	*2700 (average – wheat)* *5750 (average – sugarbeet)*	

2.2.3.4 Other environmental impacts

A study commissioned by the German EPA (Umweltbundesamt, 1998) concludes that while Rape Methy Ether (RME), biodiesel made from rapeseed oil, has a better greenhouse gas balance than diesel, farming of rape seed also causes a number of negative environmental impacts: ozone layer depletion through N_2O from fertilisers, eutrophication of water bodies and soil and groundwater contaimination through fertiliser and pesticide use, as well as low levels of biodiversity on rapeseed land.

2.3 Costs of biofuel production and CO_2 emission reduction

A range of cost estimates for biodiesel and bioethanol production can be found in the literature (see, for example, IEA 2004). They depend on a number of factors, such as crop yields, fertiliser need, capital investment, labour and distribution costs as well as the prices that can be obtained for by-products such as animal feed. While estimates vary, biofuels are in general significantly more costly to produce than fossil fuels. In this thesis I have used the following production cost estimates for biodiesel and bioethanol produced in Europe (excluding distribution): biodiesel (rapeseed oil, Germany) – 0.60€/l (German Government, June 2005); biodiesel (rapeseed oil, UK) – 0.54€/l (UK Government, 2004); biodiesel (waste vegetable oil) – 29€/l (UK Government, 2004); biodiesel (palm oil) – 0.49€/l (UK Government, 2004); bioethanol – 0.50€/l (Schmitz, 2005)[4]. The only biofuel that is close to cost competitiveness to petroleum fuels Brazilian ethanol from sugarcane, which is sold at around 0.20€/l. Figure 3 shows how the average distillery gate price of Brazilian bioethanol compares with the Rotterdam sport market price for regular petrol.

[4] I did not have access to the detailed cost calculations that explain the lower production cost estimate for rapeseed biodiesel in the UK compared to Germany.

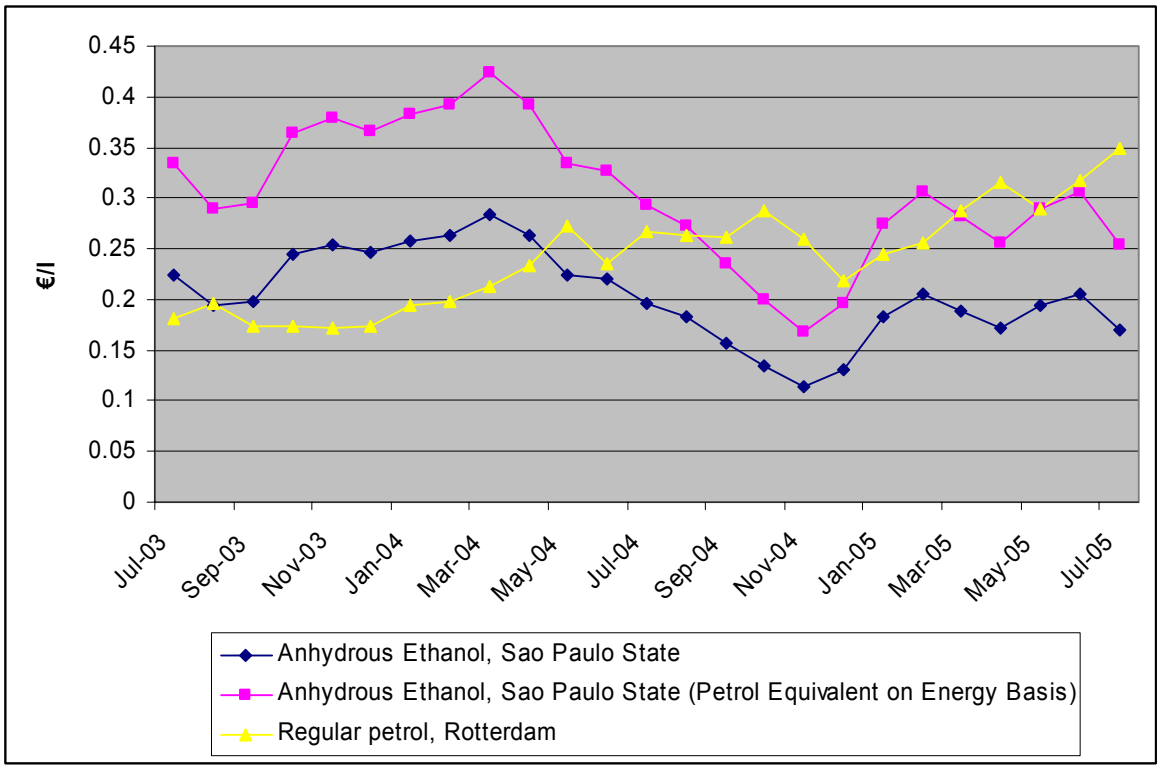

Figure 3: Average monthly prices for anhydrous bioethanol (suitable for blending), produced in Sao Paulo State, Brazil and for regular gasoline, sold at the spot market in Rotterdam, Netherlands
Sources: Bioethanol Price – Centro de Estudos Avançados em Economia Aplicada (2005); Petrol price – International Energy Agency (2005)

Since different biofuels and feedstocks have not only differing production costs but also greenhouse gas balances, the cost per tonne of CO_2 savings also differs. IEA (2004) estimates that in 2002 the cost per tonne reduction in CO_2 equivalents ranged between 325-730 € for bioethanol from cereals (EU), 145-310 € for RME (EU) but only 15-50 € for bioethanol from sugarcane (Brazil). The CO_2 emission reduction cost depends on the production cost differential between biofuels and fossil fuels. If biofuel production costs go down and the oil price up, biofuels become a cheaper carbon abatement option. Due to its low production costs and excellent greenhouse gas balance, Brazilian bioethanol is currently the cheapest biofuel option for reducing carbon emissions.

3 Theoretical background and analytical framework

3.1 Dominant technological systems and new technologies: general discussion

According to technology innovation theorists (for example, Hughes [1989], Arthur [1989], Utterback [1994], once a technology has become the societal standard it becomes increasingly difficult to dislodge by competing technologies. When a new technology becomes dominant, the phenomenon of "increasing returns to scale" is often observed: due to economies of scale and the learning effect, the more the technology is applied, the more it improves, becomes less expensive and widens its market potential (Organisation for Economic Cooperation and Development/IEA, 2003). Once this process has gained some momentum, a society may "lock-in" to a particular technology whereas competing technologies are "locked-out".

But there is more to the process by which a technology becomes dominant than the phenomenon of increasing returns to scale. Society becomes adapted to the new technology through changes in its formal and informal institutions. According to North (1990), institutions are "humanly devised constraints that shape human interaction", or, less formally, „the rules of the game in society". The institutional framework creates the incentive structure for individuals and organizations. Proponents of a technology will try to influence the evolution of the institutional framework, so that it accommodates the technology. If a technology achieves dominance, society's institutions are said to become *aligned* with it, supporting its development and obstructing that of competing technologies (e.g. Jacobsson, Sandén and Lennart, 2004)

Furthermore, large, technological systems are typically made up of a multitude of capital-intensive, durable artefacts (Hughes, 1989). If a new technology were to become dominant, these artefacts risk becoming obsolete. For this reason, actors that have heavily invested in a dominant technology have a vested interest in it and are often found to oppose a new rival technology and do what they can to prevent the new technology from eroding their market shares. It is, of course, also possible that "dominant technology" companies embrace the new technology and promote its introduction. However, they are often found to resist it, at least at the beginning. This can be explained not only by the above-mentioned large investments into infrastructure for the old technology but also because these companies "stay close to their customers" that, at first, are not interested in the new technology (Bower and Christensen, 1995).

3.2 Analytical framework

As was discussed in the previous section, new technological systems tend to face an uphill struggle to establish themselves and it is uncertain if they are able to replace the existing technology or will simply disappear from the market. Currently, biodiesel and bioethanol have achieved differing market penetrations in the countries which I studied. To find out why this is the case, I found it helpful to analyse the national context in which the technological system "biodiesel and bioethanol as road transport fuels" has evolved and is evolving in a structured manner. For this purpose I have used an analytical framework developed by Jacobsson et al, in a slightly modified way. The framework distinguishes between the *components* and the *functions* of a technological system, or sectoral innovation system as Jacobsson calls it.

A formal definition of a technological system is (Carlsson and Stankiewicz, 1991):

"network(s) of agents interacting in a specific technology area under a particular institutional infrastructure to generate, diffuse and utilise technology".

The components of a technological system are *actors* that may be organised in formal and informal *networks*, and *institutions*, such as the regulatory framework, culture and public opinion. For the biodiesel and bioethanol system I examined the following components:

- Actors: biofuel producers and suppliers, oil companies and car manufacturers, and their trade associations.

- Networks: the existence of biofuel producers' trade associations and structures in which biofuel producers collaborate with oil companies and car manufacturers.

- Institutions: the regulatory framework and the public's opinion on biofuels.

Having examined the components, the next step is to look at "what is happening" in the technological system. The contribution of a component or set of components to the overall performance of the system is called a *function*. Jacobsson et al. have identified seven functions that need to be strong for the technological system to be performing well. Looking at the strength of these functions allows to identify the factors which influence them. In particular, blocking mechanisms may thus be identified.

Table 3 lists the six functions which I used in my research. To operationalise them I have formulated one question for each, the answer to which allows to gauge the strength of the function. I did not use the seventh function "development of positive externalities". This function addresses the phenomenon that the bigger the technological system gets (larger sales volume, more actors), the stronger the other functions become. In other words, each new entrant strengthens the functions "knowledge development", "entrepreneurial experimentation", "influence on the direction of search", "legitimation" and "resource mobilisation". Since function 7 is already addressed by the other functions, I decided to skip this category in order to simplify the analysis.

Table 3: Functions of the new technological system biodiesel and bioethanol that need to be strong for it to perform well

Function	**addresses the question**
Knowledge development and diffusion	How much knowledge has been gained that is relevant to the production, distribution, marketing and use of biodiesel and –ethanol?
Influence on the direction of the search	Are potential producers and consumers attracted by biofuels?
Entrepreneurial experimentation	How diverse are the ways in which biodiesel and bioethanol are produced and marketed?
Market formation	How big is the market for biofuels and how is it evolving?
Legitimation	How strong is societal support for biodiesel and bioethanol?
Resource mobilisation	How much capital has been invested into the biodiesel and bioethanol sector?

Having introduced the reader to automotive biofuels and presented my analytical framework, I will now describe the EU regulations that affect biofuels, before applying the analytical framework to the biofuels situation in Germany and the UK.

4 The EU regulatory context for transport biofuels

4.1 The Biofuels Directive

Directive 2003/30/EC requires that Member States "ensure that a minimum proportion of biofuels and other renewable fuels is placed on their markets, and, to that effect, shall set national indicative targets". Reference values for these targets are 2% of all petrol and diesel for transport purposes by the end of 2005 and 5.75% by the end of 2010, on an energy basis. They are allowed to "give priority to the promotion of those fuels showing a very good cost-effective environmental balance, while also taking into account competitiveness and security of supply". Each year, before 1 July, Member States have to report to the European Commission on their progress in implementing the directive.

While the Member States may set targets that differ from the reference targets, this differentiation has to be motivated. Possible reasons that are mentioned in the directive are limited national potential for the production of fuels from biomass, the use of domestic biomass resources for other energy uses than transport, specific technical or climatic characteristics of the national market for transport fuels and national policies that allocate comparable resources to the production of other transport fuels based on renewable energy sources. The Commission has examined the motivations given by several Member States and 7 of them have been warned that it does not accept their 2005 targets (European Commission - Press Release, 6 July 2005). It remains to be seen how the Commission will react in 2006 should it became clear that some countries have set approved targets but not made strong enough efforts to meet them.

The directive mandates the Commission to evaluate Member States' progress by 2007 and, in particular, the need for mandatory national targets in case of lack of progress. The Commission shall also report on the cost-effectiveness of Member States' measures, and their overall economic and environmental impact.

4.2 The Energy Taxation Directive

Council Directive 2003/96/EC of 27 October 2003 sets minimum taxation levels for energy products but allows products produced from biomass to be exempt from energy taxation or benefit from a reduced rate, if Member States wish to do so. However, Member States may only make use of energy tax reductions to compensate for the extra manufacturing cost of biofuels. They are required to adjust the tax benefit to take account of changes in raw material prices and avoid over-compensation. The exemption or reduction may not be granted for more than six consecutive years; this period may be renewed.

4.3 Common Agricultural Policy and Blair House Agreement

4.3.1 Common Agricultural Policy

The Common Agricultural Policy (CAP) offers different financial incentives to farmers and influences the type of crops they chose to produce. The last reform of the CAP regime was decided in September 2003 (Council Regulation (EC) No 1782/2003). Farmers will only grow biofuel crops if they generate a higher revenue than an alternative use of the land. They currently have three main options for growing biofuel crops:

- They can cultivate them on standard agricultural land. However, biofuel production would need to generate a higher revenue than alternative food crops *plus* the

respective subsidy. In the past, this was an unlikely option. However, under the "Single Payment Scheme" the new CAP regime progressively decouples subsidies from the type and amount of crops that are farmed. Farmers continue to receive support, but are now free to produce the crops the market demands. The 2003 reform has made this option more likely, as market prices of biofuel crops now only have to beat those of other food crops (no longer directly subsidised) that could be grown on the same land.

- They can grow them on "set-aside land", land which, following the 1992 CAP reform, had to be removed from food production in order to reduce overproduction and limit the amount of money spent on the CAP. Farmers are entitled to compensation payments for setting aside land. The amount depends on the type of crop that was previously produced on the land and is typically in the range of several hundred Euro per hectare. Farmers are allowed to produce non-food crops on set-aside land and still receive the annual compensation payment.

- They can cultivate them on "voluntary set-aside land" and receive a specific subsidy of 45€/ha. This option is limited to a maximum of 1,5 million ha for the EU-25.

Set-aside land thus seems to provide the biggest financial incentive for producing biofuel crops.

4.3.2 Blair House Agreement

The Blair House Agreement is an agreement between the EU and the US that restricts oil seed crop specific aids on "food land" to 4.9 million ha in the EU. It also restricts aid to an annual output of 1 million tonne of soybean meal equivalent (an animal feed), grown on set-aside land. The second restriction would impede RME producers for whom the rapeseed meal by-product is an important source of revenue. However, it is uncertain to what extent this restriction still applies, with the new CAP replacing, respectively phasing out crop-specific subsidies (PriceWaterhouseCoopers, 2005).

4.4 European transport fuel standards

4.4.1 The Fuel Quality Directive

Directive 98/70/EC ("Fuel quality directive"), amended by Directive 2003/17/EC sets technical specifications for petrol and diesel on environmental and health grounds. Increasingly stringent norms are to come into force in 2000, 2005 and 2009. The directive allows the blending of 5% (vol.) ethanol or and 15% (vol.) ethers (e.g. ETBE) into petrol and limits summer vapour pressure to 60 kPa (70 kPa for countries with arctic climates, such as Sweden). This limit complicates the production and use of low-level petrol-ethanol blends, as will be discussed below. The European Commission is required to review the technical specifications and, among other things, to consider changing them to encourage biofuel use. The possibility to modify the maximum volatility limits for petrol is explicitly mentioned. Furthermore, the Commission is authorised to propose technical specifications for biofuels.

No Member State may prohibit, restrict or prevent the placing on the market of fuels which comply with the Fuel Quality Directive's requirements. As a consequence, regulators may not, at least directly, force petrol and diesel suppliers to blend them with a minimum percentage of biofuels.

4.4.2 Petrol standard EN 228:2004

European Norm 228 specifies the technical requirements and test methods for unleaded petrol marketed in the EU. Its latest version came into force in all Member States by July 2004, and replaced an earlier version from 1999. The standard incorporates the requirements of the Fuel Quality Directive but also sets a range of other specifications. As required by the directive, the standard allows up 5% (vol.) ethanol and 15% (vol.) ETBE in petrol and limits summer vapour pressure to a maximum of 60kPa (70 kPa in countries with arctic climates).

4.4.3 Diesel standard EN 590:2004

The diesel standard EN 590 is also in force since 2004 and replaces the 1999 version. Among other changes, it now allows a FAME content of up to 5% (vol.), as long as the FAME complies with EN 14214.

4.4.4 Biodiesel standard EN 14214:2004

The standard for FAME is in force since 2004. It is based on an earlier German standard for RME and specifies technical characteristics of biodiesel for use as a neat fuel or for blending.

4.4.5 Other biofuel standards

The European Committee for Standardization (CEN) is developing a standard for pure bioethanol, when used as a blending component in petrol. It is expected to be published in 2006 (Lindner, August 2005). CEN is also working on a standard for E85.

4.4.6 Impact of fuel standards on bioethanol and biodiesel use

The existing norms, first of all, facilitate the introduction of biofuels. Manufacturers design their vehicles so that they can run on standard petrol and diesel, which means that they are compatible with B5 and E5. Furthermore, the biodiesel standard makes it easier for vehicle manufacturers to ensure smooth engine performance and that emission norms are met with B100 (see Section 4.5).

However, the norms also create barriers for biofuels:

4.4.6.1 Bioethanol

Increasing the ethanol content in petrol first leads to an increase in fuel vapour pressure of the blend and then a decrease. According to laboratory measurements by Pumphrey, Brand and Scheller (2000), as well as by Hsieh, Chen, Wu and Lin (2002), vapour pressure peaks at an ethanol content of around 10% (see Figure 4). Measurements by da Silva, Cataluna, de Menezes, Samios and Piatnicki (2005) locate the peak between 5-10%, whereas Furey (1985), as cited in French and Malone (2005) locates it at 4-5% ethanol. It should be noted that the change in vapour pressure depends also on the composition of the base petrol.

As a consequence of this phenomenon, petrol with low-level blends of ethanol, such as E5, may have a vapour pressure that exceeds the limit of 60 kPa in summer. High vapour pressures may affect engine performance but also lead to higher evaporative emissions of pollutants. This problem can be solved by removing volatile components, such as butane, from petrol at the refinery and thus lowering its vapour pressure. This comes at a cost to the refiner as an alternative economic valorisation needs to be found for the volatile petrol

components, most likely at a lower price (PriceWaterhouseCoopers, 2005, Hodson, DG TREN, 4 July 2005).

Furthermore, according to laboratory experiments and a field trial with E5 in Berlin by the German Association for Mineral oil and Coal (Deutsche Gesellschaft für Mineralöl und Kohle – DGMK, 2005a and 2005b), a mixture of E0 and E5 may exceed the vapour pressure limit, even if, individually, the E0 and E5 conform to the standard. Mixtures of E0 and E5 may in arise when car or service station tanks that still contain one type of fuel are refilled with the other.

The EU Commission's Joint Research Council, together with CONCAWE, an organisation of European oil companies and car manufacturers' organisation EUCAR is currently carrying out research projects on this issue. The results are expected to be published early in 2006 (Larive, CONCAWE, 13 September 2005).

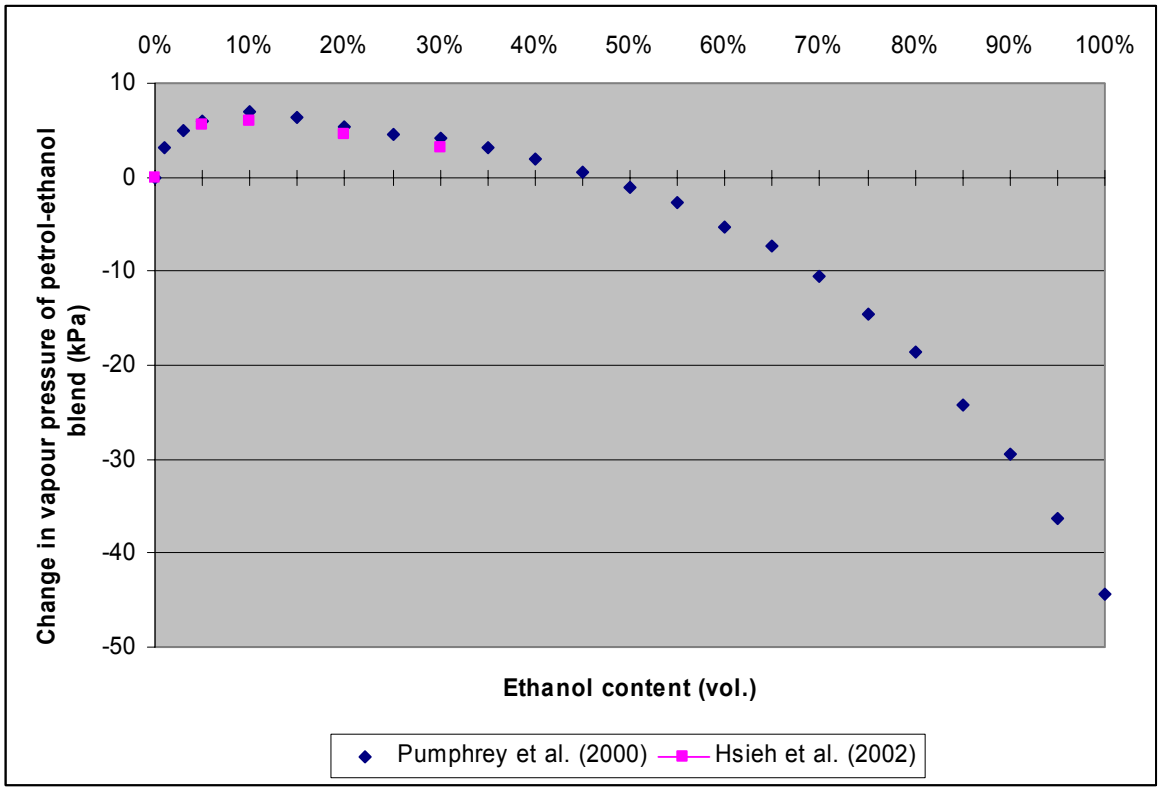

Figure 4: Changes in vapour pressure of petrol-ethanol blends with increasing ethanol content
Sources: Pumphrey, Brand and Scheller (2000); Hsieh, Chen, Wu and Lin (2002)

ETBE does not raise vapour pressure and is thus easier to blend in that ethanol. It also seems to be technically possible to add both ethanol and ETBE to petrol, as long as the limit for total oxygen content (2.7% m/m) is not exceeded. Both ethanol and ETBE contain oxygen. This oxygen content limit is reached at 7.7% ethanol or 17.2% ETBE (PriceWaterhouseCoopers, 2005).

4.4.6.2 Biodiesel

EN 14214 has been developed using FAME from rapeseed and sunflower oil. Biodiesel produced from other feedstocks, such as soy and palm oil, used cooking oils and fats or

animal tallow cannot easily meet some of the specifications, such as iodine content or "Cold Filter Plugging Point". A solution is to blend them with a sufficient amount of RME and/or use fuel additives.

4.5 Vehicle emission norms

European Directives 98/69/EC (passenger cars and light commercial vehicles) and 1999/96/EC (heavy duty vehicles) set increasingly stringent limits to tailpipe emissions of carbon monoxide, hydrocarbons, nitrogen oxides and soot particulates. The EURO 4 standards apply to new cars and trucks from 2005 and EURO 5 will enter into force in 2008.

Under the EURO 3 standard vehicles could be more easily approved for pure diesel, pure biodiesel and blends thereof. According to the manufacturers, the new EURO 4 emission standards can no longer be met with biodiesel blends above B5, unless a biodiesel sensor is used. Even though they reduce paticulate emissions further than required by the EURO 4 and 5 norms, and are thus not compulsory, some manufacturers have started to build self-regenerating particulate filters into their cars. In practice, these are not compatible with high biodiesel blends as this would require frequent cleaning of the filter (Retzlaff and Stein, Verband der Deutschen Biokraftstoffindustry (VDB)[Association of the German Transport Biofuel Industry], 30 June 2005; United States Department of Agriculture – Foreign Agricultural Service, 2004).

4.6 EU import duties

Imports into the European Union are charged with an import duty that depends on the product's "Combined Nomenclature" (CN) code, as defined in the EU's common tariff schedule. While in theory, import duties should be the same, no matter in which Member State the product enters the Customs Union, in practice they may differ. Sometimes, depending on interpretation by the customs authorities, products may fall under more than one CN-code, with different import duties (Die Zeit, 2 June 2005).

