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Final Report

Biodiesel initiatives in Germany

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1 Background and goals

The European project PREMIA /PREMIA 2005/ is to assess the effectiveness and cost efficiency of policy measures to support the market introduction of alternative motor fuels. In this framework, for single subtasks subcontracts were established. Regarding the production and usage of biodiesel in Germany the ifeu – Institute for Energy and Environmental Research Heidelberg was charged by VITO, Belgium, to create a survey.

This survey was to cover the following partial aspects:

a – the current state of the legal framework including its historic development under special consideration of the product norms and standards, authorisation and taxation of blends, systematic quality checks and certifications, incentives, and support programmes,

b – a description of concrete initiatives especially on biodiesel production plants and fleets using biodiesel,

c – an impact assessment of biodiesel with a focus on the amount of biodiesel on the market and amount of agricultural area dedicated to biodiesel, the biodiesel potentials, its public acceptance, the continued cost to the society, environmental impacts, and other effects under consideration of the share of the actions mentioned in b.

The study has been finalised on the basis of a short-term expert judgement in April and May 2005.

2 Legal framework

2.1 Product norms and standards

- Standardisation of biodiesel

As early as 1994, the first preliminary German norm for biodiesel produced from plant oils was established by the German Institute for Standardisation: DIN V 51606. This norm was improved and refined in the following years and published in a second version, DIN E 51606, in September 1997. It defined biodiesel as fatty-acid methyl ester (FAME) /ÖBI 2002/. It had still the status of a draft standard, was however fully valid and set the technical basis for almost all approvals for biodiesel by the automobile industry /AGQM 2005/.

In November 2003, the European norm EN 14214 was published in Germany as DIN EN 14214 and replaced the previous German standard of biodiesel. The new norm is more severe in some parameters than the previous one and contains additional requirements (see Table A-1 in the Annex). It represents the technical basis of the renewed fuel quality and labelling regulation (10^{th} adaptation of the Federal Immission Regulation, 10. BImSchV) for biodiesel. According to this regulation, biodiesel may be sold as a fuel only according to the parameters of DIN EN 14214. Biodiesel pumps have to be labelled explicitly to show that the biofuel sold complies with the current norm.

Apart from the official norm, there is an organisation in Germany striving for standardisation called Arbeitsgemeinschaft Qualitätsmanagement Biodiesel e. V. (AGQM, Association for the Quality Management of Biodiesel). It was founded in November 1999 on initiative of the

UFOP (Union for the Promotion of Oil and Protein Plants, Berlin). This was a time when through the increased number of biodiesel producers and trading enterprises the necessity of organised quality protection emerged. Its members are manufacturers, biodiesel traders, filling station societies as well as further prospective customers such as additive manufacturers, constructors etc. Its aims are:

- guaranteeing the minimum quality requirements according to EN 14214,
- guaranteeing the supply of bulk consumers and filling stations with quality biodiesel,
- presenting biodiesel as a high-quality product for establishing confidence with consumers and the automobile industry.

The high influence of AGQM can be noted by the fact that that well three quarters of all 1,900 biodiesel pump stations are members of AGQM (/Bockey et al. 2005/). Find a list of members of AGQM in Table A-3 in the Annex. The distribution of biodiesel filling stations in Germany can be found in Fig A-1, the distances between AGQM filling stations in Table A-6, both in the Annex.

Basically it can be observed that the AGQM quality standards for biodiesel are higher than those defined by EN 14214. The most important differences are represented in Table 1. In Table A-2 in the Annex, problems are displayed which may occur if the requirements of the AGQM standard are not met. In particular, it must be emphasized that for biodiesel according to AGQM only rapeseed oil as raw material is permissible. The reason for this is the declaration of nearly all manufacturers of passenger cars, goods vehicles, and tractors approve only RME (Rapeseed oil methyl ester) to be used as a biodiesel fuel that was pronounced due to problems in vehicles with other kinds of biodiesel.

Table 1. Important differences between DIN EN 14214 and quality standards of AGQM. Source: /Bockey 2004/.

Property	**DIN EN 14214**	**AGQM**
Water content (mass ratio)	max. 500 mg/kg	Producers: max. 220 mg/kg All members: max. 300 mg/kg
Total contamination (mass ratio)	max. 24 mg/kg	max. 20 mg/kg
Oxidation stability (induction time)	min. 6 h	min. 6 h (check point: final user) Biodiesel sold at public filling stations requires addition of oxidation stabilisers.
Period for production of winter quality biodiesel (cold filter plugging point lowered)	16/11 until 28/02	19/10 until 28/02
Fatty acid profile	–	like rapeseed (for selling at public filling stations)

- Standardisation of pure plant oil

For pure vegetable oil a quality standard has been in operation since the year 2000: the quality standard RK 5/2000 for rapeseed oil as a fuel /FNR 2005/. Due to climatic and yield reasons, rapeseed is the almost exclusively grown oil plant in Germany. This standard was improved in the meantime and is supposed to be published later this year as the preliminary standard DIN V 51605 /Rathbauer 2005/.

- Standardisation of bioethanol

For bioethanol as a pure fuel there is no standardisation in Germany. However, for taxation reasons, bioethanol is permitted only in high-concentrated, non-denatured form (with 99 % EtOH content at minimum, /UFOP 2004/). With this regulation, its properties are basically defined.

- Further standardisation

In addition there are further standardisations which refer to mixtures of biofuels with fossil fuels. See section 2.2.

- Warranty approval for the use of biodiesel by German manufacturers

Since 1996 Volkswagen has approved almost all new diesel vehicles for biodiesel fuelling. This included not only the models of VW, but also those ones the trade marks Audi, SEAT, and Skoda. Other vehicle manufacturers such as DaimlerChrysler had approved only single series for biodiesel fuelling. Since the introduction of EURO 4 engines, however, the Volkswagen group has withdrawn the general approval. In particular Bosch, the leading manufacturer for diesel injection pumps, does not give any assurances for biodiesel fuelling, which has effects on the entire automobile industry. Nevertheless to date the number of the biodiesel-approved passenger cars in circulation lies over three million /Bockey 2004/. For heavy goods vehicles, buses, and utility vehicles, most manufacturers do not provide general approvals for biodiesel, but issue them on request.

Basically only standardised biodiesel is approved as a biofuel according to EN 14214. According to /ADAC 2005/ all German car manufacturers require explicitly RME (see also “Standardisation of biodiesel” above in this section). In case fuel is used which does not keep these properties the warranty is void. A list with the manufacturer’s specifications for the approval of biodiesel can be found in Table A-4 in the appendix.

Also the conversion of older cars for biodiesel fuelling was offered occasionally in the past by different workshops. Being within the framework of the legal product liability, it has been subject to an warranty. Today the national offer is limited to authorised dealers of specific trade marks who convert suitable older models.

2.2 Authorisation and taxation of biofuel / conventional fuel blends

Due to the non-coverage in legislation, until 31/12/2003 mineral oil tax was not imposed on pure biofuels – and thus pure biodiesel. Blends were not on the market as they would have had to be taxed. It was explicitly permissible though that the end user mixed non-taxed biodiesel in his vehicle with fossil diesel.

Since 1/1/2004 all biofuels are covered by the mineral oil tax act /MinöStG 2004/. It allows in tax terms all proportions of blends of biofuels and conventional fuels, provided that blending occurs in the tax warehouse, i.e. at the refinery or with the wholesaler. If a public filling station blends a biofuel and a fossil fuel in its own tanks, the biogenous share is to be taxed subsequently /UFOP 2005/. Only internal filling stations of companies or agricultural enterprises are allowed to do so without subsequent taxation in order to facilitate the adaptation on biodiesel in this area.

Find more information on the mineral oil tax act and the calculation of the tax in section 2.4.

- Biodiesel

In the new legislation (after 1/1/2004) pure FAME is allowed, however (in spite of its fossil part from methanol) is not taxed.

According to the European standardisation DIN EN 590, which is in operation in Germany since March 2004, additions of up to 5 % biodiesel (FAME) to diesel fuel are permissible without labelling also in this country. Higher blends (except for 100 % biodiesel) may be sold, but are to be labelled accordingly.

- Bioethanol

Also for petrol, the European standardisation is valid in Germany in the form of the DIN EN 228. Additions of up to 5 % bioethanol or up to 15 % ETBE (or MTBE) are for this reason allowed.

Like for mixtures of biodiesel in diesel fuel, higher blends do not fall under this norm. In this case at public filling stations petrol pumps must be properly labelled, like is the case for diesel fuel with a biodiesel share over 5 %.

- PPO

Contrary to biodiesel, pure vegetable oils are not authorised explicitly in standardised fuels.

2.3 Systematic quality checks and certification systems

Due to the little production and usage figures of **PPO and bioethanol** as well as the missing standardisations no systematic quality controls and certification systems have been established for these biofuels so far. Controls can be carried out, however, within the framework of the governmental quality controls, which check petrol whether it complies with the norm DIN EN 228 and with the addition of bioethanol up to a maximum of 5 % (see section 2.2 above).