Table 4 shows the current EU import duties for biofuels, fossil fuels and their main feedstocks (Commission regulation 1810/2004 of 7 September 2004).

Table 4: EU import duties on biofuels, fossil fuels and their feedstocks

Product	**CN Code**	**Import duty**
Soya seeds, Rape seeds, , sunflower seeds, other oil seeds	1201 00, 1205, 1206 00, 1207 10	None
Sugar beet dried, not dried	1212 91 20, 1212 91 80	0.23 €/kg, 0.067 €/kg
Sugar cane	1212 99 20	0.046 €/kg
Crude soya bean oil, crude sunflower seed oil, Rapeseed oil	1507 10 10, 1512 11 10, 1514 11 10	3.2%
Palm oil	1511 10 10	None
Fatty Acid Methy Ester (biodiesel)	3824 90 99	6.5%
Undenatured ethanol (>80 % alcohol by vol.)	2207 1000	0.192 €/l
Denatured ethanol (any strength)	2207 2000	0.102 €/l
Crude oil	2709 00	None
Petrol	2710 11	4.7%
Diesel	2719 19 41	3.5%

5 Country study: Biofuels in Germany

5.1 The market for biofuels: past, present and future

5.1.1 1993-today

5.1.1.1 Biodiesel

Germany is the biggest producer and user of biodiesel in the EU. Consumption and production have strongly grown since the fuel's introduction in 1993 (see Figure 5). Most of it is produced domestically from rape seed with the remainder being imported[5]; exports are negligible (Retzlaff and Klein, Verband der Deutschen Biokraftstoffindustrie [Association of the German Biofuels Industry], 30 June 2005). Biodiesel had a market share of around 2%, on an energy basis, of all transport fuels in 2004[6].

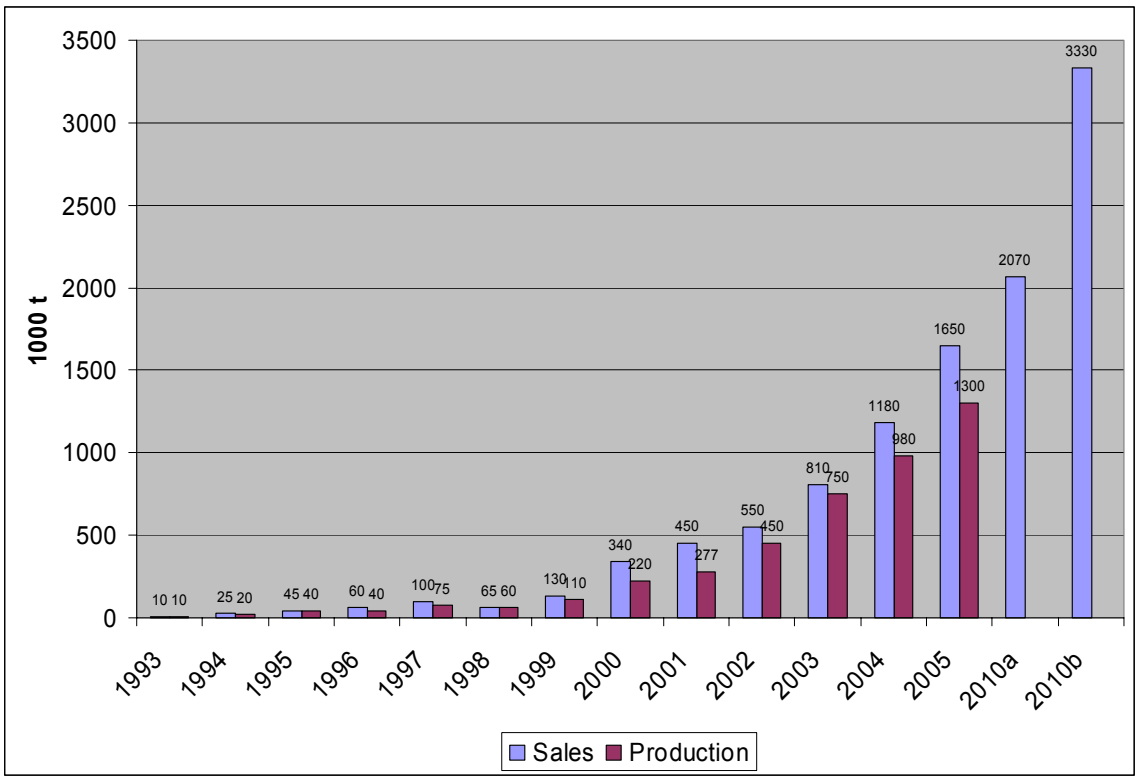

Figure 5: Sales and production of biodiesel in Germany

2010a: quantity assuming EU target is met with a 5.75% biodiesel share of diesel sales and a 5.75% bioethanol share of petrol sales.

2010b: quantity assuming EU target is met with biodiesel (9.34% of diesel sales) and ETBE substituting current MTBE use (220,000 t ethanol, corresponding to an average of some 2% ETBE content in petrol) alone; this scenario is favoured by the Mineralölwirtschaftsverband (MWV) [Association of The German Mineral Oil Industry].

Sources: Biodiesel production and sales data from VDB (June 2005); 2010 petrol and disel sales prognosis from MWV (2005); current MTBE use from German Government (June 2005).

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[5] Imports come mainly from France. In future, eastern European countries such as the Czech Republic and Poland are expected to play a more important role (Retzlaff and Stein, VDB, 30 June 05).

[6] The data of the government (1.8% market share on an energy basis) and the biofuel producers association VDB (2%) slightly differ.

As Table 5 shows, until 2004 biodiesel was only sold as B100, to car users via filling stations or directly to operators of truck and bus fleets. Since 2004, biodiesel is also sold to oil companies who use it for making low-level blends (up to B5). This segment is growing rapidly. Since January 2005, B100 is also used for agricultural vehicles.

Table 5: Biodiesel market segments

	Blends (<5% vol.)	**B100**		
		Petrol stations	Truck & bus fleets	Agric. Vehicles
1993-2003	0%	100%		
2004	25%	20%	55%	0%
2005	40%	10%	45%	5%

Source: VDB (2005).

5.1.1.2 Bioethanol

Bioethanol was not used in the transport sector until 2004 (German government, 2004 and 2005). In 2004 65,000 t of imported bioethanol were used for ETBE production[7]. Negligible quantities were used for direct blending.

5.1.1.3 Other biofuels

Very low amounts (5000 tonnes) of pure rapeseed oil haven been used for a few years in around 4000 cars and a slowly increasing number of trucks and farm vehicles. No biogas is used as a transport fuel in Germany.

5.1.2 The target for 2010

Table 6 shows the required quantities and market segments of biodiesel and –ethanol for Germany to meet the 5.75% indicative target in 2010. Roughly speaking, the consumption of biofuels needs to triple.

[7] Imports come mainly from Spain, Pakistan and Guatemala. Little, if any, ethanol is imported from Brazil. Furthermore, imports from Pakistan and Guatemala may be reduced, depending on the outcome of the current anti-dumping investigation (Klein, LAB, 30 June 05).

Table 6: Biofuel quantities and market segments required for meeting 2010 target (5.75% market share for biofuels)

		2004	2010a	2010b
Diesel consumption (million tonnes)		28.6	31.3	31.3
Biofuels share of total fuels market (energy basis)		1.91%	5.75%	5.75%
Biodiesel share of diesel market (energy basis)		3.58%	5.75%	9.34%
Biodiesel quantity (million tonnes)	*Total*	1.2	2.1	3.4
	B5	0.3	1.7	1.7
	B100	0.9	0.4	1.7
Petrol consumption (million tonnes)		25	22	22
Bioethanol share of petrol market (energy basis)		0.16%	5.75%	0.63%
Bioethanol quantity (million tonnes)	*Total*	0.065	2.0	0.2
	ETBE	0.065	0.2	0.2
	E5	0	1.2	0
	E>5	0	0.6	0

2010a: quantity assuming EU target is met with a 5.75% biodiesel share of diesel sales and a 5.75% bioethanol share of petrol sales. Current MTBE use is substituted by ETBE, B5 and E5 are introduced nation-wide.
2010b: quantity assuming EU target is met with biodiesel (9.24% of diesel sales) and ETBE substituting current MTBE use (220,000 t ethanol, corresponding to an average of some 2% ETBE content in petrol) alone; this scenario is favoured by the mineral oil industry association MWV
Sources: Biodiesel production and sales data from VDB (2005); 2010 petrol and diesel sales prognosis from MWV (2005); current MTBE use from German Government (June 2005)

If these quantities are produced domestically farmland requirements are in the range of 1.8-2.9 million ha for rape seed and 0.1-0.6 million ha for cereals and sugarbeet (see Table 7). The total biofuel crop area would take up some 20-25% of the total arable land. In 2004 rapeseed for both food and non-food uses was grown on 1.3 million ha, cereals on 6.9 million ha and sugarbeet on 0.4 million ha. These estimates show that while it does not seem impossible for Germany to meet the 2010 targets with domestic biofuel production alone this is unrealistic as a very large part of arable land would be needed to this end and would no longer be available for other purposes.

Table 7: Domestic farmland requirements for 2010 biofuels target and farmland use in 2004

	2010a (million ha)	**2010b (million ha)**
Rapeseed farmland	1.8	2.9
Cereals and sugarbeet farmland*	0.6	0.1
Total biofuel crops farmland	2.4	2.9
	2004 (million ha)	
Total arable land	11.9	
Rapeseed farmland	1.3	
Cereals farmland	6.9	
Sugarbeet farmland	0.4	

* Assuming 50% of bioethanol produced from cereals and 50% from sugarbeet.
Sources: 2004 crop production data – Eurostat (2005); yield factors – own estimates, see Section 2.2.3.3

5.2 Institutions

5.2.1 Regulatory framework

5.2.1.1 Policy measures to promote biofuels

Transport fuel strategy

Germany has already met its 2005 goal of a 2% market share for biofuels. While the 2010 target has not been officially set yet, government has announced to take the European targets as guidelines (German Government, 2004b). The target is thus likely to be around 5.75%.

The government, in collaboration with the automobile and oil industry and a number of research institutes, has formulated a transport fuels strategy (German Government, 2004b). Its primary aim is to reduce oil consumption to strengthen security of energy supply and protect the climate. The strategy identifies four main options on which efforts should be concentrated: more efficient petrol and diesel engines, synthetic fuels from biomass (BtL), hybrid drivetrains, hydrogen. The strategy considers that biodiesel and bioethanol (from sugar or starch) will continue to play an important role as blends but that their potential is limited by the availability of farmland. A 5% market share would already be a remarkable achievement.

Excise duty exemption

Until the end of 2003 neat biodiesel and plant oils were not addressed by the mineral oil tax law ("Mineralölsteuergesetz") and thus, de facto, exempt from excise duty. This encouraged the use of these biofuels in pure form, but not as blends, as the full diesel duty would still have applied to them. Since 2004 transport and heating biofuels, both in pure form or as blends[8], are now also covered by the law. They benefit from a reduced excise duty rate until the end of 2009 and are currently completely exempt from excise duty. The duty exemption on diesel is worth 0.47 €/l plus 0.08 €/l (16% VAT on excise duty), for petrol it is 0.65 €/l plus 0.10 €/l[9].

[8] Tax exemption for blends is proportional to the biofuel content in the blend.

[9] The tax exemption is made possible by Article 16 of European directive 2003/96/EC[9], which allows member states to reduce taxes on biofuels in order to compensate producers for the higher production costs. The Commission approved the exemption on the basis of the Community Guidelines on State aid for environmental protection on 18 February 2004. However, the directive prohibits overcompensation, member states have to report to the European Commission on a yearly basis and the Commission must approve the reduction.

The excise duty exemption makes biofuels price-competitive with diesel and petrol, both on a volume and energy basis (see Figure 6 and Figure 7).

While the law defines biodiesel as any kind of FAME made from plant oils or animal fats, only bioethanol that corresponds to CN code 2207 1000 and has an alcohol content of at least 99% (vol.) qualifies for the tax exemption. This means that denatured ethanol or ethanol blended with petrol, imports of which face lower import tariffs than pure ethanol, are not exempt from mineral oil tax. Most of the price advantage of Brazilian bioethanol (estimated production cost – 0.20 €/l) against EU produced alcohol (estimated production cost – 0.50 €/l) is thus lost as imports not only face additional transport costs but also the import tariff of 0.19 €/l.

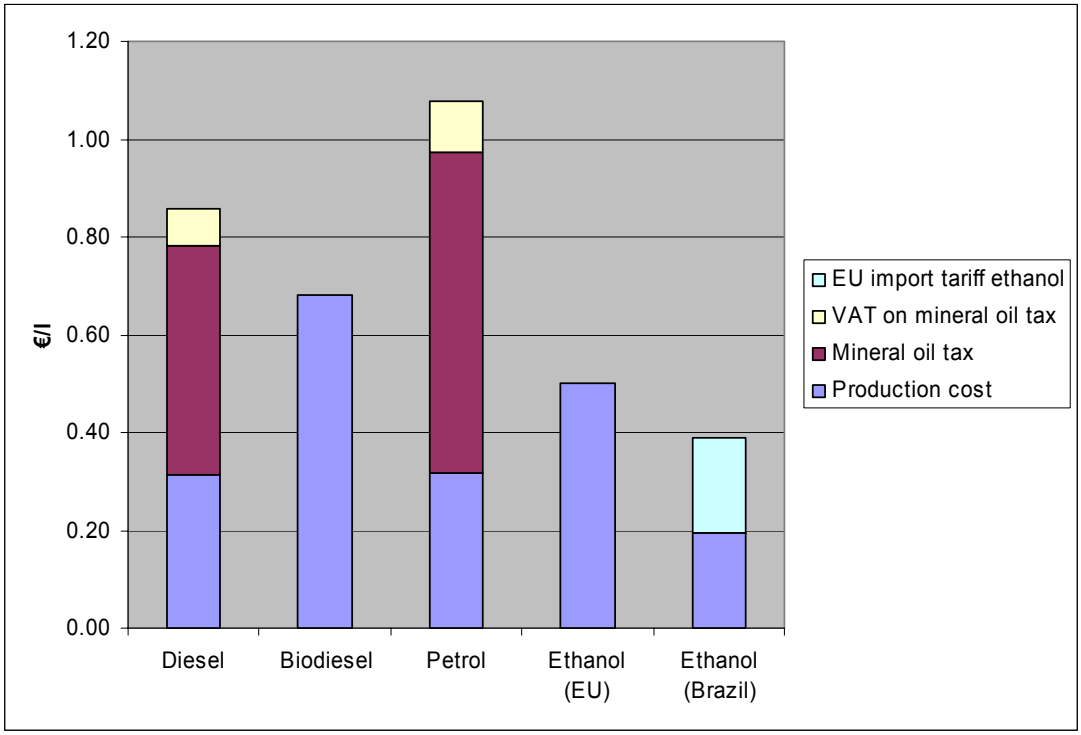

Figure 6: Production cost and taxation of transport fuels in Germany in 2004 (prices on volume basis)
Production cost data exclude VAT but include distribution cost, except for bioethanol (production only). Biodiesel production cost includes distribution cost, except blending cost of 0.03€/l (not applicable to B100). EU import tariff for undenatured bioethanol.
Sources: Production cost for diesel and petrol: average pump prices without taxes in 2004 – Eurostat (2005); production cost for biodiesel: estimate by German Government (June 2005); bioethanol production cost in EU: estimate by Schmitz (2005); bioethanol production cost in Brazil: average spot market price in the State of Sao in 2004 - Centro de Estudos Avançados em Economia Aplicada. (2005), 1 Real = 0.2903 €.

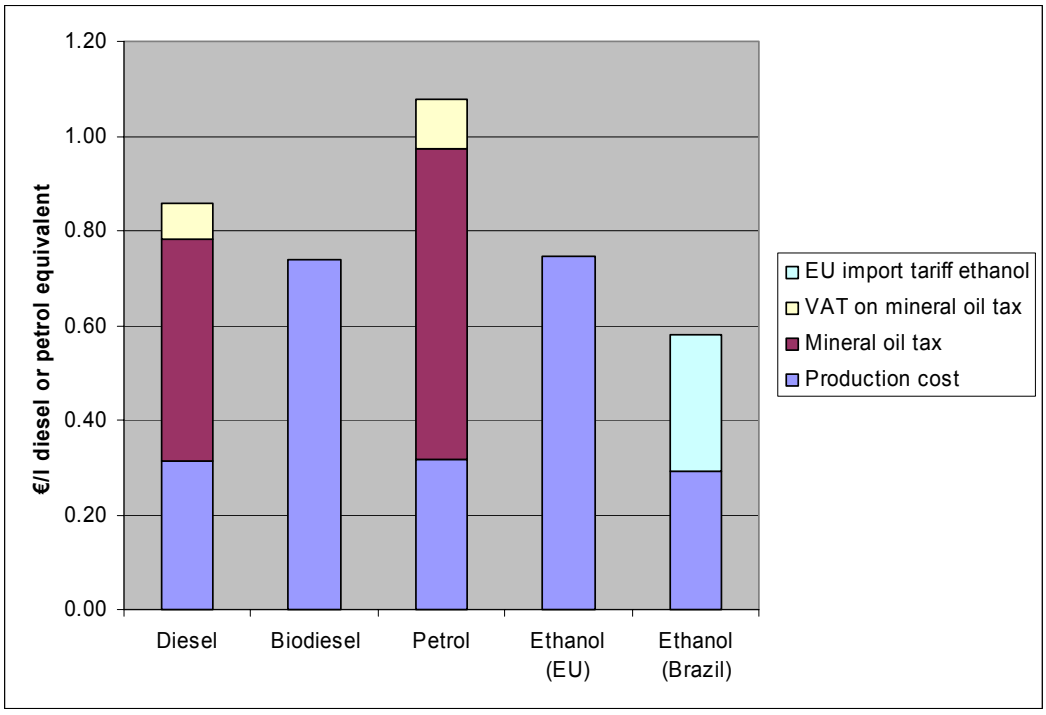

Figure 7: Production cost and taxation of transport fuels in Germany in 2004 (prices on energy basis)
Explanations and sources: see Figure 6

The law obliges the Government to report to Parliament once a year, to allow the latter to reduce the tax subsidy in case of overcompensation. The first report, published on 21 June 2005, concluded that biodiesel production was indeed being overcompensated by 5 cents/litre for pure biodiesel and 10 cents/litre for blending biodiesel. The Government proposes a "moderate" reduction of the tax exemption, and to apply different reductions for pure biodiesel and biodiesel for blending. No amount has been specified and it remains to be seen if Parliament follows the Government's recommendations. Biofuel associations LAB and VDB do not expect biofuels to benefit from a full tax break until 2009 (Klein, Retzlaff, Stein, 30 June 2005). No decision has been taken regarding the continuation of the tax incentive after 2009, although the government has declared its intention to maintain a tax subsidy (German Government, 2004b).

In 2004, the loss in tax income was ca. 700 million € (mineral oil tax and VAT on mineral oil tax); if the tax exemption remains in place and the 5.75% target is met, I estimate the loss to be around 2.5 billion € (scenario 2010a) or 2 billion (scenario 2010b).

Diesel subsidy for farmers

Since 1 January 2005, the amount of subsidised diesel for use in agriculture has been limited to 10,000 litres per year and farm. This has the effect that biodiesel is now a cost-attractive option for farmers that consume more than 10,000 litres. Farmers' association UFOP (Union zur Förderung von Oel- und Proteinpflanzen – Union for the Promotion of Oil and Protein Crops, 2005) estimates that this creates a new market of around 300,000 t/year.

Capital grants for biofuel plants

The VDB was not aware of the amount of public grants that have been used to support the construction of biofuel plants. However, they consider it likely that significant amounts of

public money have been invested, especially since many of the plants have been built in regions in Eastern Germany that qualify for regional selective assistance (Retzlaff, Stein, VDB, 30 June 2005)[10]. The three large bioethanol production plants are also located in Eastern Germany and have received capital grants of up to 35% of the total cost (Rheinischer Merkur, 16 June 2005). The 200,000 t/y bioethanol plant in Zeitz, for example has received State Aid worth 43 million € (BerliNews, 30 January 2004).

Support for research, development and demonstration

A number of Government-sponsored projects in biofuels RDD have been and are being undertaken. Table 8 lists those mentioned in the National Reports on the implementation of the Biofuels Directive for the years 2003 and 2004. The National Report for 2003 highlights that the bulk of biodiesel research has been done by the private sector. Biofuels RDD and market introduction programmes are supported by a number of federal ministries as well as institutions in the different states (Kemnitz, Fachagentur Nachwachsende Rohstoffe Agency of Renewable Resources], 7 September 2005)[11].

Table 8: Research, Development and Demonstration projects on biofuels sponsored by the government in 2003-2004

Rape seed oil	**Biodiesel**	**Bioethanol**	**BtL**
- "100 tractors demonstration project" testing the use of plant oils in tractors - Research project on the use of plant oils in internal combustion engines - Research project on engine performance with rape seed oil – diesel blends - Project on "quality assurance for decentralized plant oil production for the non-food sector"	- Demonstration project: conversion of a distillery into a biodiesel plant - Life-cycle analysis studies of RME and rape seed oil - Development of an RME sensor, enabling vehicles running on biodiesel to meet EURO4 emission standards. - Research project on the impact of RME on the lubricating properties of low-sulfur diesel - Research projects on amount and toxicity of particulate emissions from pure biodiesel - Research projects on the interaction of biodiesel and particulate emission reduction systems	- Study on the use of bioethanol and – methanol in the chemical, technical and transport fuel sector - LCA study on the use of domestic and Brazilian bioethanol as transport fuel - Demonstration project on the use of FFVs in car fleets (around 120 FFVs and 3-4 filling stations with E85) - Testing of performance and emissions of "O2-Diesel" (7-10% Bioethanol, 90% diesel and additives) in modern diesel engines	- Various pilot-plant projects projects are being prepared. The aim is to test different BtL conversion processes - Two studies on the economic and environmental implications of BtL production

Source: German Government 2004, 2005

Information and public relations activities

The government plays an active role in promoting biofuels to the general public and potential users and providing the industry with information through its "Agency of Renewable

[10] Regional selective assistance grants are one of the few methods of direct support for industry allowable under the EU's single market rules.

[11] I could not obtain information regarding the amount of public money involved.

Resources" (Fachagentur Nachwachsende Rohstoffe - FNR). It publishes studies, organises conferences and trade-fairs and coordinates public RDD.

5.2.1.2 Fuel standards

The European standards for diesel and petrol (EN 590 and 228) apply in Germany since 2004. Since 24 June 2004 only biodiesel meeting the FAME standard DIN EN 14214 is allowed for direct use or blending[12].

5.2.1.3 Emission standards

Vehicle emissions must meet the EURO 4 and 5 requirements as explained in Section 4.5. Furthermore, the coming into force of the European air quality directive (1999/30/EC) in 2005 has triggered public awareness and concern about particulate emissions from diesel cars. The government is pressurising car manufacturers to introduce particulate filters that go beyond the EURO 4 requirement and has announced its intent to subsidise them.

5.2.1.4 Alcohol legislation

The alcohol production is regulated by the "Branntweinmonopolgesetz", dating back to 1921. The original law as well as the current version, updated in 1999, was aimed at potable ethanol production in small to medium sized distilleries, but not at industrial transport fuel production (Retzlaff and Stein, 30 June). But since the latter could, in theory, also be used for drinking, it also falls under the law. This creates a set of financial and administrative problems: ethanol producers, for example, have to deposit a guarantee of 1300€/hl ethanol at customs. While this money can be recovered, the law imposes high liquidity requirements on producers and prevents them from investing their finance in a lucrative way. The law does not allow plant managers to enter their facilities without being accompanied by a customs officer. Producers are confident, however, that these obstacles will be overcome and, together with the government, are looking for solutions (Klein, LAB, 30 June 05).

5.2.2 Public opinion

5.2.2.1 Opinion leaders

Government and political parties

Government is actively promoting biofuels and bioenergy in general. The main driving force is the ministry of consumer protection, food and agriculture, under the responsibility of Ms Renate Künast (Green Party). She considers bioenergy a key future technology set and is pushing the development of the sector. Bioenergy is regarded beneficial from an environmental and security of energy supply point of view but also seen as a means to support agriculture and economically weaker areas, especially in Eastern Germany.

Federal elections are held on 18 September 2005 and there is uncertainty if and how, in case of a government change, biofuels will continue to be supported. Germany has had large budget deficits in the past years and the future finance minister is likely to look for ways to cut

[12] The corresponding regulation is the „Zehnte Verordnung zur Durchführung des Bundes-immissionsschutzgesetzes (Verordnung über die Beschaffenheit und Auszeichnung der Qualitäten von Kraftstoffen – 10. BImSchV)" [10th ordinance for the implementation of the federal imission protection law – Ordinance on the composation and labelling of the quality of transport fuels].

spending. However, support for biofuels is strong in most political parties, including the main opposition party (Christian Democratic Union) that has strong ties to the agricultural sector (Retzlaff and Stein, VDB, Klein, LAB and Meyer-Bukow, MWV)[13].

Environmental NGOs and Evironmental Protection Agency

Some of the leading environmental NGOs are highly critical towards bioethanol and biodiesel. For example, "Friends of the Earth Germany" (Bund Umwelt- und Naturschutz Deutschland – BUND) is opposed to the tax exemption for biofuels. They fear that it will lead to reduced fuel prices and increased driving and warn of the environmental impacts associated with intensive biofuel crop farming (BUND, 16 February 2004). The Verkehrsclub Deutschland (VCD), Germany's main environmental group for transport and mobility, also highlights the environmental impact associated with intensive rape farming and favours the use of biomass for stationary heat and power generation, due to the better CO_2 reduction potential (VCD, 2004). The Naturschutzbund (NABU), another large green NGO, also favours the stationary use of bioenergy over first generation biofuel production, but sees them as a first step towards more environmentally beneficial BtL fuels (NABU, 2005).

The federal EPA (Umweltbundesamt - UBA) is also opposed to bioethanol and biodiesel and their subsidisation. The EPA is considered an impartial authority on environmental questions and has published studies on the environmental and economic consequences of biodiesel production and use (UBA, 1993 and 1998). Its position can be summarised as follows (Ostermeier, 17 July 05):

a) First generation biofuels are no cost-efficient option to reduce greenhouse gases (cost of over 200€ per t $CO_{2\text{-equivalent}}$).

b) Biofuel crop farming reduces the availability of land and biomass for stationary heat and power generation. The latter option is a more efficient way to reduce greenhouse gases; reduction potential per ha is up to five times higher;

c) Biodiesel and ethanol from sugar or starch are dead end technologies that will in the mid term be replaced by the environmentally superior biofuels BtL and lignocellulosic ethanol.

d) Intensive farming of biofuel crops is bad for the environment.

The EPA argues that, rather than wasting money on first generation biofuels, policy makers should implement policies that reduce traffic, shift traffic to less environmentally harmful modes of transport and force or incentivise manufacturers to improve vehicle fuel efficiency.

The media

German media seem to be largely positive towards biodiesel and bioethanol. 62 out of 68 articles which I collected for my online media survey from 1 June – 6 August 2005 portrayed them in a positive, or mainly positive way. Only 3 articles were categorised "negative" or "mainly negative" and 3 "neutral".

[13] Three out of four parliamentary groups voted in favour of the tax exemption for biofuels (governmen parties Social Democratic Party and Green Party and main opposition party Christian Democratic Union). Only the the Liberal Democrats were opposed to it.

5.2.2.2 The general public

There has not been much of a public debate on biofuels (Klein, LAB, 30 June). The VDB believes that while most people probably perceive biofuels as something environmentally beneficial, they would not buy B100 if it was not for the lower price. They do not think there is much of a market for "green fuels" sold at a premium (Retzlaff and Stein, VDB, 30 June). Most people are probably unaware of the complex, LCA based arguments that environmental groups have against biofuels. On the other hand, the most "environmentally aware" people are the most likely to oppose biofuels for environmental reasons.

5.3 Main actors

5.3.1 Biofuel industry

5.3.1.1 Biodiesel producers

Biodiesel production started in the early nineties, encouraged by farmers' association UFOP, that was founded at that time. At the same time fossil fuel prices had risen to a level that made excise duty free biodiesel more or less competitive with diesel (Honecker, Ministry of Consumer Protection, Food and Agriculture, 2 September 2005). The biodiesel sector has grown steadily ever since. In 1998 production capacity was 65,000 t/y; it had reached around 1.2 million tonnes by the end of 2004 (VDB, 2005). For 2005-6 the construction or expansion of 10 more plants has been announced. There are around 25 biodiesel production plants with capacities ranging from 1500 to 150,000 t/y (Internationales Wirtschaftsforum Regenerative Energien [International Economic Forum Renewable Energies], 2005). While most of the producers are selling to the B100 market, some of the larger ones are selling to the major oil companies for blending[14]. The sector has been growing since 1993 and still seems attractive to newcomers. The VDB is contacted nearly daily by would-be new entrants (Retzlaff and Stein, VDB, 30 June). At least 500 million € had been invested into production plants until the end of 2004 (estimate based on Retzlaff and Stein, VDB, 30 June 05)[15].

Average biodiesel production costs, including distribution logistics, are estimated to be 0.68 €/l; the costs of blending are estimated an additional 0.03 €/l (German Government, June 2005).

There are a number of German biodiesel plant manufacturers. Probably the most widely known is Lurgi AG, a manufacturer of chemical plants, that claims to be one of the world's leaders in the biodiesel field[16].

5.3.1.2 Bioethanol producers

Until 2005 no bioethanol has been produced for the transport sector in Germany; distilleries have in the past been small to medium sized installations. This situation is changing: in 2005 three large plants with a combined capacity of some 500,000 tonnes/y have started producing bioethanol for the transport fuel market. They are designed to produce 99.9% pure ethanol.

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[14] Many of the smaller plants can only distribute their biodiesel by truck. Large-scale blending operations, as practised by the oil majors, require larger quantities of biodiesel which can only efficiently be delivered by rail or barge. Another way of facilitating transport logistics is to operate the biodiesel plant next to an oil refinery (e.g. a 150,000 t/y plant of the Sauter Group, next to the PCK refinery in Schwedt).

[15] Assuming a specific capital investment cost of 475€/t x y.

[16] www.lurgi.de

Two plants are owned by the Sauter Group, a medium-sized German company with 100 employees that sells agricultural products and services, and also operates a biodiesel plant (www.sauter-logistik.de). They are located in Zörbig, Sachsen-Anhalt (100,000 t/y, from mainly from wheat) and Schwedt, Brandenburg (200,000 t/y, mainly from rye). The other plant is located in Zeitz (200,000 t/y, from wheat and sugar syrup) and owned by Europe's largest sugar producer Südzucker. The construction of 6 more plants with a capacity of another 500,000 t/y has been announced (FNR, n.d.). Around 250 million € have been invested into the three plants (Klein, LAB, 30 June 2005; European Commission, 17 June 2005; BerliNews, 31 January 2004)[17].

The Südzucker plant has been constructed by Austrian company Vogelbusch, one of the world's leading distillery manufacturers and can be considered state-of-the-art (Schmitz, 26 July 2005). It is a combination of a bioethanol and a CHP plant, operating on coal. A significant part of the revenues is expected to come from sales of electricity (Klein, LAB, 30 June 2005).

The two Sauter plants have been designed by the group itself. They make use of novel "cold enzymes" that do not require the cereal mash to be heated to break down the starch into sugars. Sauter has also experimented with marketing the byproduct "distiller's grains"[18] as semi-dry, as is typically done in the US. Having realised that this was difficult, additional facilities were installed for drying and pelletising the byproduct[19] (Klein, LAB, 30 June 05). The Sauter plants appear to currently have major technical difficulties (Schmitz, 26 July 2005; Ernährungsdienst, 29 June 2005).

Average production costs are estimated to be 0.45-0.50 € / l, excluding distribution logistics (Schmitz, 2005).

5.3.1.3 Biofuel producers' trade associations

The biofuels sector is well organized and has set up trade associations to lobby decision makers, promote its products, coordinate research and exchange information. The main associations in the biodiesel sector are UFOP (Oil seed producers), Arbeitsgemeinschaft Qualitätsmanagement Biodiesel – AGQM - [Working Group Quality Management Biodiesel] (quality assurance and certification group run by producers and retailers), and VDB (biodiesel producers). The main lobby groups for bioethanol producers have so far been LAB and Wirtschafliche Vereinigung Zucker [Sugar Association]. Transport biofuel as well as other bioenergy interest groups are represented by Bundesverband Bioenergie (BBE) [Federal Association for Bioenergy]. The farmers's association Bauernverband is also promoting and lobbying for biofuels. The different trade associations are well connected: UFOP, AGQM and LAB are part of the Bauernverband and share the same office building. The VDB was formerly known as Verband der Deutschen Biodieselindustrie but has in July 2005 renamed itself to Verband der Deutschen Biokraftstoffindustrie and announced that it will from now also represent the interests of bioethanol producers.

Both VDB and LAB consider that the German biofuels interest groups are effective in lobbying. Germany is the biggest European biofuels producer and the German biofuels interest groups have been a major driver behind the European biofuels and energy tax

[17] Assuming a specific capital investment cost of 500€/t x y.

[18] The remnants of the mashing process, after starch removal can be sold as animal feed.

[19] The Zeitz plant also co-produces dry pellets.

directives. They have also successfully pushed for the exemption from excise duties through changes in the Mineral oil tax law[20].

VDB and LAB consider that, all in all, the regulatory framework is favourable to biofuel producers. The VDB criticise the fact that overcompensation is checked on a yearly basis as this creates uncertainty for producers and is opposed to a reduction of the tax subsidy. The VDB also opposes an obligatory biofuel quota system as it believes it not to be politically feasible and fears it would lead to the destruction of the B100 market (Retzlaff and Stein, VDB; UFOP, 2005).

5.3.1.4 Cooperation with other actors

The biofuels industry actively collaborates with the automobile and oil industry, even though interests are not always the same (Retzlaff and Stein, VDB; Klein, LAB, 30 June). Biofuel producers, for example, currently collaborate with the oil companies on field trials with biodiesel and bioethanol blends. The trials are coordinated by the Deutsche Gesellschaft für Mineralöl und Kohle (DGMK) [German Asssociation for Mineral Oil and Coal]. Biodiesel producers also collaborate with vehicle manufacturers MAN, Daimler-Chrysler and Volkswagen to assess the performance and emissions of engines running on biodiesel. They consider this collaboration essential, as engines and emission control systems are constantly evolving and becoming increasingly complex (Retzlaff and Stein, VDB, 30 June 05).

5.3.2 Oil industry

5.3.2.1 Official stance on biofuels

The Association of the German Petroleum Industry (Mineralölwirtschaftsverband - MWV), representing the interests of the large oil companies[21], is very critical of first generation biofuels and is opposed to their exemption from mineral oil tax. Similarly to the EPA and some of the leading environmental NGOs they argue that biomass should be used in stationary heat and power generation as this is a more cost-efficient option to reduce CO_2 emissions. Furthermore, they consider that biodiesel and –ethanol can only make a very small contribution to strengthening security of energy supply. The MWV proposes instead that policy should focus on improving conventional engine performance, increasing the use of electric hybrid engines, developing BtL and hydrogen as transport fuels (MWV, December 2004).

However, the MWV says that oil companies have accepted the political targets, that they believe they are likely to be met and that they are making efforts to meet them. Even though they argue that it reduces their profit margin, they have taken up the blending of biodiesel and ETBE. The oil industry fears that otherwise government might introduce mandatory quotas (Meyer-Bukow, MWV, 11 July 2005).

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[20] The VDB was opposed to these changes. It did not want the law to also address biodiesel, as this would facilitate the introduction of excise duty on biodiesel, from which it was previously de facto exempt (Klein, LAB, 30 June 2005).

[21] MWV members are Agip Deutschland GmbH, ConocoPhillips Germany GmbH, Deutsche BP AG, Esso Deutschland GmbH, Holborn Europa Raffinerie GmbH, OMV Deutschland GmbH, Orlen Deutschland AG, Shell Deutschland Oil GmbH, Total Deutschland GmbH

Stance on biodiesel and ETBE

The MWV has accepted that the blending of biodiesel and ETBE is feasible and argues that the 5.75% target can and should be met using these biofuel types alone. While the petrol standard allows up to 15% ETBE addition, the MWV believes oil companies will not add more that 1-2% to standard 95 octane petrol, due to the high production costs. They also claim to be investigating the possibility to directly process plant oils into biodiesel in their refineries (Retzlaff and Stein, VDB, 30 June).

Stance on direct blending of bioethanol

The MWV is opposed to the nation-wide introduction of E5. They say that while it would be challenging, though feasible, to make sure the supply chain is kept free of water, it would be virtually impossible to ensure that petrol-ethanol blends do not exceed the limit for fuel vapour pressure (Meyer-Bukow, MWV, 11 July 2005). With the oil companies sharing some of the fuel distribution infrastructure (e.g. refineries, pipelines) and exchanging large quantities of fuels among themselves the introduction of low-level ethanol blends would be faced with insurmountable logistic obstacles. If at all, E5 could only be supplied directly to fleet operators or, possibly, distributed on a regional basis, keeping the regional logistic chain separate from the rest of Germany.

5.3.2.2 The oil companies' use of biofuels

Use and sales of biodiesel

The oil companies have started to make blends up to B5 and have used around 300,000 t of biodiesel in 2004. Aral/BP were the first to install blending facilities at their refineries in the Berlin and Köln/Bonn region and other companies are following (Retzlaff and Stein, VDB, 30 June). The large oil companies are currently not involved in producing or importing biofuels themselves (Meyer-Bukow, 11 July 2005). However, Orlen[22], a polish oil company with a market share of 3% in the transport fuels sector, is operating a 100,000 t biodiesel plant in Poland (UFOP, 2005).

None of the large oil companies sell B100 at their filling stations (Meyer-Bukow, MWV, 11 July 2005). This is exclusively done by independent retailers and the "Deutscher Raiffeisenverband" (a farmers' trade association and service provider), at more than 1900 stations, located all over the country.

Use of ETBE

Some MTBE production facilities have been converted to ETBE production and 65,000 t of bioethanol were used in 2004. ETBE may be on its way to substitute MTBE as an octane-enhancing fuel additive in Germany. However, even though the petrol standard allows up to 15% ETBE, the MWV does not believe that oil companies will use more than is necessary to meet fuel quality requirements (around 2% (vol.) for 95 octane and 10-12% for 98 octane petrol), because of the large production costs.

[22] www.orlen.de

Use of bioethanol

Only negligible amounts of ethanol have so far been used for direct blending. All major oil companies have participated in a field trial of E5 use at 76 filling stations in the Berlin region from November 2004 to Mai 2005. Independent retailer Berliner Mineralöl-Vertrieb (BMV), as well as ConocoPhilips (JET) started to sell E5 (Schmitz, 26 July 2005). The government believes that more oil companies may start to sell blends from the end of 2005, although not on a nation-wide basis (German Government, June 2005). No E85 is currently being sold. However, a pilot project demonstrating the use of FFVs in car fleets (3-4 filling stations with E85, some 120 FFVs) is to start in summer 2005 in North-Rhine-Westfalia.

BP has announced that it will make its decision whether or not to take up direct blending all over Germany public in 2006 (Frankfurter Rundschau, 14 July 2005). Its competitors are also likely to be currently preparing their business strategies for dealing with bioethanol in future, but are keeping these secret for the moment (Meyer-Bukow, MWV, 11 July 05).

5.3.2.3 Analysis: The interests of the oil industry

The German oil industry has started to use biodiesel for low-level blends, but is resisting the country-wide introduction of E5. Official reasons are political pressure and logistic problems. While these issues are real, a closer look reveals other – financial – considerations that guide the companies' positions.

Strong demand for diesel and overproduction of petrol

Diesel and petrol are co-products of the distillation of crude oil and refineries, depending on their facilities, can only influence the yield ratio to a certain extent. As shown in Figure 8, in the last two decades demand for diesel has increased while demand for petrol has stagnated and then shrunk in the EU 15. Refinery diesel output is following demand, while the petrol surplus is becoming larger. These trends are expected to continue over the next years. The increasing demand for diesel makes biodiesel interesting to European oil companies as it allows them to increase supply by "stretching" conventional diesel. On the other hand, refineries are finding it increasingly difficult to sell their petrol on the shrinking European market and have to ship it to overseas markets (e.g. the U.S.), which reduces their profit margin. The introduction of bioethanol as a petrol substitute would accelerate this trend. The extent to which this trend negatively affects companies depends on the technical flexibility of their refineries. It can thus be expected that interests and attitudes towards using bioethanol differ between the companies.

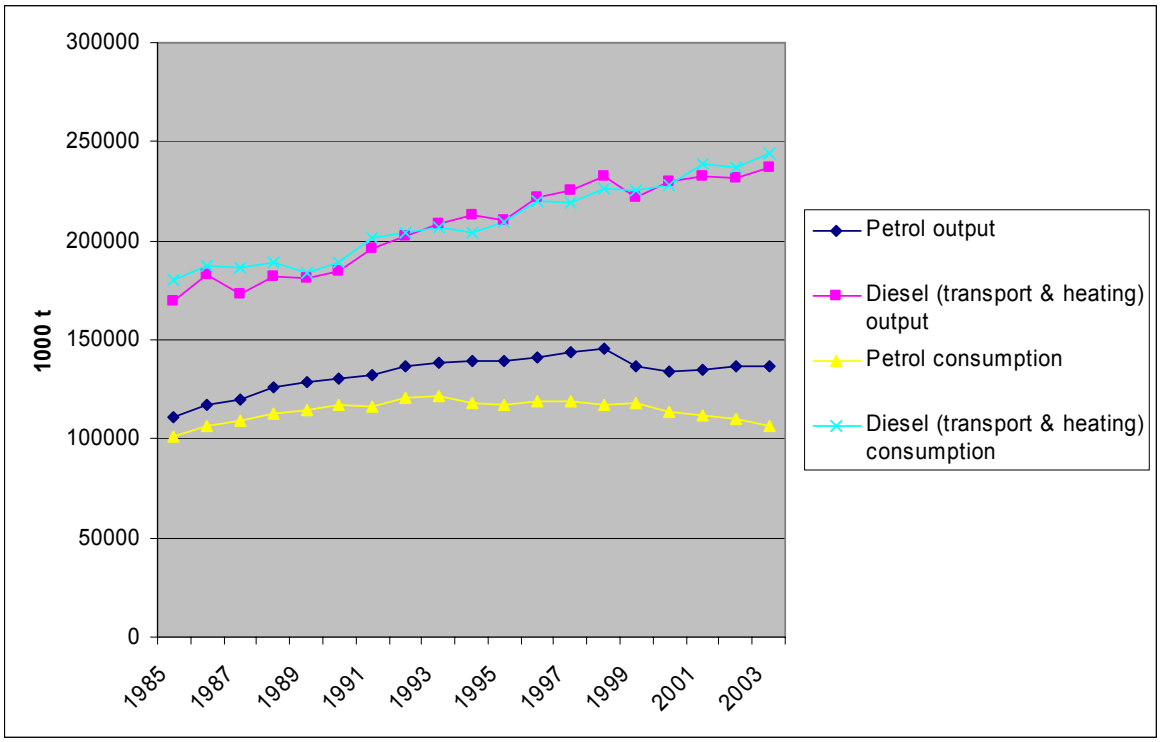

Figure 8: Diesel and petrol consumption and refinery output in the EU 15
Source: Eurostat (2005)

Petrol is a lucrative market for low-value volatile components of crude oil

Oil companies can indeed make sure that the vapour pressure of E5 stays below the legal limit by reducing the vapour pressure of the fossil part of the mix. This can be done by removing volatile components such as butane. This may not only require an additional investment into the necessary facilities, but also forces refineries to find another market for these low-value compounds (Hodson and Maniatis, DG TREN, 4 July 2005; PricewaterhouseCoopers, 2005).

Neat biofuels require additional investments in infrastructure and threaten the oil industry's core products

Unlike B5 and E5 that can be distributed and sold in the existing infrastructure, B100 and E85 would require additional investments. This is one reason why the oil majors have taken up blending but do not market "neat" biofuels in Germany. Another likely reason is of a more strategic nature: Low-level blending may allow oil companies to "stretch" their core, oil-derived, products. B100 and E85, however, can substitute (most of) their core products. By selling these biofuels, oil companies would allow external producers to capture a large part of the added value.

The tax subsidy may make blending profitable

While the MWV claims that biodiesel blending "does not pay" for the oil companies, this may well not be the case. With a tax subsidy of 55 cents/litre, it may be cheaper to purchase and blend biodiesel than to produce fossil diesel. Rather than being a show of goodwill, blending may allow companies to improve their profit margins.

5.3.3 Automobile industry

5.3.3.1 Stance on biodiesel

German car manufacturers have, in the past, allowed B100 to be used in some of their diesel models. There are currently about 3 million such cars on German roads. These are mainly models produced by Volkswagen (Volkswagen, Audi, Seat and Skoda), with BMW and Daimler-Chrysler having pulled out of the B100 segment for cars (Retzlaff and Stein, VDB, 30 June). Since 2005, VW has also stopped issuing their basic models with a B100 warranty. According to the car manufacturers, the new EURO 4 emission standards cannot be met with B100, unless a biodiesel sensor, a result of a government sponsored research and development project, is used[23]. Furthermore, the new self-regenerating particulate filters, that more and more new cars are being equipped with are incompatible with biodiesel (VDB, 2005b).

Truck manufacturers Daimler-Chrysler, MAN, Iveco and DAF are selling B100 compatible trucks. Unlike car manufacturers they seem to make stronger efforts to guarantee the biodiesel compatibility of their vehicles also in the future (Retzlaff and Stein, VDB, 30 June 2005). Daimler-Chrysler has developed a SCR[24]-based emission reduction system that meets the EURO 5 norm and announced continuing to allow B100 in its new EURO 4 and EURO 5 engines in utility vehicles. Biodiesel producers believe that, with demand from the private car segment shrinking, the freight transport segment will be their main market for B100 in the coming years (UFOP, 2005).

5.3.3.2 Stance on bioethanol

The German automobile industry association "Verband der Automobilindustrie" (VDA) has officially declared to support the blending of ethanol up to E5 (VDA, 2005). They also claim that the German automobile industry is currently testing the possibility to use E10, and that ethanol is a key element in their strategy to reduce dependency on fossil oil. They state that they are collaborating with policy makers to promote the use of ethanol in Germany and Europe. (VDA, 14 June 2005 and 4 September 2005).

There are no FFVs on German roads yet. Ford has announced to market two FFVs from summer 2005, for a premium of 300€, compared to the standard version.

5.3.3.3 Analysis: The interests of the automobile industry

Due to high fossil fuel prices, manufacturers are faced with consumer demand for vehicles running on cheaper fuels. Especially fleet operators and since 2005 also farmers are calling for trucks, buses and farm vehicles that can run on cheaper biodiesel. Manufacturers thus have an interest to provide especially B100 compatible utility vehicles, as long as tailpipe emission norms can be met.

The use of petrol-ethanol blends above E5 is considered more difficult than that of biodiesel and has for a long time been rejected by the manufacturers. However, the car manufacturers have changed their stance in the last year (Schmitz, 26 July 2005). This change is likely to be linked to increasing political pressure on the car industry to reduce the CO_2 emissions of new

[23] The new VW Golf, for example, is no longer certified in the basic version, but can optionally be equipped with a sensor.

[24] "Selective Catalytic Reduction"

cars[25]. The car and oil industry have conflicting interests regarding this issue: while car manufacturers would like to be given the credit for reducing CO_2 emissions by making their cars compatible with increasing concentrations of biofuels (e.g. E10), the oil industry claims effectively the same credit for itself, for blending and supplying the fuel.

Another motivation to endorse bioethanol may, again, be consumer demand for alternative fuels, given the current high petrol prices. Furthermore, the German car industry is leading in the field of flexible fuel technology and may like to take advantage of their competence also in their domestic market. Bosch, for example, has developed an ethanol sensor for FFVs and German brands have a market share of 66% of the Brazilian FFV market. German manufacturers are also producing FFVs for the US market (VDA, 14 June 2005).