Biodiesel, instead, is covered completely by standardisation and legislation since the fuel quality and labelling regulation in August 2004 (part of the 10th adaptation of the Federal Immission Regulation, 10. BImSchV, /BImSchV 2004/). It is subject to unannounced governmental quality controls like they have been executed already for the fossil fuels /Lieberz 2004/. A kind of certification is established by the obligation to label all fuel pumps indicating the conformity to the standard EN 14214 or (when biodiesel is added to conventional diesel fuel) to EN 590.

In addition to this, the voluntary declaration of many manufacturers, traders, and filling stations with AGQM exists (see section 2.1) about even higher requirements. AGQM has built up a multi-layer system of quality protection, which includes a certification system and quality controls:

1. Biodiesel producers

   As mentioned in section 2.1, the manufacturers have some obligations concerning to biodiesel quality exceeding the European norm EN 14214. First of all, however, they must subject themselves to an independent licensing procedure which checks among other things the personnel qualification, the minimum lab outfit, documentation of the inputs and outputs, deposit of tests as well as the pre-dispatch check. Also during operation they must subject themselves to a continuous, unannounced quality control of the delivered biodiesel. Serious deviations result in sanctions and revocation of the quality seal of the manufacturers' community.

2. Distribution and storage

   Quality assurance of the warehouse conditions requires that a modification of the product quality is impossible during storage. This is valid in particular in the case of longer storage times. Furthermore, inputs and outputs must be documented. Also during the transport special rules are valid, i.e. a mixing of biodiesel with mineral fuels or impurities in the tank chambers are to be excluded. For this, the drivers must confirm in writing the compliance of the requirements.

3. Filling station

   For the assignment of the AGQM quality label the filling stations must fulfil the following conditions: purchase of biodiesel exclusively from AGQM members, admission of unannounced inspections by AGQM, control of the compliance of the transportation companies to the requirements, provision of information on the biodiesel topic to the customers. In the case of breaches of contract sanctions occur.

4. Biodiesel clients

   Information material on quality assurance must be provided to customers. Furthermore, PR campaigns for making the AGQM logo and label known to customers have been executed.

5. Systematic analysis of problems

   In spite of the high AGQM standards and multiple inspections of course individual cases of vehicle defects in connection to biodiesel usage can not be excluded. For the evaluation of such cases the AGQM keeps continuously a close contact with biodiesel customers, workshops, and vehicle manufacturers. With these information the association can both pursue cases of nonmembers violating the EN norm and early recognise such systematic problems that can occur also in case of compliance with the norm in order to then find solutions for that.

In the past, there have been already several cases of members being excluded from the AGQM due to quality issues, among others four biodiesel producers and a large number of filling stations.

2.4 Incentives

Main incentive is the exemption of transport biofuels from the mineral oil tax:

Like mentioned in section 2.2, before 1/1/2004 the German mineral oil tax act (Mineralöl-steuergesetz, MinöStG) considered only mineral-oil based fuels as such on which to impose the mineral oil tax. For this reason, (pure) biofuels were exempt. Since that date, biofuels fall under the MinöStG act and have 0 tax rate. This is valid for all blends with conventional fuels in a way that the biogenous share is taxed with a rate of 0. For the different biofuels, the following facts are valid: biodiesel is assumed to be 100 % biogenous (in spite of the fossil methanol input), other fuels or additives like biogenous ETBE or MTBE are classified depending on the biogenous share, e.g. ETBE is said to be 47 % biogenous, consistent with the EU directive 2003/30/EC. From this, for the example ETBE 53 % of the tax on petrol are due. The tax exemption is fixed until the end of 2009. The law requires that the tax exemption is examined every year for overcompensation. The German Government has to provide evidence that the development of raw material prices for both fossil and biogenous fuels does not lead to a net advantage for biofuel producers. The next report from the Government is due this May 2005 /Bockey et al. 2005/.

Furthermore, in 1999 a step-by-step increase of the mineral oil tax has been introduced among other things by the so-called ecological tax reform (Ökosteuerreform). The declared aim was to increase the cost of fuel consumption in order to make the population driving to a lesser extent or more economically. The extra revenues however were to finance the pensions and to decrease thus the non-wage labour costs. Indirectly, this tax increase can be also seen as a small incentive for alternative fuels, which have grown more competitive. In the course of the ecological tax reform the mineral oil tax has been increased by 3.067 €ct / L petrol or diesel fuel in every of the first years, until it reached a level of 65.45 €ct / L for petrol and 47.04 €ct / L for diesel fuel in 2003.

An incentive on EU basis for biofuels production is the Council Regulation No. 1782/2003 /EU 2003a/, which defines a grant of 45 € per hectare for the cultivation of energy crops on not set-aside land. All agricultural plants except sugar-beets can be granted; and the energy-crop grant can be added to other grants (e.g. subsidies for oil seeds). The upper limit of energy crop area to be funded lies at 1.5 million hectares. If grants for a larger energy crop area are requested, each grant will be reduced pro rata.

Furthermore, there were also other forms of incentives, like subsidies for the construction of the plant, free-of-charge creation of the infrastructure of the site, low-cost development land, etc. (cf. section 3.1, Cost). However, the most important driving force for the success of biodiesel in Germany has been and still is the tax exemption.

2.5 Support programmes involving biofuels

There have been and there are a number of support programmes for the promotion of biofuels for transportation. Examples are:

- In the year 2000, the Agency of Renewable Resources (Fachagentur Nachwachsende Rohstoffe, FNR) financed by the Federal Ministry for Consumer Protection, Food and Agriculture (formerly Federal Ministry for Food, Agriculture and Forestry) has started the “Market Launch Programme Biogenous Lubricants and Transportation Fuels” (Markteinführungsprogramm Biogene Treib- und -schmierstoffe), which since then has supported the use of biogenous oils and biodiesel in areas of special environmental relevance /FNR 2002/. The programme supports, among other things, the construction or conversion of private filling stations for biodiesel and PPO through a grant of regularly 40 % of the costs, specially in the areas of agriculture, forestry, and building construction. The programme is to be continued at least until end 2006, but has undergone little success for the support of filling stations – until now (April 2005) only 54 projects have been supported (thereof about 20 % are filling stations for PPO) /Stelter 2005/. The focus is on the biogenous lubricants for which so far about 3000 projects have been supported.
- Only one year later, in 2001, the same Ministry for Consumer Protection, Food and Agriculture has started the “100-tractors programme” (100-Schlepper-Programm), which was to show the environmental soundness and technological feasibility of diesel engines converted to PPO operation /FNR 2002/. The tractors are to run on rapeseed oil according to the standard RK 5/2000 (see section 2.1). During the programme, in total 111 tractors have been converted to biodiesel operation and are technically supervised by a research team until autumn 2005. Problems occurred in part because of non-standard rapeseed oil (injection pump damage). As a third of the tractors showed heavy problems and had to

undergo extensive repairs, the necessity of basic research and applied industrial research on the use of PPO becomes obvious /AgE 2004/.

- For a new programme to be introduced, the Federal Ministry for Consumer Protection, Food and Agriculture searches operators of fleets wishing to convert their vehicles to bioethanol E85 operation. So far, no details are known.
- Also, the regional Ministry for the environment North-Rhine Westfalia has started a support programme in 2005 which is aimed at fleets of public administration for the conversion to E85 or PPO operation. Up to 80 % of the costs for advice, conversion or additional price of the vehicles, and conversion of the filling stations are incurred by the ministry.

A Non-Governmental Organisation which promotes the use of biodiesel in many ways is the Union for the Promotion of Oil Seeds and Protein Plants (Union zur Förderung von Oel- und Proteinpflanzen e. V., UFOP). It was founded in 1990 and since then has managed to bring together plant breeders, farmers, oil mills, biodiesel distributors, but also researchers, politicians, and vehicle manufacturers. Its special interest is the promotion of locally produced rapeseed oil, both for nutrition and as a renewable raw material. This includes funding of research, e.g. on new varieties of rapeseed or on the environmental and economic effects on biodiesel usage. For more information see *www.ufop.de*.

There are also a few research and development projects which UFOP has supported financially or technically. Examples:

- In the project "Biodiesel and sports boats in the EuRegio Lake of Constance" (Biodiesel und Sportschifffahrt in der EuRegio Bodensee), UFOP supported since the year 2000 the investigations on currently about 30 boats on the Lake of Constance, which were to analyse the information on the types of motors, load profile, hours of operation, and motor oil quality as well as any occurring problems /Plaettner-Hochwarth 2004/.
- UFOP has followed the project of converting the bus fleet of the former Kreiswerke Heinsberg (today WestEnergie und Verkehr) to biodiesel operation. After a test phase, about 130 buses have been converted /KWH et al. 1999/.

Finally, we want to point out that the outcome of all these programmes – both governmental and non-governmental – in terms of biodiesel consumption is insignificant compared to the consequences of the tax exemption for biofuels. They serve rather for the technical application of some open questions and/or for an increased acceptance and impact in the public.

3 Description of concrete initiatives

3.1 Biodiesel production

In Germany there are 26 transesterification plants with a total capacity of about 1.2 million tonnes per year, being mainly single plants. Of these, only two plants with over 200,000 t/a total capacity are so-called annex plants that are connected to oil mills. These two plants process exclusively, the others mainly rapeseed oil, while a smaller number converts also oils from other oil plants, used cooking oils or animal grease. The majority of the plants thus practises transesterification of rapeseed oil. The plant size lies between 2,000 and 150,000 t/a for rapeseed oil and between 5,000 and 35,000 t/a for other oils and greases. Process technology distinguishes about half a dozen different ways of producing biodiesel.