5.4 Analysis of the functional pattern

A functional analysis of the technological system allows to identify its driving and blocking mechanisms; they are listed in Table 9. The main driver has been the tax exemption, at first only for B100 and since 2004 also for low-level blends of biodiesel and bioethanol. The willingness of manufacturers to allow B100 in their vehicles and of service station operators to supply it have also been crucial for the development of the sector. Legal changes that have opened up the blending market are ensuring that biodiesel can sustain its growth and have triggered investment into bioethanol plants. The driving mechanisms that have allowed biofuel use to grow will be further discussed in Section 7.1. The main blocking mechanisms that biofuels face are their higher production costs (and the uncertainty if political support will offset these after 2009), the reluctance of the oil industry to use ethanol for direct blending and the declining number of vehicles warrantied for blends above B5 and E5.

Table 9: Functional pattern of the technological sytem "biodiese and bioethanol" in Germany

Function	**Extent to which fulfilled / drivers**	**Blocking mechanisms**
Knowledge development and diffusion	- Public and private RDD have widened the knowledge base and led to a number of technological developments (e.g. biofuel performance in engines, impact of ethanol on petrol vapour pressure, performance of diesel-ethanol blends, biodiesel sensor, FFV engine technology, FFV performance in car fleets) - Practical experience gained in B100 production, distribution, marketing and usage since 1993 - Practical experience gained in biodiesel and bioethanol blending since 2004 - Oil industry has announced to study the direct processing of plant oils in refineries - Some practical experience in large-scale production of bioethanol (started in 2005)	
Influence on the direction of search	- Biofuel producers (and MWV) believe in growth potential and are confident that policy makers will ensure that 5.75% target is met - High fuel prices make end-consumers and blenders look for alternatives, such as subsidised biofuels - Fleet operators and farmers are putting pressure	- Overproduction of petrol makes use of bioethanol as a petrol substitute unattractive to oil companies

[25] The European Commission has negotiated an agreement with the European, Japanese and Korean car manufacturers' associations (ACEA, JAMA and KAMA) according to which average CO_2 emissions of new cars will be reduced to 140 g/km by 2008 (ACEA) or 2009 (JAMA, KAMA). However, this first target makes no distinction between fossil and non-fossil CO_2 emissions (European Comission, 1999, 2000a, 2000b).

	on manufacturers to certify their utility vehicles for cheaper B100 - Increasing demand for diesel makes oil companies look ways to "stretch" supply, by adding biodiesel or, possibly, bioethanol to diesel - Threat of global warming and resulting political pressure make car manufacturers look for ways to reduce vehicle fossil CO_2 emissions - The Common Agricultural Policy provides financial incentives to farmers to produce energy crops, especially on set-aside land	
Entrepreneurial experimentation	*Biodiesel* - Relatively large number of biodiesel producers (around 30) - Variety in plant sizes: 1,500 to 150,000 t/y - Two marketing routes for biodiesel are successfully used: for the B100 market, by-passing the large oil companies, and for the blend market *Bioethanol* - Different feedstocks used in three bioethanol plants (wheat, rye, sugar syrup) - Use of novel cold enzymes in production process - Experimentation with two ways of marketing distiller's grains (semi-dry and dry pellets) - Two marketing routes for ethanol used: ether production and direct blending	*Biodiesel* - Rape seed is the dominant feedstock; only little experimentation with other feedstocks
Market formation	*Biodiesel* - Strong growth in demand due to price differential with fossil diesel (due to duty exemption of 0.48 €/l and high oil price) - Three million B100 certified private cars, as well as many utility vehicles and over 1900 filling stations provide a market for neat biodiesel - Diesel standard DIN EN 590 allows up to 5% (vol.) FAME content and oil companies have taken up blending *Bioethanol* - Strong growth in demand due to price differential with fossil diesel (due to a duty exemption of 0.65 €/l and high oil price) - Oil companies are replacing MTBE with ETBE	*Biodiesel* - Production costs are higher than those of diesel: biodiesel is not price-competitive without a tax subsidy - Volatility of feedstock and oil prices and a potential reduction of the tax subsidy may stop market growth - Stricter emission and air quality standards are difficult to meet with biodiesel: German manufacturers have stopped to certify basic car models for B100 - DIN EN 590 does not allow more than 5% biodiesel and changing the standard is a slow process - German law requires biodiesel to conform to DIN EN 141214: this limits the market for non-RME biodiesel *Bioethanol* - Production costs are higher than those of petrol: ethanol is not price-competitive without a tax subsidy - Even though petrol standard DIN EN 228 allows up to 5% (vol.) ethanol content, oil companies oppose nation-wide introduction of E5. E5 is confronted with regulatory (vapour pressure limit) and technical (affinity for water) barriers - Currently there are no E85 filling stations; 2 FFV models are only becoming available from summer 2005 - High import tariffs limit the market access for cheaper bioethanol from e.g. Brazil. WTO negotiations may remove or lower this barrier
Legitimation	*Biodiesel and bioethanol* - Three out of 4 parliamentary groups support biofuels	*Biodiesel and bioethanol* - "Green" opinion leaders EPA and leading environmental NGOs oppose biodiesel and

	- German media seem very supportive of biodiesel and bioethanol - Petrol and diesel standards allow 5% biofuel content - Biofuel producers' and farmers' asscociations are well organised, connected and active in PR, lobbying and information distribution *Biodiesel* - Some vehicle manufacturers endorse B100 - Large number of fleet operators endorse biodiesel - Biodiesel standard ensures well defined quality requirements are met and increases acceptance of biodiesel by automobile and oil industries *Bioethanol* - VDA endorses E5 and is now positive towards E10	–ethanol *Biodiesel* - Vehicle manufacturers have stopped to allow B100 in the basic versions of their new cars *Bioethanol* - VDA has for a long time rejected ethanol blends above E5
Resource mobilisation	*Biodiesel* - Over 570 million € have been invested in some 30 production plants - Independent filling station operators have put tanks and pumps for B100 in place at over 1900 stations - Major oil companies have put biodiesel blending facilities in place *Bioethanol* - Over 250 million € have been invested into three production plants	*Biodiesel* - Lack of long-term certainty of political support and favourable oil and biomass feedstock prices. Tax exemption ends 2009 and is checked every year. *Bioethanol* - Lack of long-term certainty of political support and favourable oil and biomass feedstock prices - Oil industry's opposition to nation-wide direct blending limits market size - Uncertainty if import tariffs will keep cheaper bioethanol imports (e.g. from Brazil) off market. - Uncertainty if domestic producers can compete with other EU producers.

6 Country study: United Kingdom

6.1 The market for biofuels: past, present and future

6.1.1 2002-today

6.1.1.1 Biodiesel

Production and consumption of biodiesel have only started in 2002, with the introduction of a duty incentive for this fuel (see Figure 9). Most of it is produced in small plants from waste vegetable oil, currently the cheapest feedstock, and from imported soya and palm oil[26]. Some RME is also imported from continental Europe, particularly Germany (Berry, Department for Transport [DfT], 13 July 2005). Biodiesel is mostly sold in blends, at or below the 5% level. It had a market share of 0.03%, on an energy basis, of all transport fuels in 2004.

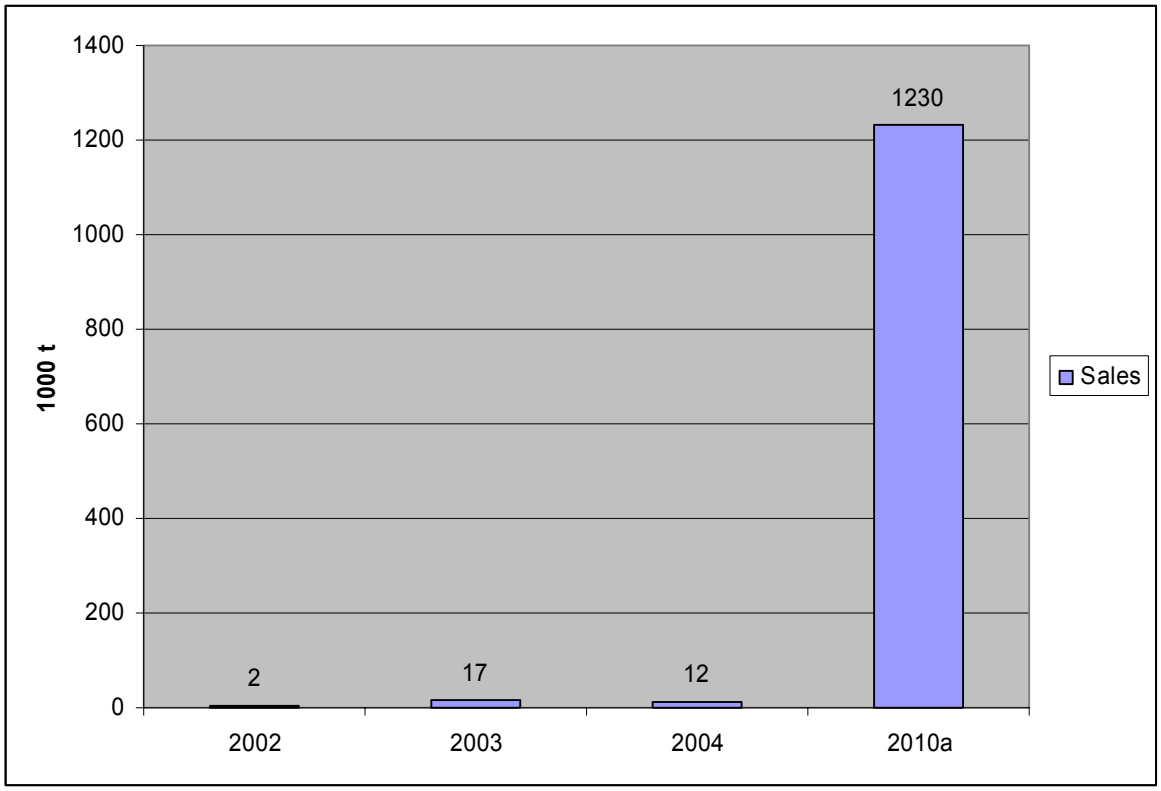

Figure 9: Sales of biodiesel in the UK

2002-4 sales data from UK Government (2005)

2010a: quantity assuming EU target is met with a 5.75% biodiesel share of diesel sales and a 5.75% bioethanol share of petrol sales; assuming petrol and diesel sales in 2010 are the same as 2004 (data from UK Government - Department for Trade and Industry [2005]).

6.1.1.2 Bioethanol

Bioethanol was not used in the transport sector until 2005, when a fuel duty incentive was also introduced for bioethanol. Since January 2005, sales have been quickly increasing and

[26] I could not find any production, import and export figures for 2002-2005.

bioethanol has become the most important biofuel. From January to May 2005 12,515 t of bioethanol were sold, compared to 7,367 t of biodiesel. Bioethanol is only used in blends up to E5. No bioethanol is currently produced in the UK, imports come predominantly from Brazil (Berry, DfT, 13 July 2005).

6.1.1.3 Other biofuels

Apart from biodiesel and –ethanol, the Government does not mention any other biofuels that are currently used in the UK (UK Government, 2005).

6.1.2 The target for 2010

Table 10 shows the required quantities and market segments of biodiesel and –ethanol for Britain to meet the 5.75% indicative target in 2010. The consumption of biofuels needs to roughly grow by a factor 300.

Table 10: Biofuel quantities required for meeting indicative 2010 target (5.75% market share for biofuels)

		2004	2010
Diesel consumption (million t)		18.5	18.5
Biofuels share of total fuels market (energy basis)		0.03%	5.75%
Biodiesel share of diesel market (energy basis)		0.06%	5.75%
Biodiesel quantity (million tonnes)	*Total*	0.01	1.2
	B5	0.01	1.0
	B>5 (B100)	0	0.2
Petrol consumption (million tonnes)		19.5	19.5
Bioethanol share of petrol market (energy basis)		0%	5.75%
Bioethanol quantity (million tonnes)	*Total*	0	1.8
	E5	0	1.0
	E>5 or ETBE	0	0.7

2010 target: quantity assuming EU target is met with a 5.75% biodiesel share of diesel sales and a 5.75% bioethanol share of petrol sales; assuming petrol and diesel consumption in 2010 is the same as in 2004; Fossil fuel consumption data from UK Government - DTI (2005), biofuel sales data from UK Government (2005).

If these quantities are produced from domestic feedstocks some 1 million ha will be needed for rape seed production (ignoring other biodiesel feedstocks) and 0.5 million ha for cereals and sugarbeet[27] (see Table 11). The total biofuel crop area would take up some 26% of the total arable land in 2004. In 2004 rapeseed for both food and non-food uses was grown on 0.6 million ha, cereals on 3.1 million ha and sugarbeet on 0.2 million ha. Similarly to Germany around a quarter of today's arable land would have to be used for biofuel crop production in 2010. While this scenario does not seem completely impossible, I think it is very unlikely.

Table 11: Estimates of UK domestic farmland requirements for 2010 biofuels target and farmland use in 2004

	2010 (million ha)
Rapeseed farmland	1.0
Cereals and sugarbeet farmland*	0.5
Total biofuel crops farmland	1.5
	2004 (million ha)
Total arable land	5.9
Rapeseed farmland	0.6
Cereals farmland	3.1
Sugarbeet farmland	0.2

* Assuming 50% of bioethanol produced from cereals and 50% from sugarbeet.

Sources: 2004 crop production data – Eurostat (2005); yield factors – own estimates, see Section 2.2.3.3

6.2 Institutions

6.2.1 Regulatory framework

6.2.1.1 Policy measures to promote biofuels

UK strategy for biofuels

The UK's official target for 2005 is a 0.3% market share for biofuels and government expresses confidence that it will be met (UK Government, 2005)[28]. The 2010 target has not been announced yet.

The government has consulted stakeholders on its future biofuels strategy and is currently preparing it. While the consultation document (UK Government, 2004) also mentions rural development opportunities and the strengthening of security of fuel supply as benefits of biofuels, the focus is clearly on climate protection. The government considers biofuels primarily within the context of its policy to create a low carbon economy. It estimates that carbon abatement costs for biodiesel and bioethanol are currently in the range of 200 - 1300 €/t (138-900 £/t), significantly higher than its valuation of 100€ (70 £) per tonne of carbon and the cost of alternative carbon abatement options, such as wind power or stationary heat and power generation from biomass. For this reason, the government wants to be cautious about the short-term promotion of biodiesel and bioethanol and rather target investment at

[27] Assuming that biodiesel is produced from rape seed and ethanol from 50% cereals and 50% sugarbeet.

[28] The European Commission has, in July 2005, rejected the UK target for not being in compliance with the biofuels directive. It has sent a letter of formal notice to the UK (European Commission, 6 July 2005).

lower cost carbon abatement options. Its Energy White Paper (UK Government, 2003) suggests that biofuels could account for some 5% of road transport fuels by 2020.

Government also expresses concern about potentially negative environmental impacts and limited carbon savings associated with biofuel production[29]. It is looking into the possibility of setting up a greenhouse gas and environmental benefit certification system for biofuels.

Fuel excise duty reduction

Fuel duty differentials are the primary means of support for biofuels. Biodiesel benefits from a reduction (but not exemption) in fuel excise duty since July 2002 and the same is true for bioethanol since January 2005. The duty rebate is worth 0.20 £/l (0.29 €/l), plus 0.05 €/l because a reduction in the amount of VAT (17.5%) payable on excise duty. The duty rebate applies for blends as well as for neat biofuels. The current tax benefit will remain in place at least until 2008, on the basis of a three year rolling guarantee[30]. As can be seen in Figure 10, on a volume basis, the duty rebate makes biodiesel and bioethanol price-competitive with diesel and petrol. Figure 11 shows that, on an energy basis, only biodiesel from waste vegetable oil and to a lesser extent from palm oil are really price-competitive. RME has about the same production cost as fully taxed diesel, and EU produced ethanol is significantly more expensive than petrol. On a volume basis, Brazilian bioethanol has slightly lower production costs than petrol, but faces additional transport costs as well as an import tariff (though possibly a lower tariff than the one for undenatured ethanol – see below). It should also be noted that estimated production costs for RME are significantly lower in the UK than in Germany (0.54 €/l compared to 0.60 €/l, excluding distribution costs). This does not seem plausible to me, but I could not compare the detailed cost calculations as these were not given in the literature I used.

The fuel duty rebate has so far mainly stimulated the blending of biodiesel from Waste Vegetable Oil (WVO) and, to a lesser extent, imported palm and soya oil as well as bioethanol imported from Brazil. B5 made with RME is being sold at a price premium. The price calculations suggest indeed that while WVO and palm oil biodiesel have a clear price advantage against diesel and Brazilian bioethanol against petrol (on a volume basis), RME only has a narrow advantage and EU produced bioethanol is not competitive. It is for this reason that would-be bioethanol producers are calling for further government support and protection from imports before setting up domestic production plants.

Biodiesel is defined as "diesel quality liquid fuel, that is produced from biomass or waste cooking oil, the ester content of which is not less than 96.5% by weight, and the sulphur content of which does not exceed 0.005% by weight or is nil" (Finance Bill, 2002). Bioethanol is defined as "a liquid fuel consisting of ethanol produced from biomass, and capable of being used for the same purposes as light oil"; it may be denatured (Finance Bill, 2004). No references are made to any CN-codes, which may allow importers to import bioethanol as a product other than undenatured bioethanol.

[29] Rainforest clearing for palm oil production in South-East Asia is explicitly mentioned (UK Government, 2004).

[30] The subsidy has been approved by the European Commission. The UK has made a commitment to submit annual reports to the European Commission on the monitoring of overcompensation (European Commission, 17 July 2002 and 3 February 2004).

In 2004, the loss in tax income was ca. 4 million € (mineral oil tax and VAT on mineral oil tax differential); if the tax exemption remains in place and the 5.75% target is met, the loss will be around 950 million €.

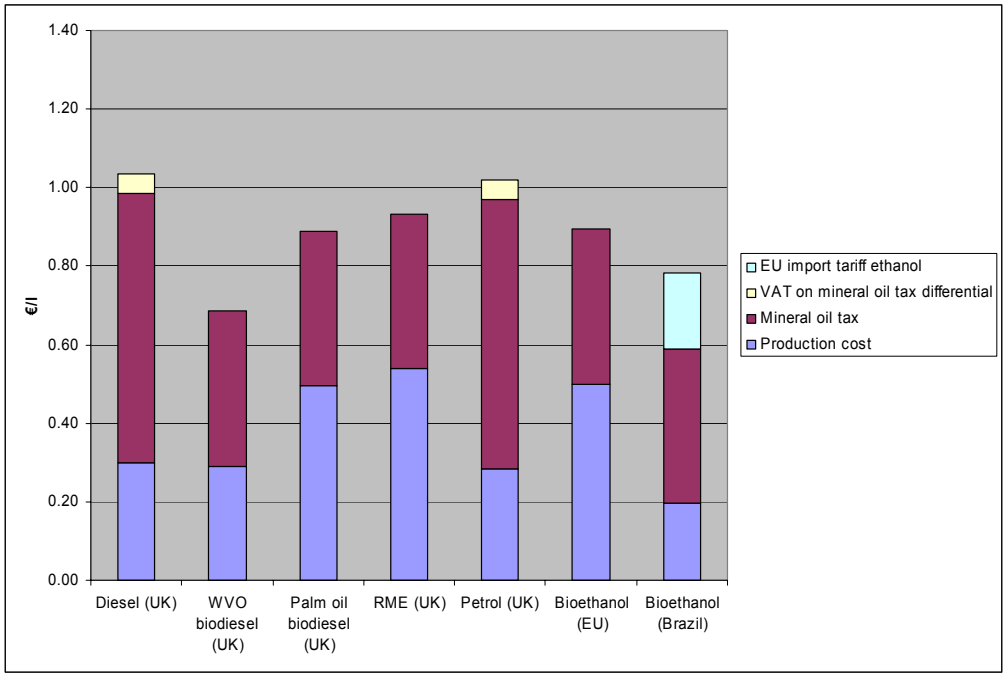

Figure 10: Production cost and taxation of transport fuels in the UK in 2004 (prices on volume basis)
Production cost data exclude VAT. Biofuel cost data exclude distribution cost. EU import tariff for undenatured bioethanol.
Sources: Production cost for diesel and petrol: average pump prices without taxes in 2004 - Eurostat; Production cost for different types of biodiesel – estimates by UK Government (2004); Bioethanol production cost in EU: estimate by Schmitz (2005); bioethanol production cost in Brazil: average spot market price in the State of Sao in 2004 - Centro de Estudos Avançados em Economia Aplicada. (2005), 1 Real = 0.2903 €.

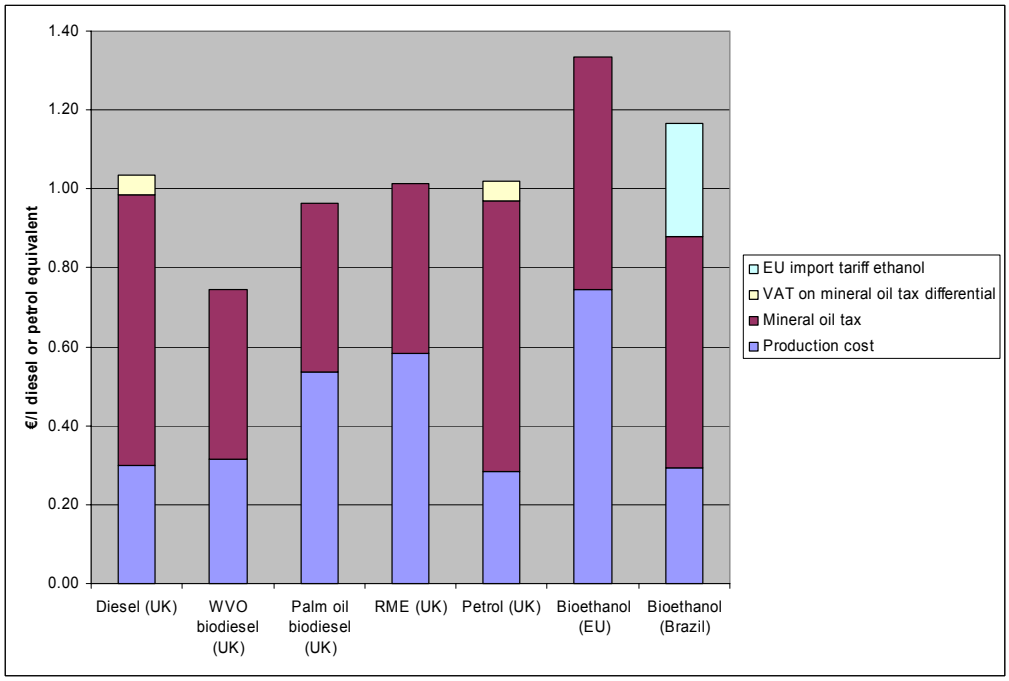

Figure 11: Production cost and taxation of transport fuels in the UK in 2004 (prices on energy basis)
Explanations and sources: See Figure 10

Capital grants for biofuel plants

A regional selective assistance grant of 1.75 million € (1.2 million £) has been given to the Argent Group to build the country's first large-scale biodiesel production plant near Motherwell, in Scotland. Another 1.75 million € grant has been offered to support the development of a biofuel plant in North-East England (UK Government, 2004b).

Support for research, development and demonstration

A number of Government-sponsored projects in biofuels RD&D have been and are being undertaken. The following are mentioned in the National Reports for the years 2003 and 2004. Furthermore, Somerset County Council is preparing a demonstration project for FFV use in fleets due to start in 2006, if EU funding is granted (BBC, 12 December 2005; Ford, 7 July 2005).

Currently, the Department of Trade and Industry supports research and development over the whole range of renewable energy technologies through a ~28 million € pa programme. The biomass part of the programme focuses on heat and electricity generation, but also supports work on next generation biofuels (but not current biofuels) (Mahtab, DfT, 14 July 2005; UK Government – DTI, 2005b).