All that shows that a “typical” biodiesel production plant does not exist. Therefore, in the following we avoid to focus on just a few single plants separately, but rather try to show analogies and typical similarities of the entirety of the plants.

Some large biodiesel plants with their capacities between 100,000 and 150,000 t/a produce about 10 % each of the German biodiesel demand; together they account for more than half of the total capacity. Especially in the case of older plants, these capacities were often created through enlargements.

The oldest production plant commercially in operation has now more than ten years. It is the transesterification plant of Oelmühle Leer and was constructed by the businessman Joosten Connemann, a farsighted entrepreneur and qualified chemist and engineer. He is regarded as the pioneer of the German biodiesel industry since as early as in the beginning of the 1990ies – and therefore earlier than everyone else – had the idea of a transesterification plant for the production of biodiesel from plant oil. Initially he built a pilot plant which was in operation from 1991 to 1995 and at the time of start-up produced 1 t daily, after an enlargement in 1993 20 t daily, i.e. up to 8,000 t per year. Already ten years ago, it was thus larger than today’s smaller commercially working plants. With the aid of the experiences gained, Connemann was then able to construct an industrial-scale plant, which went into operation in 1994. The initially planned and realised capacity was 80,000 t/a. With this plant, Connemann has in the first years (as the first producer of biodiesel in Germany) created the market and due to his marketing also a certain demand. In 1999, the plant was enlarged to a capacity of 100,000 tonnes annually and is therefore one of the largest biodiesel plants in Germany (for the development, see Table 2). Now it belongs to ADM (Archer Daniels Midland), a large US company in the agro-industrial business. This example shows on the one hand the growing market and on the other hand the increased future expectations by investors in biofuels for transportation. Many operators of oil mills have established order contracts with their clients, which guarantee on a long-term basis defined order quantities. The biodiesel traders in turn can agree upon such long-term contracts because of the tax exemption on biofuels, which until end 2009 is preserved (see section 2.4) and which allows a better investment planning. Already in former years biodiesel plant operators were engaged, however, also in the international market. As an example, Connemann sold a part of the produced biodiesel to France – politics there has approved already prior than in Germany an addition of biodiesel to conventional diesel fuel according to EN 590 (see section 2.2). With that, Connemann increased the reliability of his market by extending the consumer group under different political conditions (/IFEU 2005b/ on the basis of /ÖBI 2002/, /IWR 2005/, and other sources).

Table 2. Biodiesel production capacity of the pilot plant constructed by Connemann and ADM oil mill in Leer. Source: /IFEU 2005b/ on the basis of /ÖBI 2002/, /IWR 2005/, and other sources.

In 1,000 t/a	**1991**	**92**	**93**	**94**	**95**	**96**	**97**	**98**	**99**	**2000**	**01**	**02**	**03**	**2004**
Pilot plant by Connemann	3	7	7	8	8	–	–	–	–	–	–	–	–	–
ADM Oelmühle Leer	–	–	–	25	37	60	80	80	90	100	100	100	100	100

Envisaged effect

With the example described above, one aim of enterprises becomes clear that recently has become more and more significant: an economic interest, i.e. the search for a future-oriented market. This is especially of importance in times of economically difficult situations like they are currently present. At the beginning of the discussion on biodiesel and other renewable transportation fuels, rather other reasons were stimulating investments. The pioneers of that time, among them also Connemann, had rather the protection of the environment in mind, they showed an interest in novel technology which they wanted to advance, and they had a vision of the future in which biofuels had a high relevance.

On the contrary, the aims of the Government, but also of the EU and regional governments in Germany for funding biodiesel have been mostly in other areas:

- **Regional structural policy**. This aimed at supporting especially regions with weak infrastructure by favourable loans for the construction, price-reduced connections to the mains, low-cost construction area, and other measures. Consequently, because of appropriate funding, many biodiesel plant have been constructed in Eastern Germany.
- **Agricultural support**. By creating a new market, agricultural support served among other things for new income sources of farmers.
- **Saving or creation of jobs**. Not only in the area of agriculture, but also in the processing industry of oil mills and transesterification plants employment was to be stabilised or increased.
- **Environmental aspects**. In the framework of support programmes in Germany aspects of sustainability, of environmental protection, and of independence from fossil resources have been taken into consideration already since considerable time.

Especially in the initial phase of biodiesel in Germany the environmental aspects mentioned have been also occasion for the support of the development of environmentally friendly technologies, in this case of biodiesel production techniques. For instance, the pilot plant of Connemann was supported through the European research and development programme THERMIE, in addition also by the German Federal Government and the Land Lower Saxony.

Generally, as already mentioned elsewhere, the exemption of biodiesel from the mineral oil tax was the decisive incentive for the diffusion of biodiesel.

Further effects as a consequence of the development since 1990 are:

- Increased technical maturity of the transesterification process up to being completely developed and reliable to date,
- Improvements in the exploitation of the auxiliary materials during extraction of the plant oil and especially during transesterification (decreased quantities)
- Improved operation & maintenance due to larger series installation of biodiesel plants

- Due to increased plant size, augmented absolute investments whereas relative investments have decreased
- Decreased public support for the installation of biodiesel plants
- A coverage of the German surface with a network of 1,900 biodiesel filling stations, which in no place are further away from each other than 50 km
- Reaching the aim of a 2% share of biofuels in 2005 according to the EC directive 2003/30/EC

Cost

The height of investment for a large biodiesel transesterification plant lies in the range of over ten million euros, for a capacity of 100,000 t/a like that of ADM Oelmühle Leer 15 to 20 million € are necessary /Fischer 2005/. The height of public support has been varying in the past, but lies clearly below the investments to be taken. For a 100,000-tonnes plant, over 48 million € of tax losses annually and for a runtime of 10 years nearly 500 million € of lost mineral oil tax revenues derive. This is a multiple of the investments and particularly of the governmental subsidies. From this, it can be concluded that the governmental support for the construction of biodiesel plants has only low significance and that the tax exemption for biofuels is the main driver for the success of biodiesel in Germany.

This is confirmed by the statement that already since several years a free-trade financing of biodiesel plants is possible /Nawaros 2001/. Indeed the crude-oil and the plant-oil prices have travelled partly contrarily and due to the increased demand, rapeseed becomes more and more expensive (see Fig 1). But with the number of plants yet to be constructed, the total capacity is to rise up to over 2 million tonnes per year by the end of 2006 (see Table A-5 in the Annex) /Bockey et al. 2005/. This shows the large dynamics in the market due to the increased demand still to come and the high future expectations of the enterprises due to the legislative security.

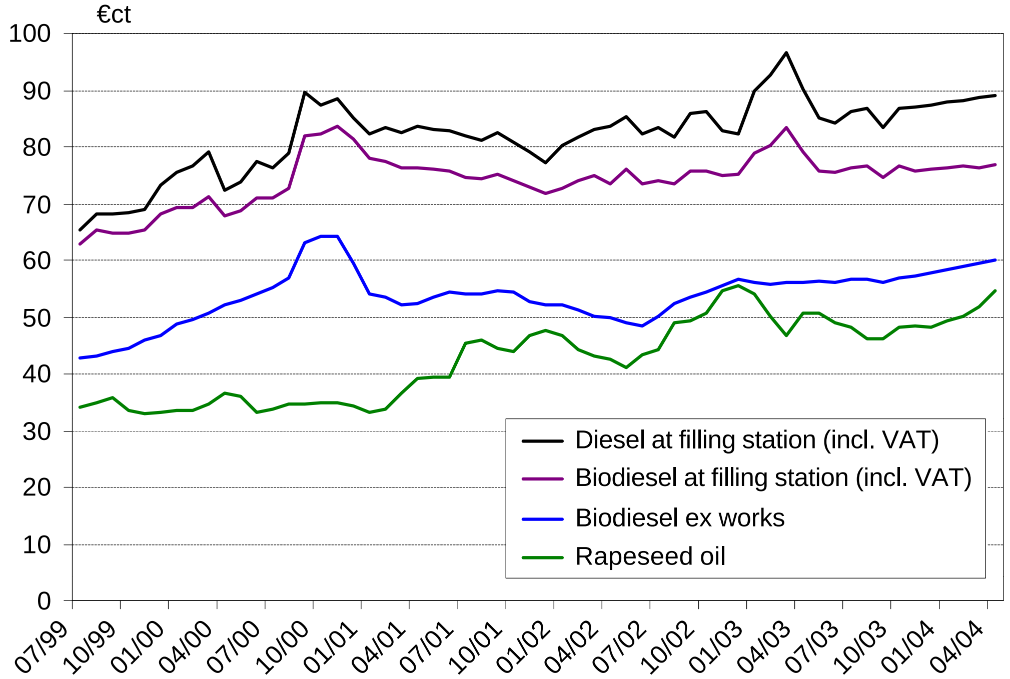

Fig 1. Price for diesel fuel and biodiesel at filling station, rapeseed oil, and biodiesel ex works from 1999 until 2004. Source: /Bockey 2004/.

3.2 Biodiesel fleets

In Germany, between 60 and 70 % of the biodiesel in commerce are consumed by fleets. Therefore, their market has been growing to a large 700,000 t in 2004.