Table 12: Research, Development and Demonstration projects on biofuels sponsored by the government in 2003-4

Biofuels and alternative fuels (general)	**Biodiesel**	**Bioethanol**
- "Technology status review and carbon abatement potential for renewable transport fuels in the UK" - "A strategic framework for hydrogen energy in the UK" - "Liquid biofuels and hydrogen from renewable resources in the UK to 2050: a technical analysis" - "Fuelling road transport – implications for energy policy" - "Expert paper on the global impacts of road transport fuels" - "The potential environmental and rural impacts of biofuels production in the UK" - "Liquid biofuels – industry support, cost of carbon savings and agricultural implications" - Study on the prospects of carbon and sustainability assurance for renewable transport fuels	- "Lipase alcoholysis of triglycerides to produce biodiesel" - "Evaluation of the comparative energy, global warming, and socio-economic costs and benefits of biodiesel"	- "Hyperthermophilic proteolytic fermentation to generate ethanol as a transport fuel" - "Biofuel production from plant biomass derived sugar"

Source: UK Government (2004b, 2005)

Information and public relations activities

The government has sponsored a number of promotional leaflets on biofuels as well as the TransportEnergy website[31] which contains information about filling stations where biofuels are available. Together with industry it also co-sponsors the Low Carbon Vehicles Partnership, a partnership of the automotive and fuel industries, Government, academia, NGOs and other stakeholders to promote the shift to clean low carbon vehicles and fuels in the UK (UK Government, 2004b, 2005).

[31] www.transportenergy.org.uk

Public procurement

A number of local authorities and police authorities, as well as the Government's "Car and Despatch Agency" (in its London-based delivery vehciles) are using B5 in their fleets (UK Government, 2004b, 2005).

Renewable transport fuel obligation

The government has conducted a feasibility study and consultative process on the prospects of a renewable transport fuel obligation (RTFO). An RTFO would require fuels producers or providers (e.g. refiners, blenders and importers) to ensure that a certain percentage of their aggregate fuel sales was biofuel. Depending on its design, the scheme may allow the trade of biofuel certificates[32]. The government is likely to announce its decision on the introduction of an RTFO in autumn 2005 when it will present its revised Climate Change Programme. If an RTFO is announced it may take until 2008-9 until it comes into force (Archer, Low Carbon Vehicle Partnership [LowCVP], 25 July 2005).

Input taxation

The government is looking at adapting the way in which fuel duty is levied in order to encourage the direct processing of plant oils, together with fossil hydrocarbons, in refineries[33]. It believes that direct processing in refineries will bring production costs down and improve the quality of the biofuel. However, the current fiscal regime focuses on the refinery output on which the full fuel duty is levied. The introduction of "input taxation" would allow refiners to reclaim a tax credit for approved biomass material that has gone into the process against the full duty that is paid on total fuel production. A pilot project to test the procedure of input taxation is expected to start in 2006 (UK Government, 2004b, 2005).

Enhanced capital allowances

The government is considering the introduction of "enhanced capital allowances" for biofuel production facilities, in order to stimulate investment into the sector. These would allow a business to write off the whole cost of qualifying capital assets against the taxable profits of the period during which the expenditure is incurred. This accelerated tax relief can provide cash flow and net present value benefits. In March 2005 government has announced that is has held discussions with the biofuels industry but that further work on the details of the scheme was necessary. It is also subject to state aid approval (UK Government, 2004b, 2005).

6.2.1.2 Fuel standards

The latest versions of the European standards for diesel and petrol are in force since 2004. There is no explicit legal requirement for biodiesel sold to meet the European and British standard for biodiesel BS EN 14214 (Finance Bill, 2002). The diesel standard EN 590, however, requires blended biodiesel to conform to EN 14214.

6.2.1.3 Emission standards

[32] A similar "tradeable permit scheme" for renewable electricity already exists in the UK.

[33] At the moment, biodiesel is produced from plant oils in a separate process and plant and then mixed with diesel at a later stage.

The EURO 4 and 5 vehicle emission standards are the same as for Germany. Unlike in Germany, there has not been much public concern and political pressure regarding particulate emissions from diesel engines.

6.2.1.4 Alcohol legislation

According to Aaron Berry's knowledge (Department for Transport, 22 August, 2005) the existing drinking alcohol legislation did not need to be changed to allow the use of bioethanol as a transport fuel. The ethanol is denatured so that no alcohol excise duty needs to be paid.

6.2.2 Public opinion

6.2.2.1 Opinion leaders

Government

While Government also recognises biofuels' potential to support British farmers and diversify sources of energy supply, they are primarily seen as a means of reducing CO_2 emissions (e.g. UK Government 2004; Berry, 20 July 2005; Archer, 25 July 2005). Government analysis points out that biodiesel and bioethanol are expensive carbon abatement options. There is also some worry that UK farmers and industry will not benefit much from biofuel promotion as imports may keep dominating supply. Government also stresses the risk of rising biofuel imports resulting in deforestation in South East Asia and South America (UK Government, 2004b). A long-term policy goal is dramatically lowering the carbon intensity of the transport sector. While in the longer term hydrogen is expexted to become the main transport fuel, it is as yet unclear what roles biodiesel and bioethanol are to play in the meantime. Government stance on first generation biofuels is expected to become more concrete in November, with the presentation of the revised Climate Change Programme and, possibly, the announcement of an RTFO.

Environmental NGOs and Nature Conservation Agency

Major environmental groups, such as Friends of the Earth (2005), Greenpeace (2003), the Royal Society for the Protection of Birds (7 June 2004) and public conservation agency English Nature (September 2004) are supportive of biofuels, under the condition that they deliver good levels of greenhouse gas savings and farming practices do not lead to further environmental damage. Most are supporting the idea of carbon certification and some sort of "sustainability assurance scheme" (Archer, LowCVP, 25 July 2005).

The argument that biomass should rather go into stationary CHP generation, as this would deliver greater carbon savings, is not used in the public debate. This may be due to the fact that the UK has a poor history of using woody biomass for CHP. The only project which got close to up and running collapsed and went into liquidation; there is a lot of reluctance to do further CHP type projects at the moment (Archer, LowCVP, 25 July 2005). Britain also has a relatively low use of combined heat and power generation: in 2000 only 6% of total electricity generation and 8% of conventional (non-nuclear) thermal electricity generation was produced in CHP plants, compared to a EU-15 average of 10% and 18% (Eurostat, 2003).

The media

The media seem to be largely positive towards biodiesel and bioethanol. The online survey of UK media from 1 June – 6 August 2005 yielded 31 articles on these biofuels, with 27 being "positive" or "mainly positive", three being "neutral" and only one critical.

6.2.2.2 The general public

Greg Archer believes that the general public has hardly any awareness about biofuels. With the exception of some "eco-branded" B5 and E5 biofuels have no visibility. Sales of premium priced B5 have shown that not many people are prepared to pay for biofuels which are more expensive.

6.3 Main actors

6.3.1 Biofuel industry

6.3.1.1 Biodiesel producers and importers

Domestic biodiesel production has only started after July 2002, when the duty rebate was introduced. Until 2005 biodiesel was produced in small plants and total output has been low. Main feedstocks are low-cost used cooking oils and some imported palm and soya oil from overseas. An example is the BIP (Oldbury) Ltd. Plant in the West Midlands which produces 12,000 t/y of biodiesel from used cooking oils (www.greenergy.co.uk, www.bip.co.uk). Little, if any RME has so far been produced domestically, although independent oil company Greenergy are importing some from continental Europe. There is no market for B100 in the UK and all producers are selling to the blending and, possibly, export market (UK Government, 2004b, 2005).

Production capacity is about to increase steeply. The Argent Group have started to operate their 100,000 t/y biodiesel near Motherwell, Scotland, in March 2005. Feedstocks are used cooking oils and animal tallow (www.argentenergy.com). Biofuels Corporation is in the process of building a 250,000 t/y biodiesel processing plant at Seal Sands, Middlesbrough on the north east coast of England. The feedstock is, again, used cooking oil (www.biofuelscorp.com). Production is expected to start by the end of September 2005. Greenergy's plant, using UK-grown rape seed, is due to begin 100,000 t/y production in 2006. The plant is located at Immingham on the east coast of England. A second plant of equal size is already planned to follow on at the same site. The world's first mobile refinery, with a capacity of 40 litres per hour, has been built by Cambridge University in order to support UK farmers by helping them to turn rape oil into bio-diesel (UK Government, 2005). By the end of 2006 domestic production capacity can thus be expected to exceed 450,000 t/y.

None of the three large plants has been or is being built by a domestic manufacturer: Greenergy's plant is built by Belgium-based multinational De Smet-Ballestra, the Argent plant has been built by Austrian manufacturer BioDiesel International and the Biofuels Corporation plant is being built by Austrian manufacturer Energea[34]. Some 77 million € are reported to have been invested in the three plants (Biofuels Corporation: 41 million €, Argent Energy: 22 million €, Greenergy: 15 million €.

[34] Sources: http://www.greenergy.co.uk/company/biodiesel_plant/partners.html, http://www.biodiesel-intl.com/referenz/referenz.htm, http://www.energea.at/de4.html

Estimates of biodiesel production costs from different feedstocks are 0.29€/l for waste vegetable oil, 0.49€/l for palm oil and 0.54€/l for rapeseed oil (UK Government, 2004).

6.3.1.2 Bioethanol producers

No bioethanol is currently being produced in Britain and most, if not all, is imported from Brazil. Oil company Greenergy is a (possibly *the*) major importer and makes blends up to E5, which are marketed via supermarket filling stations. Farmer-owned cereal trader Wessex Grain is proposing to built a 100,000 t/y wheat-to-bioethanol plant at Henstridge, Somerset/Dorset, subject to Government assuring a long-term market for domestic bioethanol[35]. British Sugar have announced their intention to build a 55,000 t/y bioethanol plant near Downham Market in Norfolk. The feedstock is sugar beet and the plant due to start production in 2007 (www.britishsugar.co.uk). They appear to be waiting for Government to announce the introduction of an RTFO before going ahead with the project.

6.3.1.3 Biofuel producers' trade associations

A websearch has allowed me to identify three trade associations representing the interests of biofuel producers[36]. The "Allied Biodiesel Industries" (ABI) are representing SMEs producing biodiesel, while the "British Asssociation for Bio-Fuels and Oils" (BABFO) are representing the biofuels industry. The Renewable Power Association has announced that it will from September 2005 on also represent the interest of the biofuels industry, and BABFO has invited its members to join the RPA (RPA, n.d.). Out of the three associations, only the RPA employs professional staff and maintains a frequently updated website.

The National Farmers' Union is also very active in lobbying Government to support the development of a UK biofuels industry.

6.3.1.4 Cooperation with other actors

There is cooperation between the biofuels, oil and motor industry. Much of their joint work is done through the government and industry sponsored Low Carbon Vehicles Partnership, which also includes representatives from government, NGOs and academia. The partnership has, for example, developed a consensus methodology for well-to-wheel analyses of bioethanol production from wheat and assessed the feasibility of implementing an RTFO. Currently, work is being done on a voluntary sustainability standard for biofuels (Archer, LowCVP, 25 July 2005). I have not found any mention of collaboration on technical issues, such as engine performance of biofuels.

Potential bioethanol producer Wessex Grain is taking part in the Somerset Biofuel Project, led by the Somerset Council, which is aiming to introduce some 40 Ford Focus FFVs for use in car fleets. If European funding is granted, the demonstration project is expected to go ahead in 2006.

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[35] Wessex Grain are express concern about competition from Brazilian producers and are asking for protectionist measures (www.wessexgrain.co.uk).

[36] Google.com search for keywords "biofuels trade association UK" (5 August 2005).

6.3.2 Oil industry

6.3.2.1 Official stance on biofuels

The UK Petroleum Industry Association (UKPIA)[37] demand from the government clear direction on whether the goal of their biofuels strategy is to reduce CO_2 emissions, increase diversity of energy supply or support British farmers. They highlight that since the amount of biomass that can be produced in the UK is limited, it should be used to generate heat and power rather than for biofuel production, if saving carbon is the primary objective.

If transport biofuels are to be promoted, the oil industry favours the use of a duty differential, such as the one currently in place, over a renewable transport fuel obligation. The duty differential could be made tax neutral to the Treasury and is believed to be quicker to install and require less bureaucracy. UKPIA also feel that the use of biofuels with the greatest well-to-wheels greenhouse gas savings should be encouraged. If a RTFO were to be introduced, they ask for a carbon reduction certificate, rewarding low carbon biofuels, to be a mandatory part of the scheme – if a practical solution can be found.

The industry are open about their petrol surplus and diesel shortage, and do not want to be forced to blend bioethanol. They prefer a scheme that allows them to decide themselves which biofuels to use (UKPIA, 2005; Vandervell, UKPIA, 12 July 2005).

For the oil companies the additional cost of biofuels is an important factor but also their quality and and continuity of supply. Furthermore, logistic difficulties are pointed out. They are considered more challenging for bioethanol blending than for biodiesel. Once biofuel blending takes off, the spokesman of UKPIA believes that a large part of the biofuels is likely to be imported (Vandervell, UKPIA, 12 July 2005).

According to Greg Archer (25 July 2005), director of LowCVP, oil companies are coming under pressure to reduce the carbon intensity of their fuels. In the long-run, perhaps 2015 and beyond, they are working on new generation biofuels (e.g. from cellulose waste) which they claim will play a very important role in their future market. On the whole the oil companies are broadly supportive of biofuels, but they see FAME and bioethanol just as short-term products, before they start to introduce 2nd generation biofuels. If the government introduces an RTFO they are willing to go along with biodiesel and bioethanol in the meantime at low blends. E85 and B100 potential is seen to be limited to small fleets with refuelling at a depot.

Stance on biodiesel

Oil companies accept the blending of biodiesel up to 5% (vol.) or the use of biodiesel as refinery feed or fuel (Vandervell, UKPIA, 12 July 2005), and at least one company is currently investigating this possibility. UKPIA also believes that, for quality reasons, the duty rebate should only incentivise BS EN 14214 conformant biodiesel rather than any biodiesel that has an ester content greater than 96.5%, as is currently the case (UKPIA, 2005)

[37] UKPIA represents the UK's oil refining and marketing industry. Its members are BP Oil UK, ConocoPhilips, Esso UK, Murco Petroleum, Petroplus UK, Shell UK, ChevronTexaco, Total UK (www.ukpia.com).

Stance on bioethanol

The oil industry is more reserved regarding the direct blending of bioethanol. They are worried about the logistic problems related to ethanol's affinity for water and the risk of exceeding the limit for fuel vapour pressure. They point out that the UK has a complex and closely integrated supply system with shared pipelines and that ethanol may have to be blended at the terminal loading point, rather than the refinery. This would increase logistics costs (Vandervell, UKPIA, 12 July 2005).

Stance on ETBE
According to Greg Archer, ETBE is not much talked about by oil companies. However, one UKPIA member has indicated its interest in switching from MTBE to ETBE (Vandervell, UKPIA, 12 July 2005).

6.3.2.2 The oil companies' use of biofuels

The oil majors' current involvement in biofuel blending is limited, but they are probably preparing themselves for the introduction of an RTFO. If it comes, they are likely to meet their obligation by blending rather than by putting up new pumps with neat biofuels (Greg Archer, date). There are currently no public plans among UKPIA members to introduce B100 or E85 (Vandervell, UKPIA, 12 July 2005)

Use of biodiesel

Some oil companies are selling biodiesel in low level blends. Petroplus is the largest UK producer. They are currently buying external biodiesel but also hold shares in the Biofuels Corporation plant which is located close to their refinery on Teesside and is expected to start operating in September 2005 (Vandervell, UKPIA, 12 July 2005).

Greenergy, an independent oil company, is selling B100 and diesel/biodiesel blends according to customer specifications. Their customers include supermarkets Tesco and Sainsbury's, other oil companies and local authorities. Their biodiesel is made from rape seed and used cooking oils. They are importing RME from the continent and are also producing 12,000 t/y themselves[38]. Their new plant in Immingham is due to go on stream in 2006 and will process UK grown rapeseed into 100,000 t/y of biodiesel (www.greenergy.co.uk). Their branded RME-B5 (GlobalDiesel) is primarily sold to supermarket filling stations at a price premium, but with a carbon savings guarantee (Archer, LowCVP, 25 July 2005; www.greenergy.co.uk).

Use of bioethanol

The use of bioethanol in E5 blends has grown rapidly since the introduction of the fuel duty differential for bioethanol in 2005. Both supermarket chains Tesco and Sainsbury's have started to sell blends up to E5 at some of their filling stations. Tesco (and possibly also Sainsbury's) are sourcing their E5 from Greenergy who are importing the bioethanol from Brazil and blend it at their importing facilities in the Thames estuary (Vandervell, UKPIA, 12 July 2005). Sainsbury's are not selling their E5 at a higher price, which suggests that they either source the bioethanol very cheaply or have reduced their profit margin to take a market lead position (Archer, LowCVP, 25 July 2005).

[38] Processing is done by contractor BIP (Oldbury) Ltd at a plant in the West Midlands.

Use of ETBE

Currently no ETBE appears to be used in the UK.

6.3.2.3 Analysis: The interests of the oil industry

The oil majors are multinational companies that operate in a global context. The interests of the British (branches of) oil companies do not differ much from those of their German counterparts (see Section 5.3.2.3). They are faced with a diesel shortage and petrol surplus, need to find a market for volatile oil compounds and can be expected to protect their core products. The fuel duty differential is lower than the German one and seems not to have been sufficient to trigger the oil majors to take up blending. The companies are probably waiting for the government to clarify its stance on biodiesel and bioethanol.

6.3.3 Automobile industry

The Society of Motor Manufacturers and Traders (SMMT), representing the UK automotive industry accepts the use of E5 and B5, as they can be applied to existing vehicles using the current distribution system and do not require expensive infrastructure investment (SMMT, 2004). The use of B100 is not an issue, as none of the large oil companies have announced that they are going to supply it. If B100 were brought to the market, vehicles that are warrantied by their manufacturers for B100 in other EU countries would probably also be so in the UK. The SMMT points out that some of its member manufacturers offer warranties for higher biodiesel mixes for specific fleet operators operating to agreed conditions on fuel quality, usage patterns and fuel storage.

Ford is planning to introduce its FFV Focus to the UK market over the next year and is hoping to sell some 40 FFVs in the context of the Somerset biofuel demonstration project. Saab are also considering the introduction of an FFV model in the UK. However, car manufacturers are faced with the lacking availability of an E85 refuelling infrastructure. Saab and Ford, together with biofuel producers, environmental organisations and other UK groups, have in a recent public declaration called on the government to introduce an RTFO to boost biofuel use (Transport and General Workers' Union, 15 June 2005).

6.3.3.1 Analysis: The interests of the automobile industry

Manufacturers produce their vehicles for the European, rather than the British or German market. For this reason, the automobile industry in both countries is likely to have similar interests (see Section 5.3.3.3).

6.4 Analysis of the functional pattern

Table 13 summarises the functional pattern of the technological system "biodiesel and bioethanol" in the UK and lists drivers and blocking mechanisms. The main driver has been the fuel duty rebates introduced since 2002. The main blocking factor is the higher costs of biofuels which – except for the cheapest biodiesel feedstocks- do not seem to be sufficiently compensated by the duty rebate to induce the uptake of nation-wide blending. Government signals on additional supporting measures have so far been ambiguous. Furthermore, biofuels support has only been available for a limited period of time and the sector is still young and

inexperienced. The mechanisms that have driven and blocked the development of biodiesel and ethanol use are further discussed in Section 7.2.

Table 13: Functional pattern of the technological system "biodiesel and bioethanol" in the UK

Function	**Extent to which fulfilled**	**Blocking mechanisms**
Knowledge development and diffusion	- Limited publicly sponsored RDD has led primarily to a better understanding of feasibility, cost and WTW carbon savings of biofuel policy options. - Some practical experience gained in biodiesel production, from different feedstocks, since 2002 - Oil companies and retailers have gained some experience with producing and marketing low-level blends of biodiesel and bioethanol - At least one oil major is looking into using plant oils as refinery feed or fuel	- Only few publicly sponsored RDD projects on technology development - Virtually no biofuel production in and import to Britain until the introduction of fiscal incentives for biodiesel (2002) and bioethanol (2005)
Influence on the direction of search	- High fuel prices make end-consumers and blenders look for alternatives, such as subsidised biofuels - Increasing demand for diesel makes oil companies look for ways to "stretch" supply by adding biodiesel or, possibly, bioethanol to diesel - Threat of global warming and resulting political pressure make car manufacturers and oil companies look for ways to reduce fossil CO_2 emissions - The Common Agricultural Policy provides financial incentives to farmers to produce energy crops, especially on set-aside land	- Potential biofuel producers feel uncertain that there will be a market for their products (no demand because of insufficient fiscal incentive, threat of cheaper imports) - Government gives mixed signals about how strong its support for biodiesel and bioethanol is (gives fiscal incentive but sets low 2005 target, warns that biofuels are no cost-efficient CO_2 abatement option). Signals may become clearer in autumn (presentation of Revised Climate Change Programme and, likely, stance on RTFO) - Overproduction of petrol makes use of bioethanol as a petrol substitute unattractive to oil companies
Entrepreneurial experimentation	- Biodiesel is produced from different feedstocks (waste vegetable oils, animal tallow, palm oil, soya oil, rapeseed oil) - Variety in biodiesel plant sizes: from a mobile plant (40 l/h) to Europe's biggest plant (250,000 t/y) - Experimentation with marketing biodiesel for "blind" blending and for making	- Few biodiesel producers, no bioethanol production yet - No attempts to create a B100 market

	premium B5 with certified carbon savings	
Market formation	- 0.29 €/l fuel duty rebate has created a certain market for biodiesel and bioethanol in low-level blends - Diesel and petrol standards allow up to 5% biodiesel and bioethanol content - Biodiesel standard is not mandatory and duty rebate also available for non-conformant biodiesel: there is also a market for non-RME biodiesel. - One oil company is considering taking up use of ETBE - Duty incentive regulation does not require non-EU bioethanol to be imported as pure bioethanol – lower import tariff facilitates market access	- 0.29€/l duty rebate does not seem sufficient to create a large enough market for meeting 5.75% indicative target - Duty rebate insufficient to make RME price competitive with diesel. RME has to be sold at a premium to a narrow niche market - Diesel and petrol standards allow no more than 5% biodiesel and bioethanol content and changing the standards is a slow and uncertain process - Volatility of biomass feedstock and oil prices and a potential reduction of the duty rebate may stop market growth - Oil companies are critical of E5 introduction (vapour pressure and water affinity problem, financial interest) - No filling stations currently interested in selling E85 and B100, even though Ford and Saab are proposing to introduce FFVs.
Legitimation	- British media seem highly supportive of biodiesel and bioethanol - Opinion leaders environmental NGOs and Nature Conservation Agency are endorsing biodiesel and bioethanol, but ask for carbon saving and sustainability criteria - Petrol and diesel standards allow 5% biofuel content - Existence of a biodiesel quality standard increases acceptance of automobile and oil industries - Two leading supermarkets endorse and market B5 and E5 - National Farmers' Union and biofuel producers' trade associations promote and lobby for biofuels	- Government policy and discourse emphasise cost-inefficiency of biodiesel and bioethanol as a CO_2 reduction option - Producers' trade associations BABFO and ABI do not employ professional staff - Currently, a reorganisation is going on among producers' groups, with BABFO members being invited to join RPA
Resource mobilization	- An estimated 77 million € have been / are being invested into three new, large biodiesel plants	- Potential producers, especially of bioethanol, are hesitating to invest. Reasons are: duty incentive insufficient, only guaranteed for three years, threat of cheap imports and volatility of feedstock and

		crude oil prices

7 Cross-country comparison and discussion of differences in national trends

Having described the national market situations and technological system and analysed their functional patterns to identify drivers and blocking mechanisms for biofuel use separately, I will now compare the two countries.

One of the purposes of this thesis is to see if and to what extent the differences in the current market situation for biodiesel and bioethanol can be explained by differences in the components of the technological system. As will be discussed below, my research suggests that there are marked differences between the components of the system in Germany and Britain and that these can plausibly explain the different market situations in 2004/5. Table 14 lists and contrasts market situation and systemic components in both countries.

Table 14: Comparison of the market situation and the components of the technological system biodiesel and bioethanol in Germany and the UK

	Germany	**United Kingdom**
Market situation	*Biodiesel in 2004* - steady growth since 1993; until 2003 no blending - sales: 1.2 million t; domestic production 1 million t - use: 25% for low-level blends, rest as B100 for truck & bus fleets (55%), petrol stations (20%) - blend segment rapidly increasing, petrol stations segment shrinking and new niche in agriculture *Bioethanol in 2004* - first year in which bioethanol used - sales: 0.065 million tonnes; no domestic production - use: ETBE production - Biofuels market share in 2004: 1.91% - 5.75% target in 2010: 2.1 million t biodiesel and 2.0 million t bioethanol	*Biodiesel in 2004* - biodiesel on market since 2002 - sales: 0.012 million tonnes - use: mainly low-level blends; virtually no B100 segment *Bioethanol in 2004* - bioethanol only introduced in 2005 - sales volume now bigger than that of biodiesel - used for direct blending - Biofuels market share in 2004: 0.03% - 5.75% target in 2010: 1.2 million t biodiesel and 1.8 million t bioethanol
Technological system component		
Regulatory framework – drivers	- Government seems committed to promoting biofuels (especially domestic production) and meeting 5.75% target - Mineral oil tax exemption for biofuels (neat and	- Government has expressed support for biofuels, but it is uncertain how strong this support really is; more certainty expected in autumn 2005 with possible announcement of RTFO - Mineral oil tax exemption for biofuels (neat and

	blended since 2004; before only neat), worth 0.55 €/l for biodiesel and 0.75€/l for bioethanol - Limitation of diesel subsidy (since 2005) gives farmers incentive to use biodiesel - Biofuel production plants have benefited from significant amounts in capital grants[39] - Federal and state governments have spent considerable amounts on biodiesel and bioethanol RDD: technical development, demonstration projects, economical and LCA studies - Government agency FNR is promoting biomass use (incl. biofuels) and coordinating public RDD - / - Fuel standards allow up to 5% (vol.) addition of biodiesel and bioethanol - Summer vapour pressure limit complicates the direct blending of bioethanol - /	blended) since 2002 (biodiesel) and 2005 (bioethanol), worth 0.34 €/l; three year rolling guarantee, at least until 2008 - / - Two biofuel plants have been supported with capital grants (2 x 1.75 million €) - Limited public spending on biodiesel and bioethanol RDD: mainly policy and LCA studies, few technological development projects - / - Government considering the introduction of "input taxation" and "enhanced capital allowances" to promote biofuels production - Fuel standards allow up to 5% (vol.) addition of biodiesel and bioethanol - Summer vapour pressure limit complicates the direct blending of bioethanol - Tax subsidy also available for denatured ethanol (no CN-Code specified): possible to import at lower tariff
Regulatory framework – blocking mechanisms	- Uncertainty what the future government's biofuels policy will be (elections on 18 September 2005) - Tax reduction scheme ends in 2009; uncertainty regarding its continuation - Tax reduction checked on a yearly basis; may be changed each year in case of overcompensation - EURO 4 and 5 emission norms reduce number of new vehicles that are compatible with B100 - Political pressure on manufacturers to equip cars with particulate filters that are incompatible with biodiesel - (Potable) alcohol legislation creates obstacles for bioethanol production for transport sector - Tax subsidy only available for 99% pure, undenatured bioethanol (CN Code 2207 1000) - High EU import tariff for undenatured ethanol (0.19 €/l)	- Uncertain how committed Government is to meeting 5.75% target; biodiesel and bioethanol seen as expensive carbon-saving option - Uncertainty about tax rebate after 2008 - Tax reduction checked on a yearly basis - Not an issue, since no use of B100 - Not an issue - Apparently no obstacles for bioethanol imports; no domestic production for fuel market at the moment - / - Less serious obstacle, bioethanol can be denatured/blended and imported at lower tariff
Public opinion / opinion leaders – drivers	- Strong political support in most political parties - Vast majority of media positive towards biofuels - /	- Government expresses general support for biofuels - Vast majority of media positive towards biofuels

[39] I could not obtain figures on total public spending on all biodiesel on all bioethanol plants. However, the bioethanol plant in Zeitz alone has received state aid worth 43 million €.

	- Some awareness of biodiesel among general public, since marketed as pure product; broadly perceived as environmentall friendly	- Leading environmental NGOs and Nature Conservation Agency are supportive of biofuels - /
Public opinion / opinion leaders – blocking mechanisms	- Leading environmental NGOs and EPA hostile to first-generation biofuels - Few consumers prepared to pay a price premium for biofuels	- / - Few consumers prepared to pay a price premium for biofuels
Biofuels industry – drivers	- Largest biofuel industry in Europe (production capacity, large number of companies, domestic equipment manufacturers), has developed since 1993: sector has gained a strong constituency and political weight - Farmers, plant oil producers and biofuel producers have professional lobbying organizations promoting their interests - Biofuels industry collaborates in networks with oil and aumobile industry; this includes technological development projects	- Young and small biofuels industry whose development only started in 2002: limited constituency and political weight (however, 3 new actors expected to start producing some 450,000 t/y biodiesel in 2005-6) - Farmers have professional trade association lobbying for biofuels; - Biofuels industry collaborates in networks with oil and aumobile industry; but little work is done on technological development projects
Biofuels industry – blocking mechanisms	- /	- Biofuel producers did not have a professional trade body until 2005
Biofuels industry – blocking mechnanisms	- Domestic biodiesel and bioethanol production costs higher than those of diesel and petrol	- Domestic biodiesel and bioethanol production costs higher than those of diesel and petrol
Oil companies - drivers	- Large oil companies have taken up biodiesel blending; trend expected to continue - Two retailing companies have started selling E5 - Large oil companies have started switching from MTBE to ETBE addition; trend expected to continue - Independent service stations and those owned by farmers' association "Raiffeisenverband" are selling B100	- Oil majors (except Petroplus) are not blending biofuels at the moment, but are likely to prepare themselves for the introduction of an RTFO - Some service station operators (primarily supermarket chains Tesco's and Sainsbury's) have started selling B5 and E5 - Independent oil company Greenergy is marketing E5 and B5, blended with (mainly) imported biofuels - One oil major is considering switching to ETBE - /
Oil companies – blocking mechanisms	- Large oil companies not interested in marketing B100 (or E85) - Large oil companies are reserved regarding the direct blending of ethanol	- Large oil companies not interested in marketing B100 (or E85) - Large oil companies are reserved regarding the direct blending of ethanol
Automobile	- Around 3 million Germany cars are certified	- / (no B100 is publicly available)

industry – drivers	compatible with B100 - Truck manufacturers are looking into ensuring emission standard compliance with B100 also in future - Ford are introducing 2 FFV models (E85) in summer 2005 - Car manufacturers support B5 and E5 and are positive towards E10	- / - Ford and Saab are considering introducing FFV models; they are publicly promoting an RTFO - Motor Industry association supports B5 and E5
Automobile industry – barriers	- Fewer new cars are warrantied for B100 - No public filling stations with E85 currently available	- / - No public filling stations with E85 currently available

7.1 Biodiesel and bioethanol in Germany

Germany is the biggest biofuel producer and consumer in Europe. Biodiesel is by far the dominant biofuel, bioethanol only appeared on the market in 2004 and still plays a marginal role. RME production and consumption has been steadily growing since the 1990s and is still showing strong growth today. In 2004 1.2 million tonnes of biodiesel were sold (25% in blends, 75% as neat biodiesel) and biodiesel had a market share of 2% of the road transport fuels market.

The following are the main reasons for the relatively large production and use of biodiesel in Germany: since the early days of the industry in the 90s, biodiesel has benefited from a large tax subsidy (0.55€/l in 2005), service station operators were prepared to market B100 and manufacturers to warrant their vehicles. Experience with biodiesel production and use could thus be gained for more than a decade and production capacity be built up. Government strongly supports biofuels and, since 2004, has opened up the blend market for biodiesel (and bioethanol) through a legal change. I will now discuss these issues in more detail.

Since biodiesel was not addressed by the mineral oil tax law until 2004, it was for a long time de facto exempt from mineral oil tax, if used as a neat fuel. This de facto tax benefit and a rise in fossil fuel prices allowed domestic producers to start selling a biofuel that was more or less price-competitive with diesel and that could be used in the same engines since the early nineties. While the oil majors have not been prepared to market B100, the appearance of this new, attractively priced fuel has allowed independent service station operators and those part of the Raiffeisenverband to differentiate their offer. The Raiffeisenverband, a farmers' association, could thus also provide its members with a new outlet for their rape seed crop. At the same time Volkswagen, and some other manufacturers, have started to allow B100 on some of their diesel vehicles. Consumers could thus buy ordinary diesel vehicles, at the same price and with the same performance as conventional ones, that could run on both fossil diesel and biodiesel. The appearance of a road fuel cheaper than diesel has attracted truck and bus fleet operators for whom fuel costs are important for their competitiveness. Manufacturers have responded to this demand by providing B100 compatible utility vehicles. To be able to ensure smooth engine performance the car industry has successfully called for the creation of a national biodiesel standard, which was later developed into the European standard EN 14214. This standard was based on the physical and chemical properties of RME, since rape seed was the dominant feedstock for biodiesel in Germany.

Biofuels blended with diesel or petrol blends were not tax exempt until 2004. Furthermore, the European standard for diesel EN 590 did not allow biodiesel addition until 2004[40]. After changes in the mineral oil tax law and the diesel standard, the blend market has formed as a new outlet for biodiesel producers. Biodiesel blending has rapidly been taken up by the oil majors, either to give in to political pressure and avoid a fuel obligation, or because of financial reasons (cheaper diesel component due to detaxation, shortage in diesel production). While the private car market segment is shrinking (fewer certified models, due to stricter emission laws), the blending segment is strongly growing. Furthermore, a reduction in the amount of subsidised diesel that farmers are entitled to has opened a new niche for biodiesel in the agricultural sector.

After the change in the mineral oil tax law, bioethanol has also been used since 2004[41], but only to a limited extend. The oil majors have started to convert from MTBE addition to ETBE (again, because of political pressure or because it is financially attractive). So far, however, they oppose nation-wide direct blending of bioethanol, for reasons related to logistics, the summer vapour pressure limit, and the overproduction of petrol in European refineries.

Government has played an active role in the development of a market for biofuels and a domestic industry. Its main contribution has been to ensure that the tax advantage ensures the price competitiveness of biodiesel and bioethanol. Green minister of agriculture Renate Künast, in office since 2001 sees the biomass and bioenergy sector as a key future industry and is championing its development. Governement has sponsored research that was essential for ensuring the existence of markets for bioethanol and biodiesel, such as the development of an RME sensor to control tailpipe emissions, the study of the interaction of biodiesel and particulate matter filters, the use of bioethanol as a diesel additive, demonstration of E85 use in FFV fleets and biodiesel in agricultural vehicles. A government agency (FNR) has been created to promote the use of biomass and bioenergy; it coordinates research and spreads information on biofuels. What has also been important for the relative success of biofuels is the fact that the sector is well networked and is represented by professional lobbying/PR organisations. Its relatively large size (according to a study by the IFO Institute for Economic Research [March 2002], some 18-19,000 jobs are dependent on the biodiesel sector) gives it a non-negligible political weight. It has been successful in ensuring that policy makers protect domestic producers from competition from overseas: the cheapest biofuel currently available, bioethanol from Brazil, has to be imported as undenatured bioethanol and faces an import tariff of 0.19€/l; only EN 14214 conformant biodiesel is allowed to be sold – this favours RME which is produced mainly in Europe. The legal framework does not offer any protection against producers in other EU countries.

The critical attitude of leading environmental NGOs and the EPA seems so far not to have hindered the development of the industry: for most users the price argument is clearly more important than environmental considerations regarding the life cycle of biofuels.

7.2 Biodiesel and bioethanol in the United Kingdom

Only small volumes of biodiesel and bioethanol are currently consumed and produced in Britain. In 2004 0.012 million t of biodiesel – 1% of the amount sold in Germany in the same year - and no bioethanol were sold; biodiesel had a market share of 0.03%. Since 2005,

[40] The petrol standard EN 228 did, however, allow up to 5% ethanol and up to 15% ETBE, at least since 1999.

[41] Bioethanol benefits from a tax exemption worth 0.75€/l

bioethanol is also used in Britain. The biofuels are only used for blending, there is no B100 market. Some biodiesel is produced domestically in small plants, from waste vegetable oil, animal tallow and imported soya and palm oil. The sector is, however, growing fast. Several larger biodiesel plants are under construction or have just gone on stream, but no bioethanol plants have been developed past the planning stage. The main reasons for this situation are the following: the very recent introduction of a tax incentive for biodiesel and bioethanol, uncertainty about future government support for biofuels and the existence of a blending market at the time when biodiesel and bioethanol are introduced. They are discussed below:

In the UK, biofuel use has only started recently, with the introduction of a tax reduction of 0.34€/l for biodiesel (since 2002) and bioethanol (since 2005). Unlike in Germany, where biodiesel has been produced and used since the 90s, the British experience has only started recently. Similarly to Germany, the tax advantage has triggered the development of a biofuels industry, but the first large-scale production plant has only come on stream in 2005. Unlike in Germany, biodiesel is not produced domestically from rape seed, although a first RME plant is expected to start operating in 2006. It seems that the tax rebate, which is lower than the German one, is not sufficient to offset the extra production costs of RME compared to diesel. It seems to just be enough to make biodiesel from cheaper feedstocks price attractive. Unlike in Germany the sale of biodiesel that does not meet EN 14214 specifications is not banned by law and also qualifies for the duty rebate. However, the European diesel standard explicitly requires added biodiesel to be EN 14214 conformant. It is not clear to me if domestically produced, non-RME biodiesel can indeed meet the EN 14214 specifications, if the regulator is turning a blind eye on the violation of the diesel standard or if some other loophole is exploited.

Government has so far had quite an ambiguous stance on biodiesel and bioethanol. Biofuels are primarily considered an expensive carbon-saving option, rather than a means of strengthening security of energy supply or the domestic agricultural sector. Currently, the duty rebate is only guaranteed until 2008. For this reason, many would-be biofuel producers (especially bioethanol producers) are waiting for the announcement of a renewable transport fuels obligation, possibly in autumn 2005. First generation biofuel technology has not been of much importance to publicly sponsored RDD. Most of the projects carried out on the subject in recent years were LCA and strategic policy studies, rather than applied technology development. One reason for limited political support may also be due to the fact that the young biofuels sectors has not yet had time to develop a large enough constituency to increase its political weight. Furthermore, until 2005 none of the transport biofuel producers' associations employed professional staff, which is likely to have limited their effectiveness in lobbying and promoting biofuels.

In the absence of strong government support for biofuels and a larger duty rebate most of the oil majors have adopted a "wait and see" strategy and left the biofuel blending market to independent company Greenergy. For similar reasons than the German oil companies, they seem to be more ready to take up biodiesel blending, in case an RTFO forces them to, than ethanol blending.

When biodiesel appeared on the German market in the 90s it was neither allowed, nor did it make economic sense to use it for blending with diesel. A market for B100 was thus created. This situation is different today. As it is cheaper and easier to market biodiesel through low-level blending than as a neat fuel, at a time when fewer new vehicles are certified for B100 by manufacturers, it comes as no surprise that no new market for B100 has come into existence in Britain.

Similarly to Germany, for the general public personal cost is a stronger argument than public environmental benefit or harm. While the leading environmental NGOs and the public Nature Conservation Agency are promoting the use of biofuels, the public has, in general, not been prepared to buy biofuel blends which are sold at a price premium.

8 General conclusions and recommendations for policy makers

I have derived a number of general conclusions from my assessment of the German and British experience with biodiesel and bioethanol, that I believe can be of use to policy makers wanting to implement or amend a biofuels policy:

Consumers buy cheap rather than green

If given a choice, most consumers will only buy biofuels if they are cheaper than conventional ones. In Germany, the price advantage of untaxed biodiesel has allowed B100 to establish itself on the market and biodiesel sales to keep growing until today. The UK experience shows that only few people are prepared to pay a premium for B5, even if it comes with a 5% CO_2 savings guarantee.

Excise duty reductions can trigger the sales of biofuels

Excise duty reductions may give biofuels a price advantage. In general, the bigger the tax rebate, the bigger the price differential between biofuels and fossil fuels, the faster the market penetration of biofuels and the higher the loss in tax income to the state. In countries such as Germany and Sweden a full exemption from excise duty has led to strong growth in biodiesel and bioethanol sales. The exise duties exemptions subsidise biodiesel by 0.47€/l (Germany), 0.36 €/l (Sweden, 2004) and bioethanol by 0.65€/l (Germany) and 0.52 €/l (Sweden, 2004). Both countries are expected to exceed the 2005 indicative target of 2%. In the UK, an excise duty reduction of 0.29€/l, also has triggered the use of biofuels. However, this rebate only seems sufficient to offset the extra biodiesel production costs from low-cost feedstocks such as waste vegetatble oil, animal tallow and possibly imported soya and palm oil. Europe's most widely produced type of biodiesel, RME, has to be sold at a higher price than diesel. It can be doubted that the current tax rebate will be sufficient for Britain to achieve the EU 2010 target.

Government commitment is crucial

To achieve the 2010 reference target, it is important for the government to clearly signal to the market players its intent to do so. In Germany, strong backing of biofuels by the government has given investors the necessary confidence to invest in production plants and encouraged the oil industry to take up blending. In the UK, the government's support of biofuels has been less clear. Investors have so far mainly put their money in a few low-cost feedstock production plants, while plans for bioethanol plant are on hold until the announcement of further public support. The oil majors have been slow to take up biodiesel blending and have adopted a "wait-and-see" strategy.

Low-level blending is the easiest and cheapest route for marketing biofuels

The distribution of B5 and E5 requires little additional investment in distribution infrastructure and no new pumps or even labels. This makes most oil companies more willing to sell low-level blends than B100 or E85. In Germany, the extension of the tax incentive to blends since 2004 has led to a doubling of biodiesel sales in two years (2003-2005). In the UK, blending has been taken up since the introduction of the tax rebate, but not marketing of neat biofuels. This also leads to the conclusion that the oil industry is the key to the rapid introduction of biofuels, as the establishment of a new, parallel distribution would come at a very high cost and take a long time.

Nation-wide introduction of B5 and E5 is not enough to meet 5.75% target

On an energy basis, it would only substitute 4.61% of diesel and 3.35% of petrol sales. To meet the targets, the European diesel and petrol standards would need to be changed to allow higher shares of biodiesel and bioethanol (at least 6.24% for biodiesel and 8.57% for bioethanol) and/or signifant amounts of neat biofuels (higher level blends) have to be sold. Possible target consumers are private owners of B100 and E85 compatible cars, truck drivers (many truck models are B100 certfied), fleet operators and farmers.

The 2010 goal may be hard to achieve without imports

According to my estimates, biofuel crops would have to be grown on roughly a quarter of the current arable land in Germany and Britain in case these countries want to meet the EU target with domestic production alone. I do not think that this is a realistic scenario and a significant share of the total biofuel need will have to be met with imports.

The oil industry's financial interests make it more willing to use biodiesel than ethanol

European refineries face oversupply of petrol and a shortage of diesel. In both the UK and Germany, oil companies are very critical of bioethanol and less opposed to biodiesel. If policy makers want to get bioethanol on the market, they are likely to have to provide a bigger incentive or exert more pressure on oil companies than for biodiesel.

Logistic issues complicate direct blending of bioethanol but can be solved

While biodiesel can be distributed fairly easily, both in blends or as neat fuel, bioethanol is faced with the problems of its water affinity and high vapour pressure in low level blends. In Sweden, the UK and Germany petrol-ethanol blends have been successfully distributed, showing that the water issue can be solved by keeping the distribution chain water-free. To what extent the vapour pressure limit is being exceeded, what problems, if any, this may cause and how this can be solved is still being debated. A study by EU Joint Research Centre (JRC), the European refiners' organisation CONCAWE and car manufacturers' organisation EUCAR is to be published early in 2006. The Fuel Quality Directive also calls on the European Commission to investigate the possibility to raise the limit. It is technically feasible to keep vapour pressure below the 60 kPa limit, but this is likely to cause additional costs to the oil refiners.

EU farmers and biofuel producers can be partly protected through import tariffs and technical barriers

The European biodiesel standard favours rape seed, produced primarily in the EU, as feedstock. It is however possible to use other feedstocks, including palm and soya oil and waste vegetable oil, with additives or blended with rape seed oil. This is done in the UK, and to a lesser extent in Germany. Oil seeds, plant oils and processed biodiesel can be imported into the EU at fairly low import tariffs. Undenatured ethanol faces a relatively high import tariff of 0.19€/l, but it can also be imported as denatured ethanol or as a chemical product, which have lower import tariffs. Legislation can force importers to pay the high tariff for undenatured ethanol by limiting the subsidy to ethanol falling under the corresponding customs code. EU producers can thus be given partial protection, but industry and end-consumers have to bear extra costs. Future import tariffs depend on the outcome of WTO negotiations; the trend tends towards lower tariffs. In recent talks, the EU has offered the Mercosur countries, which include Brazil, a contingent of one million tonnes of import duty-free bioethanol (Die Zeit, 27 May 2005).

Environmental and climate benefits of different biofuels vary

The environmental impact and carbon balance of biofuels depend on their feedstock and the way it is farmed, processed and distributed. European biodiesel and bioethanol has been calculated to save 15-70% in $CO_{2\text{-equivalents}}$ emissions, compared to fossil fuels (European Comission – JRC/CONCAWE/EUCAR, 2004), while Brazilian bioethanol is thought to save over 90% (Government of the State of Sao Paulo). The German EPA points out negative environmental impacts of rapeseed farming, such as soil and groundwater pollution through fertilisers and pesticides. The WWF has reported that rainforests have been cleared in Malaysia to make room for oil palm plantations.

The Biofuels Directive allows Member States to promote those biofuels with a particularly good "cost-effective environmental balance". Currently, neither the German nor British systems discriminate between different feedstocks and production process. The UK government is however carrying out a feasibility study on the possible inclusion of carbon certification, or even wider "sustainability" certification into a renewable transport fuel obligation scheme. It remains to be seen if preferential support for biofuels with superior environmental well-to-wheels performance can be given without violating WTO rules.

More than one political goal can be achieved by promoting biofuels

The Biofuels Directive lists three main goals: reduction of greenhouse gas emissions, strengthening of security of energy supply and support for rural economies. Governments' views on the importance of the goals differ: while the German government sees its biofuels policy as a means to become an industry leader in what is considered a key future technology field and support its farmers, the UK political discourse focuses on cost-efficient carbon savings.

The media like biofuels no matter what NGOs say

Media surveys in both Britain and Germany showed that the vast majority of articles published on the subject were positive about biofuels and their environmental merits. The critical attitude of leading German environmental NGOs against biofuels seems not to have tarnished their reputation in the minds of most journalists.

Current biofuel policies are unlikely to cause "technology lock-in"

As biodiesel and bioethanol can be blended with conventional fuels no costly new distribution infrastructure and vehicle technology are needed. Second-generation biofuels such as lignocellulosic ethanol and BtL diesel, that may become widely available in a decade, can also be distributed in the same infrastructure and used in standard internal combustion engines. Farmers can also fairly easily switch from producing one (energy) crop to another. If new fuels manage to make a breakthrough conventional biodiesel and bioethanol production plants may become obsolete – but this risk applies to any technology.

Having drawn general conclusions from my assessment of the German and British situation, I will now discuss how these can be applied in the specific context of Luxembourg.

9 Implementing the Biofuels Directive in Luxembourg

9.1 The market for biofuels: past, present and future

9.1.1 1994-today

The use of biodiesel started in 1994 when the public bus company of Luxembourg-City ("Autobus de la Ville de Luxembourg" – AVL) and the public national bus and train company "Chemins de Fer du Luxembourg" (CFL) started to convert some of their buses to B100. Today only AVL continue to use neat biodiesel, in 45 out of 130 buses. Annual consumption is around 700-900 t (Jung, Agence de l'Énergie du Luxembourg - AEL [Luxembourg Energy Agency], 21 June 2005). On an energy basis, this corresponds to 0.04% of diesel sales and 0.03% of total transport fuel sales. The rape seed feedstock is grown in Luxembourg on 1,200 ha by some 500 farmers of the association "Agroénergie". The rape seeds are exported to France, where they are processed into biodiesel and then reimported by petrol company TOTAL (Jung, AEL, 21 June 2005).