There are many hundreds, possibly thousands, of fleets running on biodiesel, with most different characteristics (/IFEU 2005b based on /Bockey 2005/). The vehicles running on biodiesel are to a large extent heavy goods vehicles of forwarding agencies, but also passenger cars in taxi fleets, buses and coaches in the public transport and private sector, and utility vehicles in building companies, mining, etc. run on biodiesel. Apart from enterprises which have converted their complete fleet to biodiesel there are many having a mixed fleet with only a part of the vehicles running on biodiesel and the remainder still running on conventional diesel fuel or petrol. Furthermore, the fleets are very different in size: from the small company fleet of two cars or vans up to the largest with over a hundred buses or lorries, the range is large. Like already for the biodiesel production plants (see section 3.1 above), we cannot talk about typical initiatives among the fleets.

For this reason, in the following general characteristics of the fleets are presented and details are given for different examples.

There is only one thing all fleets have in common: even the largest fleets have only an insignificantly small share of the total biodiesel consumption in Germany. One of the largest fleets, which is run by WestEnergie, Erkelenz, has about 130 buses consuming 2 million litres biodiesel per year /Hoffmann 2005/, that is about 1,750 t/a and therefore under 2‰ of the total biodiesel consumption in Germany /IFEU 2005/. Even the fleet with the highest biodiesel consumption in Germany reaches a share of just over 1 % /IFEU 2005/: 54 utility vehicles of the Wismut GmbH, a company owned by the German Government, are used for redevelopment of the open-cast mines and heaps in Ronneburg. They consume 11,500 tonnes of biodiesel per year /Mischke 2005/, that is more than the production of a smaller biodiesel plant like Cordes & Stoltenburg in Schleswig. Medium-sized biodiesel fleets operate one or two dozens of vehicles like the sugar-beet loading and transport association ZAAG, Reichelsheim (see Table 3), or the brewery “Brauerei Clemens Härle”, Leutkirch (Table 4).

If a company considers the conversion of its fleet to biodiesel there is the tendency that the decision is influenced by the fact whether the vehicles can be refuelled at an internal filling

Table 3. Details on the biodiesel fleet of ZAAG, Reichelsheim. Sources: /FNR 2002/, /Weckler 2005/

The sugar-beet loading and transport association ZAAG (Zuckerrübenauflade- und -abfuhrgemeinschaft Wetterau Nord, located in Reichelsheim) has converted its fleet of 24 heavy goods vehicles and two loaders to biodiesel in the year 2000. Through operating optimisation the fleet has been reduced to now 12 lorries, with, however, the relatively high consumption of 700,000 L/a (620 t/a /IFEU 2005/), which is not less than the previous fleet of double the amount of vehicles consumed. Most of this amount, around 500,000 L, is consumed during the about 100 days of sugar-beet campaign.

There was no necessity to convert the lorries of the fleet, being all produced by MAN, in order to run on biodiesel. The internal biodiesel filling station set up in the year 2000 permits the use also for other agricultural associations in the region, increasing the consumption of biodiesel to around 2 million litres a year.

For reasons and effects of the conversion see the section “Envisaged effect” in this section.

station in order to make sure a constant supply of all vehicles with a well-known, high-quality biodiesel. For other uses such as international carriers or fleets without the possibility of an internal filling station, the conversion to biodiesel is less interesting as more problems during operation and higher maintenance costs are feared.

However, companies generally have some advantage versus private car owners concerning biodiesel: they often have a wider choice in vehicles approved for biodiesel. Examples are the many heavy goods vehicles by MAN or DaimlerChrysler, tractors by Fendt, forklifts by Linde, and passenger cars with taxi equipment by DaimlerChrysler being biodiesel approved.

Table 5 lists the characteristics of the different fleet initiatives mentioned. See Table 9 for the impact assessment of these initiatives.

Table 4. Details on the biodiesel fleet of Brauerei Clemens Härle, Leutkirch. Sources: /Knigge et al. 2004/ and /Völk 2005/

Brauerei (brewery) Clemens Härle, located in Leutkirch, has a fleet of 2 passenger cars and 11 light goods vehicles for the distribution of the eight types of beer they sell. The consumption lies at about 40,000 L/a (35 t/a /IFEU 2005/). There are 5 other vehicles in the fleet running on conventional diesel fuel or petrol. The internal filling station with a tank of 20,000 L receives biodiesel twice a year, in summer and in winter quality.

Owner Gottfried Härle converted the fleet about ten years ago. At that time it consisted of 12 light goods vehicles and 4 passenger cars. He aims at a sustainable production within the regional context of the site. All raw materials for the beer production stem from within a radius of about 70 km, the distribution is even more restricted to a radius of about 50 km.

For more reasons and effects see the section “Envisaged effect” in this section.

Table 5. Characteristics of biodiesel fleets in Germany. Source: /IFEU 2005b/ on the basis of different sources.

	Wismut	**WestEnergie**	**ZAAG**	**Brauerei Härle**
Biodiesel fleet				
Utility vehicles	about 54 caterpillars, tractors, excavators etc.	about 130 buses	initially: 24, now: 12 goods vehicles; plus 2 loaders	prior: 12, now: 11 goods vehicles
Passenger cars	–	5-10 small vans and passenger cars	–	prior: 4, now: 2
Year of start-up	2002 (trials) / 2003	1996 (trials) / 1999	2001	about 1993
Own filling station	– (direct refuelling from tanker)	● (2)	●	●
Filling station used also by other customers	–	–	●	–
Biodiesel consumption per year	13,000,000 L = 11,500 tonnes	2,000,000 L = 1,750 tonnes	700,000 L = 620 tonnes	40,000 L = 35 tonnes
Incentives for conversion	–	–	●	●
Initiator(s)	management	management	associates	Gottfried Härle (owner)

Envisaged effect

The reasons for the conversion of fleets differ quite a lot between the companies. In the earlier days of biodiesel in Germany, there have been many idealistic entrepreneurs and other stakeholders wanting to minimise their environmental impact or trying to make their part of economy more sustainable. For instance, Brauerei Härle receives all their raw material from within a radius of 70 km and sells their beverages in a radius of 50 km /Knigge et al. 2004/. Later on, when biodiesel had been widely accepted, publicity was increasingly important and attributes like “clean transport” or “clean company” got a positive meaning. It was then that many lorries were provided with large-format writings explaining that the present vehicle ran on biodiesel. Since several years, the main driving force is the cost aspect. The increase in oil prices has led not only to an increasing share of diesel vehicles on the streets (especially among those with higher mileages) since diesel fuel, due to taxation, costs between 10 and 20 €ct per litre less than petrol, but also to an awareness of other possibilities of saving money when driving. But especially fleet owners think of possibilities to lower their costs and calculate them thoroughly. The savings can be large, as shows the case of the largest biodiesel consumer Wismut GmbH, which last year has saved 2 million € due to biodiesel use /Mischke 2005/.

Apart from these general reasons, certain triggers have led in many cases to the conversion of fleets to biodiesel operation. For example, the former Kreiswerke Heinsberg GmbH (today WestEnergie und Verkehr GmbH & Co. KG) had the duty to reduce the pollutant concentration within a closed filling station and washing plant. They calculated different options (exhaust system in the hall, conversion of the fleet to natural gas, conversion to biodiesel), executed emission tests with biodiesel and finally converted the complete bus fleet to biodiesel – with a saving of over 250,000 € due to the exhaust system not necessary anymore /Hoffmann 2005/. Another idea was trigger for the conversion of the ZAAG fleet. The EU Common Agricultural Policy impelled farmers not to grow food crops on a share of their land (for a long time 10 %). As the ZAAG co-operative farmers produced some rapeseed on that set-aside land the idea was born to return the rapeseed to the association through a contract with an oil mill and biodiesel producer /Weckler 2005/.

The “Market Launch Programme Biogenous Lubricants and Transportation Fuels” mentioned in section 2.5 supports, among other things, the conversion or installation of private filling stations for biodiesel fleets. Its aim is mainly to increase the acceptance and diffusion of biodiesel in Germany /FNR 2002/.

But again, more than all programmes for funding plants and installations, the tax exemption of biofuels has been determining for its success – see also chapter 2 and *Cost* down in this section.

Cost

Since the establishment of the Market Launch Programme that supports the conversion of fleets to biodiesel operation in 2000 (see section 2.5), the German Government has supported 54 projects of internal filling stations in the framework of this programme (thereof also a few PPO filling stations). Compared with the amount of many hundreds, according to /Bockey 2005/ even thousands of existing internal filling stations, this figure is rather low. The reason for that is not only that the financial resources of the programme are restricted but also that the conversion costs are rather low with respect to the possible savings due to lower fuel costs.

As already stated for the biodiesel production plants, also for the fleets the amount of necessary investments is low compared to the subsequent biodiesel throughput and to the loss incurred by the German Government due to the tax exemption. An example calculation shall explain this: if a 20,000-L tank with pump costs – roughly estimated – 10,000 € within the Market Launch Programme it is funded by FNR generally with a sum of 4,000 €. With a consumption of one tank filling per month this corresponds to an amount of 120,000 L biodiesel per year. By this quantity, the Government loses more than 50,000 € per year, that is over an assumed life of 20 years a total of 1 million €, i.e. 250 times more.

In the last months the biodiesel price at public filling stations has fallen to as much as 15 €ct below the price of conventional diesel fuel /Bockey et al. 2005/. Even considering that the biodiesel consumption per kilometre is 5-10 % higher than fossil diesel consumption (reason is the energy content of biodiesel), one still saves about half of the amount, i.e. between 5 and 10 €ct per litre biodiesel. Different fleet owners have shown that maintenance costs need not necessarily increase when fuelling biodiesel, so that finally on 10,000 L biodiesel the savings are 500 to 1,000 € /IFEU 2005/.

From this it can be seen that like for biodiesel production plants the tax exemption for biofuels is the most relevant governmental incentive for the biodiesel fleets.

4 Impact assessment

This chapter will evaluate the German biodiesel market and the initiatives described in chapter 3 within the market with respect to different statistical, environmental, and socio-economic categories.

4.1 Amount of biodiesel on the market

The amount of biodiesel has been growing rapidly in the last years. According to UFOP consumption was 1.18 million tonnes in 2004 /Bockey et al. 2005/. While there have been some unused capacities in recent years, the production plants are now working nearly at their limit.

Fig 2 shows these figures for the years between 1995 and 2004.

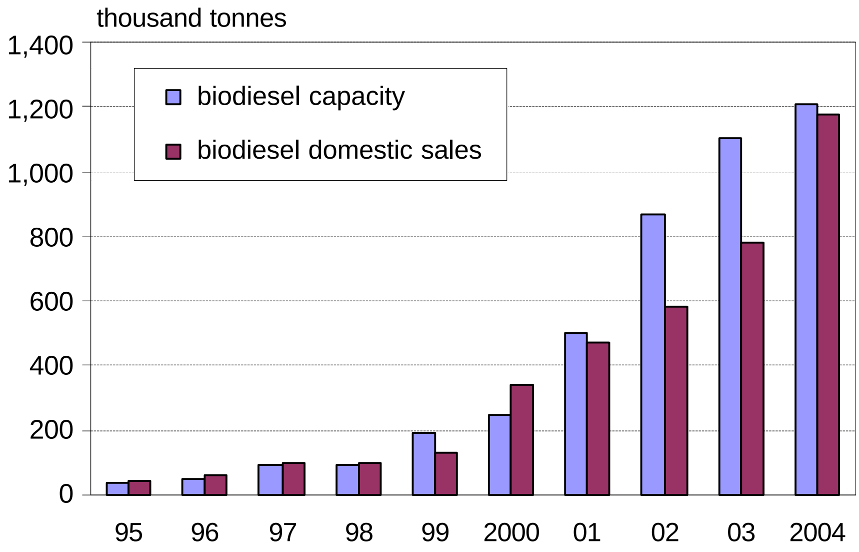

Fig 2. Production capacity and sales of biodiesel in Germany, 1995-2004.
Source: /IFEU 2005/ on the basis of /Bockey 2004/, /ÖBI 2002/, /IWR 2005/

4.2 Amount of agricultural area dedicated to biodiesel production

Biodiesel can be produced not only from rapeseed oil. As different transesterification plants practise, also other raw materials can be used, such as sunflower or soy oil, used cooking oil, or animal grease. Today, used cooking oils and animal grease each year are converted to biodiesel in a quantity of 47,000 t. Due to the relatively small amounts freely available and the market restrictions imposed by the vehicle manufacturers and AGQM (see section 2.1), rapeseed remains the most important raw material for biodiesel. The agricultural area occupied for biodiesel in Germany lies at around 650,000 ha. If the biodiesel sold in Germany had to be produced completely from German rapeseed, i.e. if imports and other raw materials for biodiesel could not be taken into account, the area would be over 950,000 ha /IFEU 2005/.

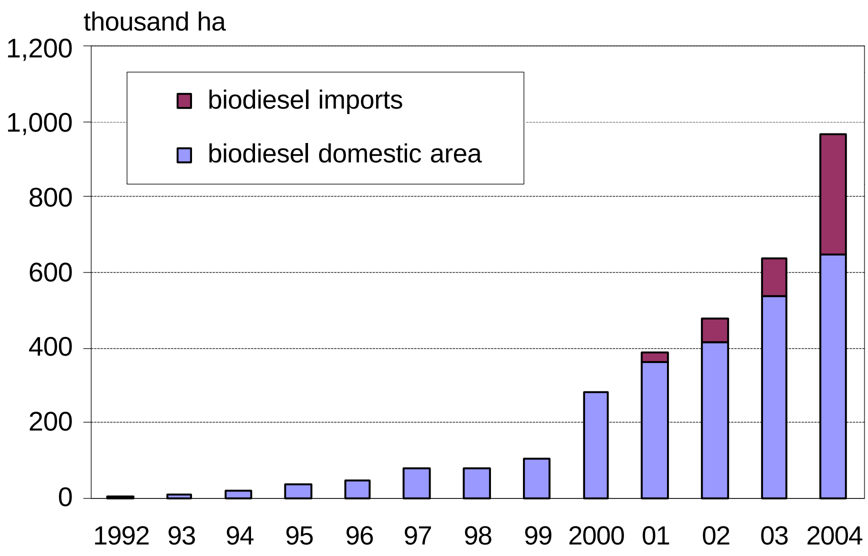

Fig 3. Rapeseed cultivation area for biodiesel in Germany von 1996-2004.
Source: /IFEU 2005/ based on different sources.

The development of the cultivation area for biodiesel rapeseed in the last years in Germany is displayed in Fig 3. The strong increase in cultivation area of over 100,000 ha per year since 1999 is striking. In these years, there was also a change of the type of area where rapeseed for biodiesel was grown, from non-food areas to areas where food may be produced, i.e. set-aside land to "basic area". Table 6 shows the area distribution for the cultivation of biodiesel for industrial and energetic aims (i.e. mainly biodiesel). While in the beginning virtually all of the rapeseed used for industrial and energetic aims was grown on set-aside areas, the relation has reverted. The relatively high rapeseed cultivation on food area for biodiesel in the years 1997 and 1998 and/or the low food area for biodiesel rapeseed in 1999, respectively, are not explainable from the available sources. Since 2004, the trend is likely to increase even more as due to the Council Regulation (EC) 1782/2003 grants are paid for each hectare of energy crops grown (for details, see section 2.4).

Table 6. Agricultural area for the cultivation of rapeseed with non-food use (biodiesel, oleochemistry, lubricants). Usage of rapeseed oil in oleochemistry and for lubricants: about 75,000 t in 2003 (/IFEU 2005/ based on /Reuter 2003/).
Source: /IFEU 2005/ based on /IWGB 2001/, /Reuter 2003/, /UFOP 2004a/, /FNR 2005a/.

	set-aside area [ha]	basic area [ha]	set-aside : basic area [%]	Source: /IFEU 2005/ based on
1996	226,915	5,000	98 : 2	/IWGB 2001/
1997	106,149	80,000	57 : 43	/IWGB 2001/
1998	143,270	81,000	64 : 36	/IWGB 2001/
1999	359,765	10,000	97 : 3	/IWGB 2001/
2000	332,978	75,000	82 : 18	/IWGB 2001/
2001	322,698	190,000	63 : 37	/UFOP 2004a/
2002	342,171	320,000	52 : 48	/UFOP 2004a/
2003	328,751	340,000	49 : 51	/UFOP 2004a/
2004	209,907[a]	496,800[b]	30 : 70	[a] /FNR 2005a/, [b] /UFOP 2004a/

4.3 Potentials

For the potentials of biodiesel, generally we have to distinguish between biodiesel from cultivated biomass (in Germany usually rapeseed) and biodiesel from residues: for cultivated biomass, one must consider that there is competition on the one hand in area and on the other hand in usage of the biomass produced, both restricting the production or the use of biodiesel, respectively. Residues are available only up to a certain quantity and often used in another, potentially more economic way, such that it is not possible to produce any amount of biodiesel from those.

For area competition, in Germany particularly the various area demands of defined or as yet undefined sustainability goals from the following areas play a role:

- **Organic farming**. In compliance with the aims of the Federal Ministry of Consumer Protection, Food and Agriculture (BMVEL), the percentage of organic farming in the framework of the Agricultural Turning should increase to 20 % by 2010.
- **Sealing of natural ground**. Aim of the “National Sustainability Strategy” is to reduce the utilisation of land area for housing and traffic purposes, which mostly originate from the area of agriculture, from approx. 130 ha/day by 2020 to 30 ha/day, which – slightly – counteracts the area competition.
- Nature conservation – **Biotope network**. §3 of the German Federal Nature Conservation Act (BNatSchG) specifies that 10 % of the total area of Germany must be designated for the national biotope network – however without a time limit.
- Nature conservation – **Compensation areas**. Compensational measures of the so-called impact regulation under nature protection laws or building laws claim until now and in the future agricultural cropland as compensating areas.
- **Water protection and soil conservation**. For reasons of water protection and soil conservation, cultivation of annual cultures is preferred to cultivation of perennial cultures in areas strongly endangered by erosion. Thus a reduction of “available” areas results, but on the other hand the perennial crops can, e.g., be used as energy crops, so that synergy effects arise.