Currently, there is no other use of biofuels in Luxembourg. There is no B100 or E85 available to the general public, no low-level blends are used and there are no biodiesel or bioethanol plants.

9.1.2 The target for 2010

Table 15 shows the required quantities and market segments of biodiesel and –ethanol for Luxembourg to meet the 5.75% indicative target in 2010. The consumption of biofuels needs to roughly grow by a factor 200. 75% of all road fuel sold in Luxembourg is diesel, which means that, for meeting the EU targets, mostly biodiesel will be needed. Furthermore, while my 2010 prognosis is based on stable fossil fuel sales, in reality, the market share for diesel is increasing (+21.70% from 2003-04), while petrol consumption is is decreasing (-2.5% from 2003-4). The road fuel market is characterised by a large share, probably around 70%, of the petrol and diesel purchased in Luxembourg being consumed abroad (Winkin, Groupement Pétrolier du Luxembourg - GPL [Luxembourg Petroleum Association], 23 August 2005). This situation is due to fuel excise duties being significantly lower than in the three neighbouring countries Belgium, France and Germany. This makes it attractive to both inhabitants of neighbouring regions and drivers passing through Luxembourg (especially lorry drivers) to purchase their fuels in Luxembourg.

Table 15: Biofuel quantities required for meeting indicative 2010 target (5.75% market share for biofuels)

		2004	2010
Diesel consumption (million t)		1.62	1.62
Biofuels share of total fuels market (energy basis)		0.03%	5.75%
Biodiesel share of diesel market (energy basis)		0.04%	5.75%
Biodiesel quantity (million tonnes)	*Total*	0.001	0.11
	B5	0	0.09
	B100	0.001	0.02
Petrol consumption (million tonnes)		0.55	0.55
Bioethanol share of petrol market (energy basis)		0%	5.75%
Bioethanol quantity (million tonnes)	*Total*	0	0.05
	E5	0	0.03
	E>5 or ETBE	0	0.02

2010 target: quantity assuming EU target is met with a 5.75% biodiesel share of diesel sales and a 5.75% bioethanol share of petrol sales; assuming petrol and diesel consumption in 2010 is the same as in 2004; Fuel consumption data from Ministère de l'Économie (2004)

Table 16 shows that if the 2010 target quantities of biodiesel and bioethanol were to be made from domestically grown feedstocks, an estimated 105,000 ha would need to be converted to biofuel crop farming. In 2004, however, a total area of only 62,000 ha was devoted to crop farming. It can thus be concluded that even if farmers were to produce increasing amounts of biofuel crops over the next years, the major part of Luxembourg's biofuel need will have to be imported.

Table 16: Estimates of Luxembourg's domestic farmland requirements for 2010 biofuels target and farmland use in 2004

	2010 (ha)
Rapeseed farmland	90,256
Cereals and sugarbeet farmland*	14,939
Total biofuel crops farmland	105,194
	2004 (ha)
Total arable land	61,570
Rapeseed farmland	4,190
Cereals farmland	27,880
Sugarbeet farmland	0

** Assuming 50% of bioethanol produced from cereals and 50% from sugarbeet.*
Sources: 2004 crop production data – Eurostat (2005); yield factors – own estimates, see Section 2.2.3.3

9.2 The regulatory framework for biofuels

9.2.1 Transport fuel strategy and biofuels policy

The government does not have a long term transport fuels strategy (Groff, Ministère de l'Économie, 23 August 2005). The Biofuels Directive has not been implemented yet, but the government is working on it. No national reports on the directive's implementation have been submitted in 2004 and 2005 and the European Commission has sent Luxembourg a letter of formal notice (i.e. a warning), in March 2005 (European Comission, 16 March 2005).

9.2.2 Excise duty on transport fuels

9.2.2.1 Current excise duty and price impacts of a full duty exemption for biofuels

Luxembourg does not have a reduced excise duty for biofuels at the moment. The Budget Law for 2005 (21 December 2004) does not list biodiesel or bioethanol as transport fuels for which excise duty must be paid. This suggests that it may be possible to sell neat biodiesel (or bioethanol) without having to pay excise duty; and it is probably this "loophole" that allows AVL to purchase untaxed biodiesel. On low-level blends, on the other hand, full excise duties would apply. This situation is similar to the German one, where biofuels were not addressed by the mineral oil tax law until 2004 and B100 could thus be sold untaxed.

Unlike in Germany, however, even a full tax exemption for biofuels would not make biodiesel price-competitive with diesel. As can be seen in Figure 12 and Figure 13 a full excise duty exemption, worth 0.25€/l[42] plus 0.04€/l (VAT on excise duty), would not be enough to offset the higher production cost of biodiesel and make it look cheaper at the pump (price per litre), let alone make it cheaper on an energy content basis (price per litre diesel equivalent). As petrol excise duty is higher than that for diesel, a full exemption would give bioethanol a bigger tax advantage (0.44€/l plus 0.07€/l) and make it indeed price-competitive with petrol.

[42] Excise duty on diesel has been slightly increased to 0.27€/l, since January 2005. However, this increase is too small to affect the price competitiveness of diesel compared to biodiesel or diesel sold in neighbouring countries, as discussed in this and the following sections.

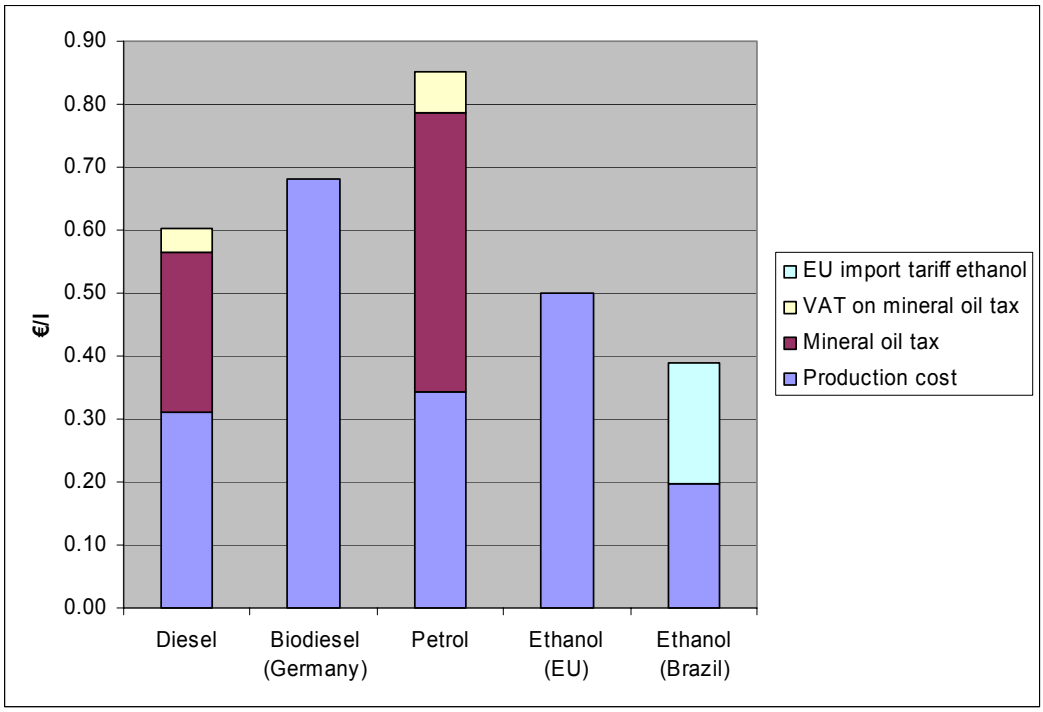

Figure 12: Production cost and taxation of transport fuels in Luxembourg in 2004 (prices on volume basis)
Production cost data exclude VAT but include distribution cost, except for bioethanol (production only). Biodiesel production cost includes distribution cost, except blending cost of 0.03€/l (not applicable to B100). Sources: Production cost for diesel and petrol: average pump prices without taxes in 2004 - Eurostat; production cost for biodiesel: estimate by Bundestagsbericht; bioethanol production cost in EU: estimate by Schmitz (2005); bioethanol production cost in Brazil: average spot market price in the State of Sao in 2004 - Centro de Estudos Avançados em Economia Aplicada. (2005), 1 Real = 0.2903 €.

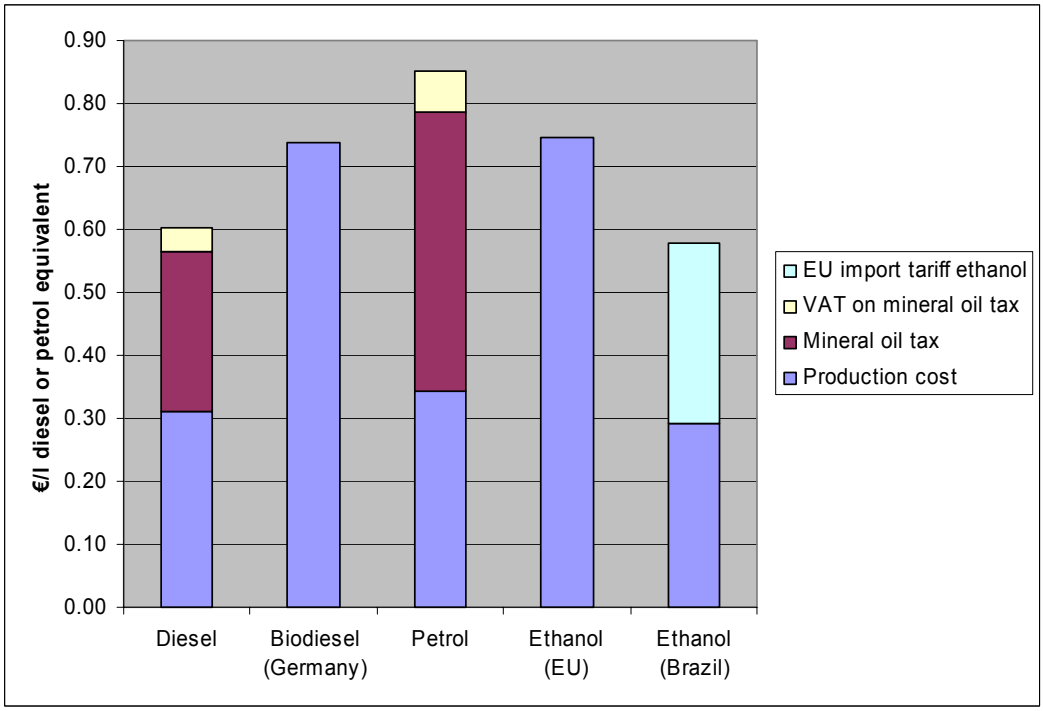

Figure 13: Production cost and taxation of transport fuels in Luxembourg in 2004 (prices on energy basis)
Sources: see Figure 12

9.2.2.2 Tax competition with neighbouring countries

Even if the diesel price were to increase or biodiesel production costs to fall, so that biodiesel becomes price-competitive, only limited amounts of it, or of bioethanol, may be exported to Luxembourg. The reason for this is tax competition. Due to the lower excise duty rates, diesel and petrol prices are lower in Luxembourg than in the neighbouring countries (see Table 17): this implies that biofuel producers can obtain higher prices in Germany, France and Belgium than in Luxembourg – in case the neighbouring countries also exempt biofuels from excise duty and have an open market. This is currently the case Germany, the largest (bio)-fuel market in the EU, as discussed earlier.

France grants a partial duty exemption to biofuels, worth 0.33 €/l for biodiesel, 0.37 €/l for bioethanol and 0.38 €/l for ETBE in 2004-5 (PriceWaterhouseCoopers, 2005). Furthermore, since January 2005 fuel distributors must pay an additional tax of 1.2% on the value of the diesel and petrol product, unless they can prove that *each* cubic meter sold contains 1.2% biofuels. The tax penalty, as well as the amount of biofuels required for an exemption, are to increase to 5.75% in 2010. The tax exemption is only accorded for a defined quota of biofuels, produced by producers selected through a call for tenders procedure. These producers have agreed that they will supply the French market with certain amounts of biodiesel and bioethanol for a period of 6 years (PriceWaterhouseCoopers, 2005). For production above quota no tax reduction is available in France, and these amounts are likely to be exported, most likely to the countries where the highest prices can be obtained. The importance of imports into France depends on the ability of foreign producers to win tenders and their willingness to commit to selling (part of) their biofuel production on the French market while higher prices may be obtained elsewhere.

Belgium is currently preparing its biofuels policy and proposes to introduce a tax subsidy of 0.49 €/l for biodiesel and 0.59 €/l bioethanol. This is worth more than a full duty exemption in Luxembourg would be, which may thus be insufficient to attract biofuels to Luxembourg if they can be brought to the Belgian market instead.

Table 17: Taxation of diesel and petrol in Luxembourg and its neighbouring countries in 2005

Country	Excise duty on diesel	Excise duty on petrol	VAT
Luxembourg	0.27 €/l	0.44 €/l	15%
Germany	0.47 €/l	0.65 €/l	16%
Belgium	0.32 €/l	0.56 €/l	21%
France	0.42 €/l	0.59 €/l	19.6%

Source: Eurostat (2005)

9.2.3 Transport fuel price mechanism

Unlike in Germany or the UK the Luxembourg government sets retail price maxima for transport fuels. The maximum retail price is calculated by adding the base price, profit margins for the oil company and service station operators, a compensation for transport, storage and environmental protection costs, excise duty and VAT. Apart from the base price all other components are set by government or parliament. The base price is the "Cost Insurance Freight" (CIF) price for fuels sold off the pipeline in Antwerp, Belgium. It fluctuates on a

daily basis; once the difference between the "official" price in Luxembourg and the market price in Antwerp exceeds 10€/1000l for more than 2 consecutive days, the government sets new price maxima.

The main reason for this price mechanism is to prevent the oil companies from pocketing most of the excise duty differential between Luxembourg and the neighbouring states rather than passing it on to the end-consumers. Currently, there is little price competition between oil companies and service station operators: most fossil fuels are sold at the maximum price (Groff, Ministère de l'Économie, 23 August 05).

9.2.4 Policy measures supporting biofuels production and RDD

So far, biofuels have not been of much interest to policy makers. There are no specific policy measures aimed at promoting biodiesel and bioethanol production and consumption or RDD on biofuels.

9.2.5 Belgian biofuels policy

Petroleum use and taxation in Luxembourg is strongly influenced by the Belgian context: there are no domestic refineries and most fossil fuels are imported from Belgium. Furthermore, for historic reasons Luxembourg's excise duties are based on the Belgian model. Both countries have the same excise duty system and share a "common excise duty", a component of the total excise duty on diesel and petrol. The rest of Luxembourg's total excise duty consists of two "autonomous excise duties", because of which the total duty differs in the two states. For these reasons, the Belgian biofuels policy may also have an important impact on the use of biodiesel and bioethanol in Luxembourg.

Until now, biodiesel and bioethanol use have not been specifically supported in Belgium. However, government has proposed a law to parliament on 31 May 2005 that also contains fiscal measures to promote the sales of biodiesel and bioethanol ("Projet de Loi-Programme"). Excise duty on purely fossil diesel and petrol will be increased to 0.37€/l and 0.63€/l. Diesel containing a minimum of 2.45% (vol.) biodiesel that conforms with standard EN 14214 and falls under code CN 3824 90 99 benefits from a rebate in excise duty of 0.01€/l, compared to the new rate. This corresponds to a duty reduction of 2.66%, compared to purely fossil diesel, or to a subsidy of 0.49€ per litre of biodiesel. Every year until the end of 2007 the excise duty on diesel is to be adapted in order to allow for the biodiesel content to increase in a linear way by 0.92% each year, up to a maximum of 5% (vol.). Petrol containing a minimum of 7% (vol.) of undenatured, at least 99% pure bioethanol benefits from an excise duty rebate of 0.04 €/l. This corresponds to a duty reduction of 6.61%, compared to normal petrol, or to a subsidy of 0.59€ per litre of bioethanol. The law gives government the right to, proportionally, further reduce excise duty for higher blend levels of biodiesel and bioethanol (Belgian Government, 2005).

It should be noted that, on a volumetric basis, the mineral oil tax subsidy for biodiesel is worth more than a full exemption. It is also bigger than the German one, making Belgium an attractive market for biodiesel producers. The Belgian system is less flexible than the British or German one, as blenders have no fiscal incentive to deviate from the biodiesel levels set by government: 2.45% in 2005, 3.37% in 2006, 4.29% in 2007 and 5% in 2008. Bioethanol, on the other hand, only benefits from a partial tax exemption. Furthermore, the minimum level of bioethanol that blenders must put into petrol blends to benefit from the duty rebate exceeds the maximum amount allowed by European norm EN 228. If the law is adopted unchanged, it is very unlikely that any bioethanol will be used for direct blending at all, until a new European petrol standard is adopted that allows higher blend levels. With the current

proposal, would-be bioethanol blenders would face the uncomfortable choice of not benefiting from the duty rebate or breaking the law by violating the standard. The standard allows a 7% ethanol content, if added in the form of ETBE, but it is doubtful if oil companies will add such high levels of ETBE (nearly 15%), which is costlier than simple ethanol blending. The Belgian proposal would also, similarly to Germany but unlike the UK, prevent bioethanol importers from importing the fuel under a customs code other than undenatured ethanol.

9.2.6 Fuel and emission standards

The same European fuel standards (EN 228 and EN 590) and vehicle emission standards (EURO 4 and, from 2008, EURO 5) that apply in Germany and Britain are also in force in Luxembourg. The Fuel Quality Ordinance (2000, 2001 and 2003) does not address biodiesel or bioethanol.

9.2.7 Alcohol legislation

An excise duty is payable on drinking alcohol. Ethanol that is used for other purposes than drinking can be exempt from excise duty, if a range of conditions are met, such as the use of an officially approved denaturant. Public administrators have so far not looked into how alcohol legislation might affect the production or import of bioethanol for blending with petrol (Reinert, Administration des Douanes et Accises [Customs and Excise Administration], 24 August 2005).

9.3 Main actors

9.3.1 Biofuel industry

No biofuels are produced in Luxembourg. Farmers' association Agroénergie produce feedstock for some 800 t/y of RME; the biodiesel is produced in France. Apart from these 800 t, no biodiesel or bioethanol is used in the country at the moment.

9.3.2 Oil industry

9.3.2.1 Overview of the Luxembourg oil sector

The Luxembourg oil sector is dominated by international oil companies. The major players are Shell, Total, BP/Aral, Esso and Q8 (Winkin, GPL, 23 August 2005). Texaco and Conocophilips/JET are also present. 157 service stations are owned by the oil companies and 83 are independently owned. Most of the independent retailers are marketing the products of an oil major, but are free to change brand when the contract runs out (Groff, Ministère de l'Économie, 23 August 2005). A few retailers are importing fuels themselves and market them under their own brand. 95% of all petrol and 85% of all diesel are sold at service stations open to the general public, the rest being dispensed at private pumps by fleet operators (Groff, Ministère de l'Économie, 23 August 2005).

There are no refineries in Luxembourg. In 2004 around 40% of all petrol and diesel (heating and transport) were imported by truck, 40% by trains and 20% by river barge. While the trucks unload directly at the service stations, trains and river barges deliver the fuels to a number of depots (Bertrange, Dippach, Cessange, Leudelange, Mertert) (Winkin, GPL, 23 August 2005). The lion's share of the fuels is imported from Belgium and produced in Belgian or Dutch refineries (96% of the petrol, 82% of transport and heating diesel). All oil companies import basically identical diesel and petrol from Belgium, brand-specific additives are added at

the moment when the fuel is loaded onto the truck before being delivered to the service station (Groff, Ministère de l'Économie, 23 August 2005).

9.3.2.2 Official stance on biofuels

The stance of the industry's national trade association "Groupement Pétrolier Luxembourgeois" (GPL) on biofuels in general, is similar to that of the European or indeed German or British trade associations. They question the use of biomass for making transport fuels, as greater CO_2 savings could be obtained through other forms of bioenergy. They also criticise the fact that the Biofuels Directive allows Member States to implement it in a very heterogeneous way. The GPL would have preferred biofuels to be promoted via EU-wide mandatory fuel standards.

Regarding the implementation of the directive in Luxembourg, the GPL would like to see the government to wait for Belgium to decide on its biofuels supporting measures and copy these. The GPL argues that since Luxembourg does not have any refineries and it cannot control what is produced in Belgium, costly investments in additional infrastructure (e.g. biofuel blending facilities in Belgium or Luxembourg) would have to be made if Luxembourg were to require different fuel qualities than Belgium. Furthermore, the fact that Luxembourg and Belgium have a common excise duty on transport fuels would be a legal obstacle to an independent biofuels policy.

9.3.3 Automobile industry

For most car companies, their Belgian subsidiaries are controlling car marketing in Luxembourg (Jung, AEL, 21 June 2005).

9.4 Recommendations for policy makers in Luxembourg

9.4.1 Selection of three policy options that could be implemented in Luxembourg

Based on my assessment of the German and British biofuels policies I have derived a number of recommendations on how to implement the Biofuels Directive in Luxembourg, taking into account the specific national context. I will discuss three policy options: copying the Belgian law proposal, reducing the rate of excise duty on biofuels and introducing an obligatory biofuel quota. I have chosen excise duty reductions and biofuel quotas as they are the most widely used or discussed policy instruments for promoting biofuel use in the EU. 14 countries state in their progress reports that they have put some sort of duty reduction in place (PriceWaterhouseCoopers, 2005). Austria has introduced an obligatory biofuels quota, and this instrument is also considered in other Member States, such as the UK or Sweden. The Belgian law proposal is assessed because Luxembourg traditionally follows the Belgian excise duty system and some 90% of all transport fuels are imported from Belgium. I will present advantages and drawbacks of these options and explain why I believe the Luxembourg government should introduce an obligatory biofuel quota (option 3). Furthermore, a number of recommendations on issues that are relevant for all three policy options will be given.

I believe that, even though biofuels have so far played only a marginal role in Luxembourg, the EU indicative target for 2010 can be met as only comparatively small quantities of biofuels are required, due to the small size of the country and fuel market.

9.4.2 Policy option 1: Copying the Belgian law proposal

Belgium proposes to raise excise duties on conventional transport fuels but lower these on diesel and petrol which contain a minimum amount of biodiesel or bioethanol. The biodiesel amount is set at 2.45% (vol.) for 2005; this level is to increase in a linear way by 0.92% each year until it reaches 5%. Minimum bioethanol content must be 7% (vol.). Biofuels as such are not detaxed, unless they are blended into fossil fuels at the right level. The effective tax subsidy is 0.49€/l for biodiesel and 0.59€/l for bioethanol. The biodiesel subsidy is higher than in Germany and I expect it to boost the blending of biodiesel. However, as has been explained before, it is most likely that no bioethanol will be used, neither for direct blending nor in the form of ETBE.

If Luxembourg were to copy the Belgian approach it would have to ensure that the tax advantage for the defined diesel-biodiesel blends is similar to that of Belgium or Germany. Otherwise tax competition may direct biodiesel away from the Luxembourg fuel market.