Furthermore, with directive 2003/30/EC a “sustainable” EU goal exists on the share of bioenergy in the transport sector.

- **EU goal regarding biofuels for transportation**. 5.75 % of the total fuel market in 2010 should be biofuels (2 % in 2005).

On this basis, for different sustainability scenarios the “available” area potential can be identified, which then, e.g., would be utilisable for energy crop cultivation. The demand of areas for the above mentioned sustainability goals, including the EU goals for biofuels, amounts to a total of over 4.8 million hectares in 2010 /Reinhardt et al. 2005/. Fig 4 confronts the area demand and the available area if 100 % or 80 % of the food consumed in Germany is produced within the country. Approximately 2.3 million hectares are applicable to the areas “organic farming, compensation areas, biotope network, nature and soil conservation, and water protection”. This is the mere area available in 2010 if we assume a 100 % agricultural self-sufficiency. On top of that, about 2.5 million hectares would be needed for achieving the EU goal regarding biofuels if all biofuels are derived from energy crops produced in Germany. So if all the sustainability goals which are currently agreed or being discussed, should be converted to 100 % by 2010[1] there would be a certain conflict of objectives: not all sustainability goals can be met simultaneously.

On the other hand, many aims are not realisable until 2010, have significant costs and for this reason are in dispute. And there are other biofuels having a higher yield per area, which in part are still in the development stage. Bioethanol has indeed since 2005 a small share of the transport biofuels production (about 480,000 t/a capacity are planned or being built), but even if instead of rapeseed for biodiesel crops like wheat and sugar-beets for bioethanol were grown, the area necessary to meet the EU aim for 2010 would decrease by only a fifth to about 2 million hectares.

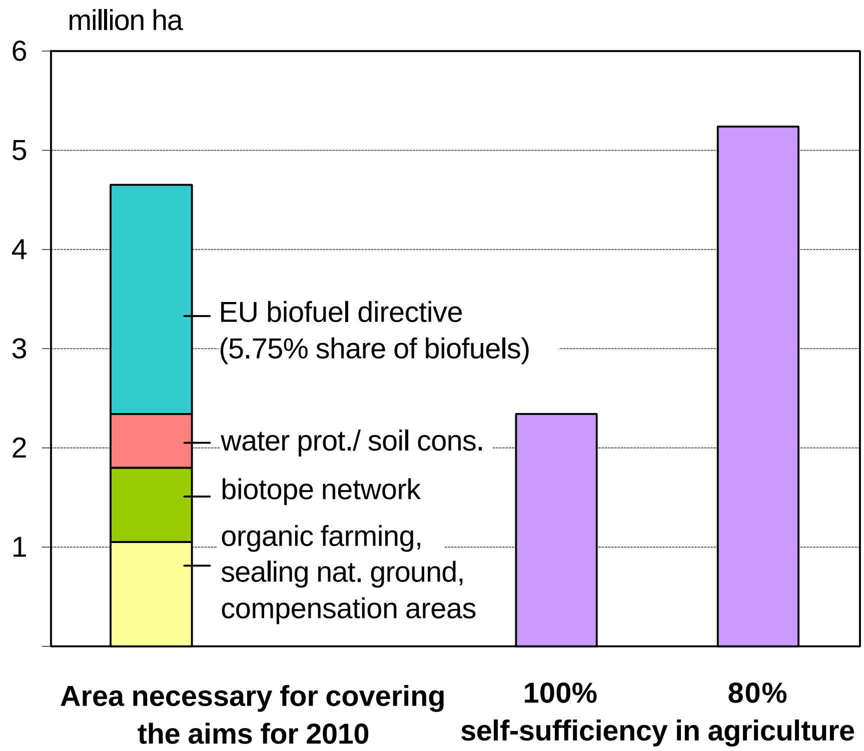

Fig 4. Area demand by different sustainability goals in Germany 2010 and available area. Source: /IFEU 2005/ on the basis of /Reinhardt et al. 2005/

Apart from the area competition, there is also a competition in usage – rapeseed can be used as well in stationary plants or for biobased materials. Likewise, other plants can be grown on the field and used for instance as energy plants for stationary energy supply or as industrial crops for different applications in technology. Already today, about 200,000 ha agricultural area are used for industrial crops /IFEU 2005/ and biomass, also cultivated biomass, is used e.g. for power production. Long-term aim of the European Commission is, as mentioned in the Green Paper “Towards a European strategy for energy supply security”, that 20% of conventional fuels should be replaced with alternative fuels by 2020 /EC 2001/. So not only different area demands, but also different usage aims are opposing each other, which restricts the potential further. Table 7 shows the biomass potentials in 2010 and 2020 for the following two cases:

- *Maximum*: energy crops are given priority over all sustainability goals, i.e. no extension of organic farming, no extension of the biotope network, no production of biobased materials.

[1] It has to be considered that not all sustainability goals are aimed at 2010.

- *Minimum*: all sustainability goals are preferred to the cultivation of energy crops; only the remaining areas are available for biomass production.

Table 7. Biomass potentials for the extreme values “Maximum = priority biomass” and “Minimum = priority other sustainability goals” (see text) in PJ / a.
Source: /IFEU 2005/ and /Reinhardt et al. 2005/.

	2010		2020	
	Maximum	Minimum	Maximum	Minimum
Cultivated biomass	218	0	352	93
Residues	34*	24*	370	276
Biogas	155*	145*	152	145
Sum for using biomass entirely as a biofuel for transportation	218	0	875	514
Share in the forecast total transport biofuel consumption**	10 %	0 %	43 %	26 %

* until 2010 not completely usable in the transportation sector
** forecast consumption 2010: 2,150 PJ, 2020: 2,010 PJ

Also, for residues there is a competition of usage. The potential of 300,000 t animal grease per year in Germany is used mainly thermically /Fritsche et al. 2004/; used cooking oil is accumulating locally and from 2005 has to be used energetically in disposal. Therefore, a further part of biodiesel demand in Germany could be covered with these amounts, but economic and energetic reasons could be in favour of other usages.

4.4 Public acceptance

At the beginning of the biodiesel era, biodiesel was experiencing a niche and was not noticed very much by the German population. Interested public, however, generally had a positive attitude towards the fuel regarded to be “environmentally friendly”. Only occasionally voices became public that discarded the use of biodiesel to be the silly idea out of an environmentalist’s brain or that disliked the typical “French fries” smell of biodiesel.

Two main incisions led to significant problems in public acceptance:

1. the publication by the Federal Environmental Agency (Umweltbundesamt, UBA) “Ökologische Bilanz von Rapsöl bzw. Rapsölmethylester als Ersatz von Dieselkraftstoff” /UBA 1993/. In an update of this investigation, “Aktuelle Bewertung des Einsatzes von Rapsöl/RME im Vergleich zu Dieselkraftstoff” /UBA 1999/ the statements concerning the environmental impacts have been significantly revised, however, in the new study political reasons against biodiesel have been stated, i.e. that biodiesel is too expensive for the national economy to justify the small advantages.
2. massively occurring engine problems. In the time of the first biodiesel boom varying biodiesel qualities caused engine defects in many vehicles. The young and not yet finalised norm DIN E 51606 had not been met by all biodiesel batches and at the same time biodiesel experience on the part of the vehicle manufacturers was low.

While the first UBA study led to several other surveys that found different result (see also section 4.5), the engine problems involved various efforts of biodiesel producers and distributors as well as vehicle manufacturers:

2a. the foundation of AGQM in 1999 (see also sections 2.1 and 2.3), which introduced quality controls and a quality label guaranteeing the conformity of the biodiesel to the AGQM standard. Today, three quarters of all public biodiesel filling stations are member of AGQM.

2b. the claim of car manufacturers to use a certain type of biodiesel (i.e. RME). This was also introduced as an additional defining quality attribute for biodiesel in the specifications of AGQM /UFOP 2005a/.

With increasing interest of the public in alternative fuels, also the less conservative side has become stronger – the PPO lobby. Their arguments are that with respect to pure plant oil technology the transesterification process is too complex and too costly and it contradicts the principle of decentralisation. However, up to now only the interested public knows the difference between biodiesel and PPO.

Generally, discussions between consumers and car drivers continue on the technical, financial, and environmental usefulness of fuelling biodiesel. As also in other cases, often people accept the technology in general, but not in their own car. Nonetheless, biodiesel has in public a good image as being environmentally advantageous – last but not least due to the lower price.

4.5 Continued cost to the German society

Around the turn of the millennium, two studies regarding the economic implications of biodiesel were published, which both have been discussed controversially. /UBA 1999/ and /IFO 2002/ had different results, which are due to different questions and thus are not comparable. For this reason, the only clear statement that can be derived from this is the fact that the Government has incurred a loss of thousands of million € of taxes (see Fig 5). Which savings due to higher tax revenues in other areas and higher employment arise can not be quantified here.

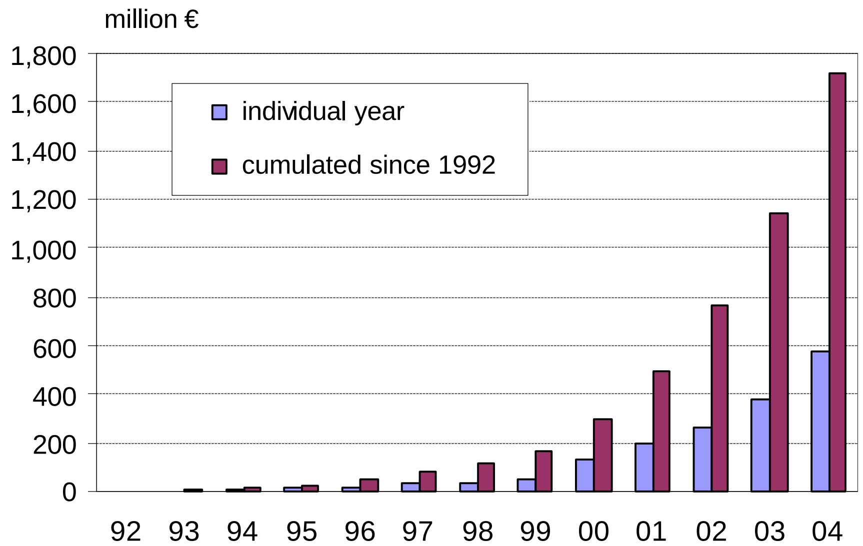

Fig 5. Mineral oil tax loss due to biodiesel consumption since 1992. Source: /IFEU 2005/

4.6 Environmental impacts

The environmental impacts analysed in this study are listed in Table 8 below. Meaningful and advanced balances for the impact categories human toxicity and ecotoxicity are currently, in our opinion, impossible to calculate because the databases in the area of fuel combustion are insufficient. Photo smog shows no significant results in the comparison between biodiesel and diesel fuel. And for the other two environmental impact categories of the DIN-NAGUS – noise and land use – a generally accepted balancing approach is currently still unavailable.

Table 8. Environmental impacts and their characteristics.

Environmental impact	Description
Greenhouse effect	Global warming as a consequence of the release of greenhouse gases by man. Most important greenhouse gas: carbon dioxide (CO_2) due to the combustion of fossil energy carriers. Here emissions of CO_2, methane, and nitrous oxide are recorded.
Energy savings	In this investigation the protection of the resources of non-renewable energy carriers is calculated, i.e. the non-renewable fossil fuels mineral oil, natural gas, and coal as well as uranium ore. In the following, based on the uniform tendency, the results of this impact category are termed ‘energy savings’.
Acidification	Shift of the acid/base equilibrium in soils and water bodies by acid forming gases (keyword ‘acid rain’). Emissions of sulfur dioxide, nitrogen oxides, ammonia, and hydrogen chloride are recorded.
Nutrient inputs	Input of nutrients into soils and water bodies (keyword ‘algal bloom’). Synonymous: eutrophication. Nitrogen oxides and ammonia are taken into account.
Ozone depletion	Reduction of the protective ozone layer in the stratosphere by certain gases like CFCs or nitrous oxide (keyword ‘Ozone hole’). Here nitrous oxide is recorded.

Accomplished GHG reduction

According to current studies /IFEU 2005a/, the usage of standard biodiesel in Germany (i.e. from rapeseed) instead of conventional diesel fuel saves greenhouse gases to an amount of 2.8 kg CO_2 equivalents per kg biodiesel. This corresponds to a saving of 3.3 million tonnes CO_2 equivalents in 2004. So far, in total 3.8 million tonnes biodiesel have been produced in Germany, that is equivalent to a saving of over 10 million tonnes CO_2 equivalent (see Fig 6).

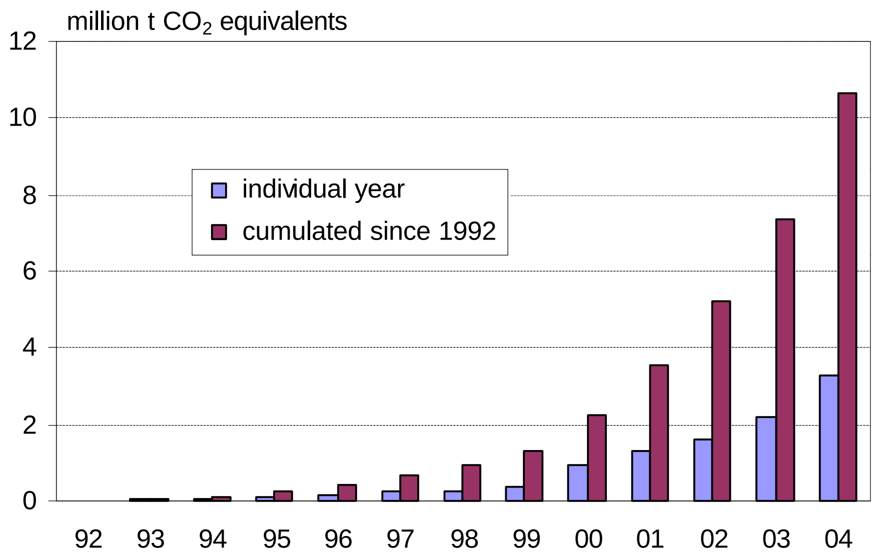

Fig 6. Savings of greenhouse gases due to biodiesel consumption since 1992. Source: /IFEU 2005/

Other environmental impacts

According to /IFEU 2005a/, greenhouse gases and depletable energy resources are saved if biodiesel is used instead of diesel fuel. However, the emissions causing acidification, nutrient inputs, and ozone depletion are all disadvantageous for RME, i.e. they increase if RME instead of diesel fuel is used. Considering the total consumption in 2004, 56 PJ less energy were consumed and 10,300 t SO_2 equivalents more acidifying gases, 2,400 t PO_4 equivalents more nutrifying gases, and 2,200 t more N_2O have been emitted. Fig 7 shows the annual and the cumulated energy savings due to biodiesel usage in Germany since 1992. Fig 8 displays the annual extra emissions causing acidification, nutrient inputs, and ozone depletion, whereas Fig 9 illustrates the respective cumulated emissions since 1992.

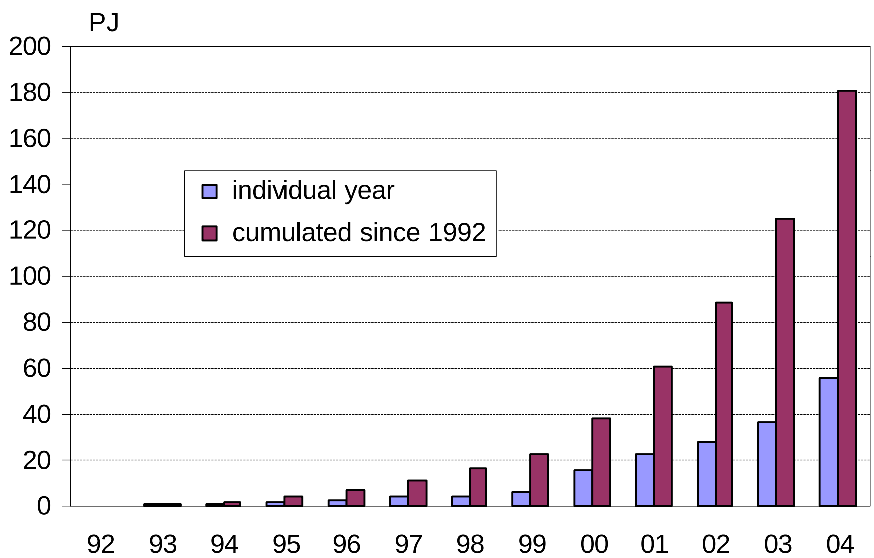

Fig 7. Energy savings due to biodiesel consumption since 1992. Source: /IFEU 2005/

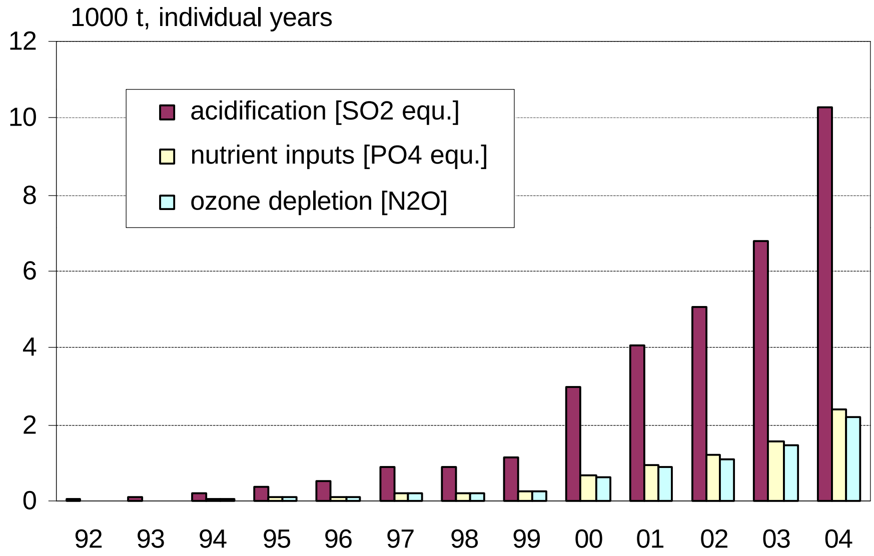

Fig 8. Surplus emissions due to biodiesel compared with fossil diesel taking the whole life cycle into account. Shown are acidification, nutrient input, and ozone depletion for the individual years. Source: /IFEU 2005/