Copying the Belgian law would allow importers to keep importing diesel refined and blended for the Belgian market that would – if the incentive is sufficient – contain certain amounts of biodiesel. They would not need to set up additional blending infrastructure for the Luxembourg market only. However, policy options 2 and 3 can also be designed to have this advantage. Furthermore, the Belgian proposal has some serious drawbacks:

- The system is inflexible, burdening fuel supplier with additional costs. Suppliers, in practice, have no choice but to blend in exactly the amount of biofuel set by government or not to blend in any biofuel at all. If they blend in more, they do not get any reward for the extra amount, if they blend in less, they do not get any subsidy at all. This has the following consequences:
    - Fuel suppliers cannot respond to biofuel price fluctuations, by, for example, blending in less when biofuel prices are high and more when they are low and still meet a yearly average target.
    - Importers that cannot blend themselves can only buy from refineries and wholesalers that provide the exact blend level set by government. If, for example, a German refinery sells B3 (3% biodiesel by vol.) for the German market, the biodiesel level would have to be adjusted to B2.45, at an extra cost.
    - There will be no market for B100 or E85 as they cannot benefit from the duty rebate.
- Bioethanol use is unlikely to take off, for reasons mentioned above. While diesel is the main transport fuel in Luxembourg, the petrol segment must also be addressed for meeting the Biofuel Directive's targets.
- The Energy Taxation Directive does not allow tax reductions to lead to overcompensation. They may only bring the price of biofuels down to that of the fossil alternative but, in theory, not below. It remains to be seen what the stance of the European Commission will be, given the rather high tax reductions that Belgium proposes to introduce. There is some risk that the Commission will ask for a reduction of the subsidy.

- High tax subsidies may result in high tax income losses for the state. However, the losses may be compensated by the increase in excise duties on fuels without biogenic content. If Luxembourg were to introduce the same effective tax subsidy for biofuels as in Belgium, the losses were not compensated by higher taxes on fossil fuels and a 5.75% market share can be attained, the annual loss to the treasury would be some 90 million € (excise duty and VAT).

- As it is, the law will not lead to a 5.75% market share for biofuels in 2010. As European standards only allow a maximum of 5% (vol.) biodiesel and bioethanol in diesel and petrol, B100 and E85 also need to be used. Their use is unlikely as they do not benefit from a tax subsidy.

For these reasons I do not recommend to implement the proposed Belgian system in Luxembourg but rather go for options 2 or 3 (preferred).

9.4.3 Policy option 2: Excise duty reduction for biodiesel and bioethanol

Among EU states this is the most widely used policy instrument for implementing the Biofuels Directive. I believe it could also boost biofuel use in Luxembourg, if designed in the following way:

- The rebate should apply for biodiesel and bioethanol, both as neat fuels and in any blend ratio. This allows fuel suppliers to be more flexible and adapt to changing market situations.

- The rebate needs to be sufficiently large to compensate their extra production cost and make biofuels price-competitive. The 2004 data (see Figure 12) show that for this biodiesel may need more than a full duty exemption. Government ought to verify if EU legislation allows this[43].

- Furthermore, the duty rebate must be large enough to favourably compare with the rebates in neighbouring countries, to avoid tax competition diverting biofuel trade away from the Luxembourg market.

- The duty rebate can be made tax neutral by increasing excise duty on fossil fuels. The actual effect on the market of changes in taxation are difficult to predict and it may be worthwhile for government to do some economic modelling if it decides to chose this option. While a duty increase will result in a higher tax income per litre of fossil fuel sold, it may also lead to a reduction in demand, especially from drivers transiting through Luxembourg or living in the neighbouring regions. A reduction in road transport may lead to a loss in excise duty income but also have beneficial effects, such as a reduction in the costs of road transport (e.g. road maintenance, accidents, health and environmental impacts of noise and air pollution). In particular, it would reduce CO_2 emission growth from the transport sector, helping Luxembourg to meet its Kyoto commitments.

This scheme would also allow fuel importers to take advantage of the blends that are prepared for the Belgian market. But, on top of that, they would be free to import different blends from

[43] The Energy Taxation Directive only mentions the possibility of an „exemption or reduction in taxation" (Article 16).

other suppliers in other countries, or make their own blends and adapt the biofuel level to the market situation. However, the scheme also has some disadvantages:

- As has already been pointed out for policy option 1, the Energy Taxation Directive does not allow tax reductions to lead to overcompensation and it remains to be seen what the stance of the European Commission will be on this issue.

- Large subsidies, if successful, may result in high income losses for the state (see policy option 1). But, as been said above, the losses can be compensated by an increase in duty on fossil fuels.

- There is no guarantee if the target will be met and when it will be met. Depending on the level of the rebate, the biofuel sales may not reach the target or overshoot it.

9.4.4 Policy option 3: Obligatory biofuel quota

Such a scheme has been implemented in Austria and is being considered in the UK and Sweden. It functions according to the following principle: government sets yearly biofuel targets which increase step by step to reach 5.75% in 2010. Fuel suppliers get a certificate for each quantity of biofuel sold (neat or as a blend) and must prove at the end of the year that a certain percentage of their aggregate fuel sales were biofuels. The suppliers are free to supply fuels with varying biofuel contents or neat biofuels, as long as, on average, the target percentage is met. It should be noted that the obligatory quota must apply to aggregate sales and not each litre of petrol or diesel sold. The Fuel Quality Directive does not allow Member States to ban the sale of fuels that meet its requirements. The following parameters should be considered when designing the scheme:

- The obligation should be placed on the actors at the narrowest point of the fuel supply chain, which in the case of Luxembourg are the importers. If each service station had to prove it sold a minimum amount of biofuels the system would become very cumbersome to administrate.

- The scheme can be kept simple, with each importer having to meet the quota. Alternatively, the trading of certificates may be allowed, as is, for example, the case for the EU's greenhouse gas emission trading scheme. In this case, importers can chose to supply biofuels themselves or purchase extra certificates from competitors that supply more than required. This option is more complex to implement but allows greater flexibility for the actors.

- It is possible to have a single, overall biofuel obligation, or separate ones for biodiesel and bioethanol. I recommend a single obligation, as this gives fuel suppliers the freedom to supply more than needed of one biofuel type, to compensate for insufficient sales of the other.

- The extra costs that are incurred by fuel suppliers may be compensated in two ways: a) By reducing the excise duty on biofuels, and, possibly, increase that on fossil fuels to limit the loss to the state in tax income. Options 2 and 3 can thus be combined. b) By allowing higher margins for the fuel suppliers in the maximum price mechanism, who could then pass their costs on to the end-consumers.

- The penalty must be sufficiently large to deter fuel suppliers from non-compliance with the targets.

Similarly to the previous policy options, an obligatory fuel quota scheme also allows importers to take advantage of the biodiesel blends produced for the Belgian market: the mandatory quota must follow the minimum biodiesel level for which a duty rebate is available in Belgium. It allows greater flexibility and lower costs than the Belgium system. Its major advantage over the excise duty rebate option is that it provides a higher guarantee that the 2010 target will be met. The policy option's main disadvantage is that few such schemes have so far been implemented and, due to lack of experience, it may be harder or take longer to get it started.

9.4.5 Other policy design considerations relevant to all three options

9.4.5.1 Clear government commitment to biofuels is important

Economic actors have to make business decisions, e.g. to invest in biofuel blending and distribution infrastructure or to start farming biofuel crops. To allow them to plan ahead government should send out a clear message that it wants to meet the 5.75% target in 2010 and that it is prepared to amend its policy if it becomes obvious that the targets will not be reached.

9.4.5.2 The use of neat biofuels and high level blends must be encouraged

Even if all diesel and petrol is sold as B5 and E5, another 20,000 t of biodiesel and 20,000 t of bioethanol need to be brought to the market. This can be done by changing the diesel and petrol standard at EU level to allow higher biofuel content. However, it is not sure if and when this change will be made. For this reason, it is advisable to also promote the sales of neat biofuels or higher level blends. For this, a number of policy measures can be taken, such as:

- Information campaigns about which vehicles can run on B100 or E85 and from which service stations these fuels are available;

- Introduction of direct subsidies for the purchase of new B100-compatible or flex-fuel vehicles;

- Reduction in motor tax for B100 and flex-fuel vehicles;

- Introduction of a public procurement obligation: e.g. 25% of all new vehicles must be "green";

Because of Luxembourg's small size, it should be fairly easy to overcome the "chicken and egg problem", as only a few publicly available pumps with B100 or E85 are necessary to cover the entire country. Sales of B100 and E85 may prove to be a lucrative business opportunity for service station operators. In case they are reluctant to provide the pumps government may, for example, adopt a law currently being proposed in Sweden that would force operators of large service stations to provide at least one biofuel pump. It should be noted, that for consumers to opt for B100 or E85, government must ensure through tax rebates that these fuels have a price advantage over diesel and petrol.

9.4.5.3 Free trade of bioethanol or protectionism?

The Biofuels Directive can be implemented in a way that ensures that a high import tariff must be paid on imports of bioethanol from non-EU countries, by making biofuels support conditional to bioethanol falling into customs category CN 2207 10 00. It is also possible to use a broader definition of bioethanol that allows it to be imported under a lower customs tariff. The advantage of a protectionist law is that it encourages the use of EU-produced bioethanol, strengthening EU agriculture and energy autarky. The disadvantage is the additional cost to end-consumers and the state, with bioethanol being roughly twice as expensive to produce in Europe than in Brazil. Furthermore, with current practices bioethanol from Brazil, and potentially also from other warm countries, can be produced with a much better CO_2 balance than ethanol in the EU.

I recommend the Luxembourg government not to adopt a protectionist stance (as in Germany or Belgium) but to encourage free trade (as in the UK or Sweden). Luxembourg has no transport bioethanol industry that would benefit from protection. State revenue would only benefit little from a high import tariff as 75% of it would go to the EU budget and 25% to the country where the ethanol is imported (most likely not Luxembourg). Sugarcane ethanol production is cost-competitive with that of petrol, which will increase the acceptance of oil companies and consumers, require less subsidisation and speed up market penetration. And while sugarcane ethanol does not strengthen energy autarky it does strengthen security of supply by broadening the supply base. I believe that if biofuels are to play an important role, rather than occupy a symbolic niche, in the future it is crucial that they can compete with fossil fuels on a level playing field with fossil fuels: these are traded globally and face low import tariffs (e.g. petrol and diesel) or none at all (e.g. crude oil).

9.4.5.4 Ensuring greenhouse gas savings and sustainability of biofuel production

Biofuels, depending on their feedstock and production methods can deliver very low (or negative) to very high carbon savings. The Government could design its biofuels policy in order to promote those biofuels most which deliver the greatest greenhouse gas emission reductions. One possibility would be to grant more certificates to such biofuels, under a biofuel quota scheme. The drawback of such a system is additional complexity and, possibly, conflict with WTO rules. However, without it, the effectiveness of the policy to fight global warming is reduced. I recommend to consider the results of the feasibility study carried out by UK government on this issue, which is likely to be published in the latter course of 2005.

Government could also address wider sustainability concerns about biofuel production (e.g. rainforest clearing in Malaysia, as reported by the WWF) by encouraging producers and importers to adopt a voluntary codex, for which an eco-label could be awarded. Such voluntary schemes are being elaborated in the UK (Low Carbon Vehicle Partnership) and Sweden (Kåberger, Lund University, June 2005).

9.4.5.5 Supporting the domestic production of biofuels

Current methods of producing biodiesel and bioethanol are considered mature technologies that will in the mid-term (10-20 years) be replaced with more efficient processes such as lignocellulosic ethanol production, or Fischer-Tropsch diesel synthesis through gasification or hydrothermal upgrading. I believe that, rather than spending public money on capital grants for "dead end" technologies, it should be used for supporting RDD on advanced biofuels, other forms of bioenergy, renewable energy or energy efficiency.

9.4.5.6 Alcohol legislation

In some EU countries the existing drinking alcohol legislation has also affected transport bioethanol and created regulatory barriers to its use. Before implementing the Biofuels Directive government should make sure that no alcohol excise duty has to be paid on transport bioethanol and other possible legal obstacles are identified and removed.

9.4.5.7 Fuel composition control

When introducing an obligatory biofuel quota and/or tax exemption it is important to make sure that adequate control mechanisms to verify that the biofuel quantities declared by fuel suppliers are indeed brought to the market. Currently, Customs & Excise (Administration des Douanes et Accises) are using a system based on document control to levy excise duty on fuels (Reinert, Administration des Douanes et Accises, 24 August 2005). It should be investigated with Customs & Excise if this system can be adapted to accommodate biofuels or if it needs to be complemented by, for example, taking of samples and chemical analyses. There are European standards for establishing the FAME and ethanol content of fuels (EN 14078 for FAME, EN 1601 and EN 13132 for ethanol). Detection of *bio*-ethanol requires more expensive techniques, such as carbon dating (PWC, 2005). I did not look into the precision of the measuring techniques.

9.4.5.8 Labelling of pumps

When preparing biofuels legislation, pump labelling regulations should also be updated, so that B100, E85 or other blends with a biofuel content exceeding 5% can be marketed in a transparent, uniform way.

9.4.5.9 A closer look at the vapour pressure issue of low level bioethanol-petrol blends

It is not clear to what extent this issue is a real problem, or simply an excuse by the oil industry for not having to market bioethanol. A study by the European Commission's Joint Research Centre, refiners' association CONCAWE and car manufacturers' association EUCAR, to be published early in 2006, may shed more light on this issue.

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Abbreviations

ABI	Allied Biodiesel Industries
ACEA	European Automobile Manufacturers Association
AEL	Agence de l'Énergie du Luxembourg [Luxembourg Energy Agency]
AGQM	Arbeitsgemeinschaft Qualitätsmanagement Biodiesel [Working Group Quality Management Biodiesel]
AVL	Autobus de la Ville de Luxembourg [Luxembourg City Buses]
B5, B10, etc.	Diesel fuel with a biodiesel content of 5%, 10%, etc.
BABFO	British Asssociation for Bio-Fuels and Oils
BBE	Bundesverband Bioenergie [Federal Association for Bioenergy]
BMV	Berliner Mineralöl-Vertrieb [Berlin mineral oil distribution]
BtL	Biomass-to-liquid
BUND	Bund Umwelt- und Naturschutz Deutschland [Association for the protection of the environment and nature]
CAP	Common Agricultural Policy
CEN	European Committee for Standardization
CFL	Chemins de Fer du Luxembourg [Luxembourg Rail]
CHP	Combined heat and power
CN	Combined Nomenclature
CONCAWE	Conservation of Clean Air and Water in Europe [The oil companies' European association for environment, health and safety in refining and distribution]
DfT	Department for Transport
DG TREN	Directorate-General Energy and Transport
DGMK	Deutsche Gesellschaft für Mineralöl und Kohle [German Association for Mineral oil and Coal]
DME	Dimetyl ether
DTI	Department of Trade and Industry
E5, E10, etc.	Petrol fuel with an ethanol content of 5%, 10%, etc.
EPA	Environmental Protection Agency
ETBE	Ethyl tertiary butyl ether
EU	European Union
EUCAR	European Council for Automotive R&D [established by the Association of European Automobile Manufacturers]
FAME	Fatty acid methyl ester
FFV	Flexible fuel vehicle
FNR	Fachagentur Nachwachsende Rohstoffe [Agency of Renewable Resources]
GPL	Groupement Pétrolier du Luxembourg [Luxembourg Petroleum Association]
ha	hectare
hl	hectolitre

HTU	Hydrothermal upgrading
IEA	International Energy Agency
JAMA	Japan Automobile Manufacturers Association
JRC	Joint Research Centre
KAMA	Korean Automobile Manufacturers Association
kg	kilogramme
kPa	kilopascal
l	litre
LAB	Landwirtschaftliche Arbeitsgemeinschaft Biokraftstoffe [Agricultural working group for transport biofuels]
LCA	Life cycle analysis
LowCVP	Low Carbon Vehicle Partnership
MJ	Megajoule
MTBE	Methyl tertiary butyl ether
MWV	Mineralölwirtschaftsverband [Association of The German Mineral Oil Industry]
NABU	Naturschutzbund [Nature protection association]
NGO	Non-governmental organisation
RDD	Research, development and demonstration
RME	Rapeseed methyl ester
RPA	Renewable Power Association
RTFO	Renewable transport fuel obligation
SCR	Selective catalytic reduction
SME	Small or medium enterprise
SMMT	Society of Motor Manufacturers and Traders
t	tonne
UBA	Umweltbundesamt [Federal environmental protection agency]
UFOP	Union zur Förderung von Oel- und Proteinpflanzen [Union for the Promotion of Oil and Protein Crops]
UK	United Kingdom
UKPIA	UK Petroleum Industry Association
US	United States
VAT	Value added tax
VCD	Verkehrsclub Deutschland [Transport club Germany]
VDA	Verband der Automobilindustrie [Association of the automobile industry association]
VDB	Verband der Deutschen Biokraftstoffindustry [Association of the German Transport Biofuel Industry
WTO	World Trade Organisation
WTW	well-to-wheels
WVO	Waste vegetable oil

WWF	World Wildlife Fund
y	year

Appendix

Appendix 1: Energy content and density of transport fuels

	Energy content (MJ/kg)	Energy content (MJ/l)	Density (kg/l)	1 l Diesel/Petrol energy equivalency	Source
Diesel	42.408	35.283	0.832	100%	Austrian Ordinance on transport fuels (2004)
Diesel	42.200	35.870	0.850	100%	German Government (2005)
Diesel	42.335	35.350	0.835	100%	Valbiom (2003)
Petrol	41.724	30.959	0.742	100%	Austrian Ordinance on transport fuels (2004)
Petrol	43.307	32.480	0.750	100%	German Government (2005)
Petrol	41.600	31.200	0.750	100%	Valbiom (2003)
Biodiesel	35.172	32.358	0.920	91.71%	Austrian Ordinance on transport fuels (2004)
Biodiesel	37.314	32.650	0.875	91.02%	German Government (2005)
Biodiesel	37.699	33.175	0.880	93.85%	Valbiom (2003)
Ethanol	26.676	21.181	0.794	68.42%	Austrian Ordinance on transport fuels (2004)
Ethanol	26.691	21.060	0.789	64.84%	German Government (2005)
Ethanol	26.763	21.250	0.794	68.11%	Valbiom (2003)
Diesel (average)	*42.314*	*35.501*	*0.839*	*100%*	
Petrol (average)	*42.210*	*31.546*	*0.747*	*100%*	
Biodiesel (average)	*36.728*	*32.728*	*0.892*	*92.19%*	
Ethanol (average)	*26.710*	*21.164*	*0.792*	*67.09%*	

Appendix 2: Online media survey

German and British online media sources were surveyed for period 1 June – 6 August 2005. I used "Google News" (news.google.com) to search for articles containing the keywords "biofuels, bio-fuels, bioethanol, bio-ethanol, biodiesel, bio-diesel, biokraftstoffe", that were published by German or British sources.

German online media

Article **Source. (date). Title**	**Positive**	**Mainly positive, some negative aspects**	**Neutral**	**Mainly negative, some positive aopects**	**Negative**
Allgemeine Zeitung Bad Kreuznach. (6 August 2005). Steuervorteil Sichert Zukunft Des Biodiesels		X			
EnergiePortal24 (2 August 2005). Biosprit – Welche Studie Sagt Die Wahrheit?		X			
Oeko-Test. (1 August 2005). Alkohol im Tank: Ford bietet ab August Fahrzeuge an	X				
Solarserver. (31 July 2005). Biodieselabsatz an öffentlichen Tankstellen klettert auf Rekordmarke		X			
VerkehrsRundschau. (29 July 2005). Den Haag – Biodiesel Soll Ab 2006 Niedriger Besteuert Werden	X				
IWR. (28 July 2005). Biodiesel-Absatz steigt		X			

auf Rekordniveau					
Handelsblatt. (28 July 2005). Alkohol Im Benzintank – Von Mineraloelsteuer Befreit	X				
SaechsischeZeitung. (28 July 2005). Biodiesel bleibt weiter auf dem Vormarsch		X			
Gross Gerauer Echo Online. (27 July 2005). Kraftstoffalternative – Oekosprit Bis Zu 20 Cent Billiger	X				
Presseportal. (27 July 2005). Biodieselabsatz An Oeffentlichen Tankstellen Kletter Auf Rekordmarke		X			
Rubin. (27 July 2005). Bioraffiniert Vom Acker In Den Tank	X				
Ernaehrungsdienst. (28 July 2005). Kommentar Zur Bioenergie Realitaet	X				
IWR. (22 July 2005). Berichtigung – Bundesregierung Will Biodiesel Anteilig Besteuern			X		
VDINachrichten. (22 July 2005). Deutsche Bank sieht Bioenergie als Hoffnungsträger	X				
KoelnischeRundschau. (22 July 2005). Biosprit – Die Preiswerte Alternative		X			
DresdnerNeuesteNachrichten. (21 July 2005). Freiberger Firma stellte Fuhrpark auf Pflanzenöl um		X			
Muenchner Merkur. (20 July 2005). Bioenergie – Teures Oel Macht Alternative Konkurrenzfaehig	X				
WaldeckischeLandeszeitung. (21 July 2005). Biotreibstoff Fuer Motoren Und Die Region	X				
WolfsburgerNachrichten. (22 July 2005). Landwirte der Region setzen auf Raps	X				
MitteldeutscheZeitung. (21 July 2005). Gruener Kraftstoff Von Gelben Feldern	X				
SchwaebischeZeitung. (20 July 2005). Daryl Hannah Engagiert Sich Fuer Die Umwelt	X				

SchwaebischeZeitung (20 July 2005). Motoroeffnung – Zustand Ist Erstaunlich Gut	X				
Presseportal. (20 July 2005). Alkohol Tanken Geld Sparen Umwelt Schonen	X				
AllerZeitung. (19 July 2005). Besichtigung Der Oelmuehle	X				
KielerNachrichten. (20 July 2005). Trockenheit Mindert Den Ertrag	X				
HR Online. (20 July 2005). Autofahren mit Kartoffeln	X				
MitteldeutscheZeitung. (19 July 2005). Neues Werk Stinkt Nachbarn					X
Umweltmagazin (19 July 2005). UFOP Spricht Sich Gegen Teilbesteuerung Von Biodiesel Aus	X				
Pressrelations. (15 July 2005). UFOP: Biosprit Hat Positive Bilanz	X				
RotenburgerRundschau. (13 July 2005). Ein Hektar Mais Reicht Fuer 65000 Kilometer				X	
MitteldeutscheZeitung. (12 July 2005). Neue Biodieselanlage im Piesteritzer Südwerk		X			
SpiegelOnline. (13 July 2005). Leistungsplus Dank Alkohol	X				
AutoMotorSport. (8 July 2005). Regierung will Biodiesel anteilig besteuern			X		
Sonnenseite. (8 July 2005). Pflanzenoel Erdgas Oder Biodiesel	X				
WolfsburgerNachrichten. (7 July 2005). Im Trend – Biogene Kraftstoffe		X			
Netzeitung (6 July 2005). Ford Setzt Auf Ethanolantrieb	X				
AutoMotorSport (6 July 2005). Ford Focus Und C-Max: Alkoholbetrieb	X				
FinanzenNet. (30 June 2005). Suedzucker Kursziel 22 Euro	X				

Pressrelations. (27 June 2005). Food Und Non Food Winterrapsanbau	X				
Schwabmuenchner Allgemeine. (29 June 2005). Ölpreis als Motor des Fortschritts	X				
IWR. (27 June 2005). Biodieselverband Vertritt Kuenftig Interessen Der Bioethanolhersteller			X		
Autoflotte. (24 June 2005). Ford Bringt Ethanolfahrzeuge Auch In Deutschland An Den Start	X				
AutoServicePraxis. (24 June 2005). Biodieselverband benennt sich um	X				
EnergiePortal24. (24 June 2005). Biodiesel Boomt	X				
VDINachrichten. (24 June 2005). Pack Gutes aus Korn in den Benzintank	X				
TAZ. (23 June 2005). Rekord bei Biodiesel		X			
Finanzen. (22 June 2005). Biodiesel schaffte Durchbruch am Markt		X			
HROnline. (21 June 2005). Rekord-Preise Fuer Benzin				X	
News4Press. (21 June 2005). Bauerntag- Sprit Vom Acker Boomt	X				
Koelnische Rundschau. (20 June 2005). Biosprit Als Alternative Zum Schwarzen Gold		X			
Energieportal24. (17 June 06). Ford bietet Ethanol Pkw ab August auch in Deutschland an	X				
Autokiste. (16 June 2005). Ford: Focus mit Ethanol-Antrieb bald auch in Deutschland	X				
AutoServicePraxis. (16 June 2005). Toyota füllt Alkohol in den Tank	X				
EnergiePortal24. (13 June 2005).DaimlerChrysler treibt Biokraftstoffe in den USA voran	X				

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