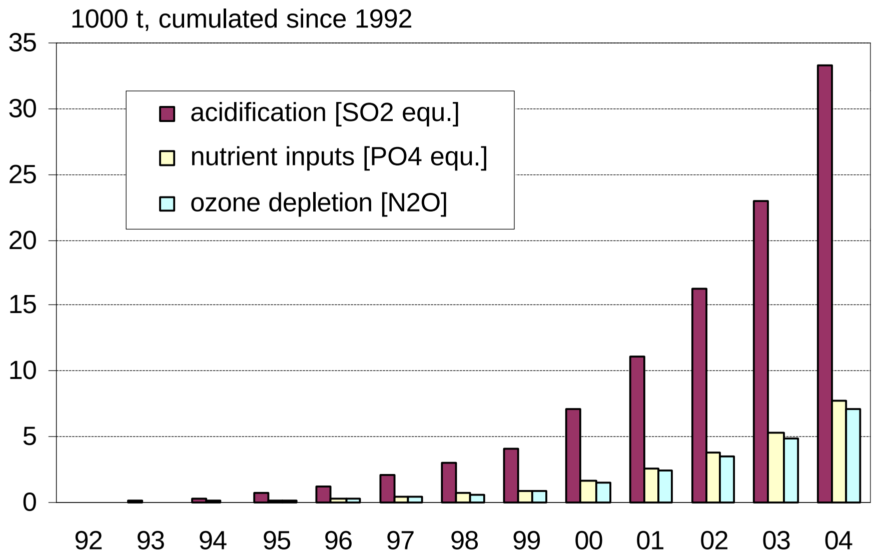

Fig 9. Surplus emissions due to biodiesel compared with fossil diesel taking the whole life cycle into account. Shown are acidification, nutrient input, and ozone depletion cumulated since 1992. Source: /IFEU 2005/

4.7 Extra effects

Employment

Also concerning employment, the two controversial studies mentioned in section 4.5, /UBA 1999/ and /IFO 2002/ take position. And again, also in this area different statements result. Generally however the following can be said: through biodiesel, jobs are created /IFO 2002/. On the other hand, if the lost tax revenues had been invested in another way they could have led to the same or even a higher number of new jobs /UBA 1999/. For this reason, the results depend on the particular question.

Waste

In the process steps of the production of biodiesel and conventional diesel fuel different types of waste occur, however the resulting quantities and types are not relevant under the conditions prevailing in Germany.

Risk

Biodiesel has a lower toxicity and a higher biodegradability compared to conventional diesel fuel. For this reason, biodiesel is advantageous being applied in water protection areas, agriculture and forestry since in case of accidents a water pollution is less serious than if using diesel fuel. By German legislation, this is accounted for by classifying biodiesel into water pollution class 1 and therefore in a lower pollution class than conventional diesel fuel, which is classified into water pollution class 2 /FNR 2005/.

Furthermore it is to be named that in case of biodiesel usage the risk of oil pollutions is reduced through the missing shipment of crude oil.

4.8 Share of the initiatives

For comparison, the biodiesel production in Germany is confronted with the biodiesel production and consumption, respectively, of different initiatives mentioned in chapter 3: from the variety of biodiesel production plants, ADM Oelmühle Leer Connemann is specified, while from the large number of biodiesel fleets, the fleets of WestEnergie und Verkehr, Erkelenz, of ZAAG Wetterau Nord, Reichelsheim, and of Brauerei Clemens Härle, Leutkirch, are presented. As regards the Market Launch Programme "Biogenous Lubricants and Transportation Fuels" described in section 2.5, there are no reliable statistics on the total biodiesel consumption stimulated by the funding and therefore no calculations are made.

It is, however, possible to give an estimate. Since 2000, the Market Launch Programme has helped constructing or converting about 50 private filling stations to biodiesel operation /Stelter 2005/. With quite a uniform distribution of tank sizes (a third each of over 20,000 L, between 5,000 and 20,000 L, below 5,000 L /Stelter 2005/) and a rough estimate of 12 tank fillings per year for the larger tanks, a total consumption between 5 and 10 million litres per year due to the Programme results /IFEU 2005/. With the throughput of 2 million litres, the ZAAG filling station is certainly one of the largest supported by the Programme[2]. This shows also, however, how vague this estimate is. Nonetheless, the share of the Programme in the German biodiesel market is in the range of one percent, its significance is thus small.

Biodiesel consumption and production. All the fleets described above have still less influence: together they contribute less than 3 ‰ to biodiesel consumption in Germany. Only going back in time, the biodiesel pioneer Härle once had a higher share. The share of its fleet in 1993 (assuming the same consumption at that time) would have been nearly 5 ‰ while it is now 0.05 ‰, a hundred times smaller.
ADM Oelmühle Leer Connemann, being one of the largest biodiesel producers in Germany, provides about 10 % of the German biodiesel consumption and has thus a visible market share.

[2] Also some external fleets are refuelled at this filling station, leading to a higher throughput than found in Table 5 and Table 9.

This demonstrates that the single initiatives, except for large biodiesel producers as ADM Oelmühle Leer Connemann, do not have a significant share in the total biodiesel consumption in Germany. Table 9 shows the impacts of biodiesel in Germany and due to the different initiatives mentioned above.

Table 9. Total biodiesel sales in Germany 2004, yearly production and consumption in the initiatives of chapter 3 as well as agricultural area used, tax loss, energy savings, and emissions due to the initiatives. Source: /IFEU 2005/ based on different sources.

		Germany [2004]	ADM Oelmühle Leer [annually]	WestEnergie und Verkehr [annually]	ZAAG Wetterau Nord [annually]	Brauerei Härle [annually]
Consumption	[t]	1,180,000	100,000*	1,750	620	44
Agricultural area	[ha]	650,000**	82,000	1,400	510	36
Tax loss	[thousand €]	580,000	49,000	850	300	21
Energy savings	[TJ]	56,000	4,700	83	29	2
Greenhouse gas reduction	[t CO_2 equiv.]	3,300,000	280,000	4,900	1,700	120
Increase in acidifying gases	[kg SO_2 equiv.]	10,300,000	870,000	15,000	5,400	380
Increase in nutrient inputs	[kg PO_4 equiv.]	2,400,000	200,000	3,500	1,200	89
Increase in ozone depletion	[kg N_2O]	2,200,000	190,000	3,200	1,100	82

* production

** without imports

Agricultural area. Concerning the area demand analysed in section 4.2, the results for the single initiatives described in chapter 3 are displayed also in Table 9. As all of the initiatives produce or use RME, the agricultural area engaged is according. Also in area demand, ADM Oelmühle Leer Connemann has a high share, while the fleet initiatives are of less importance.

Cost to the Government. Most of the initiatives presented in chapter 3 contribute only to a small extent to the burden on the national budget. As shown in Fig 10, the share of ADM Oelmühle Leer in the continued cost to the Government is substantial. While currently the yearly share of ADM Oelmühle Leer in the lost mineral oil tax revenues lies at about 10 %, the share in the cumulated tax losses is by far higher, summing up to 25 %. This is result of the much higher market share of the company in the previous years.

Environmental impacts. For details, see Table 9.

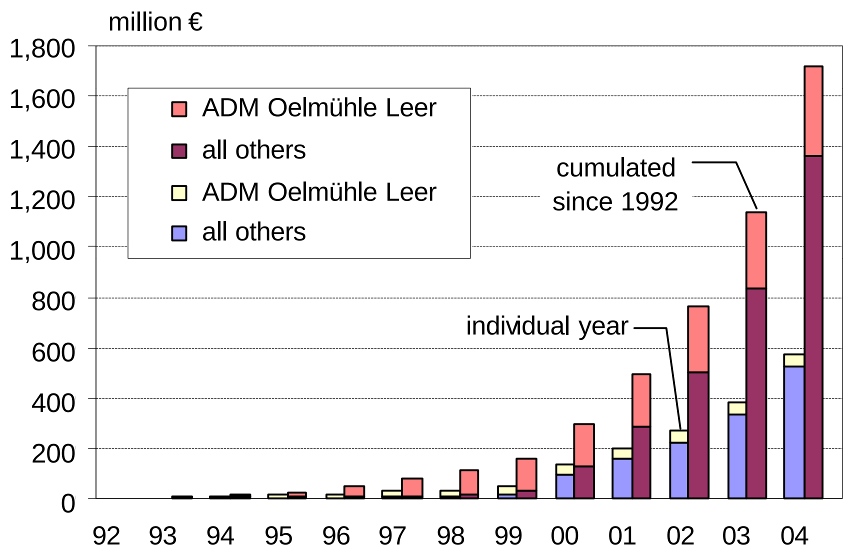

Fig 10. Mineral oil tax loss due to biodiesel consumption since 1992. Source: /IFEU 2005/

5 Summary

With currently over 1 million tonnes of biodiesel per year, Germany has grown to the biggest biodiesel producer and consumer world-wide. On the last 15 years' path, though, there have been several stumbling stones challenging stakeholders. For instance, in the mid of the 1990ies partly large acceptance problems occurred both in the public and among biodiesel users. This was due to different reasons. The most influencing reason was that biodiesel operation at that time led to a number of breakdowns in consequence of – on the one hand – biodiesel usage in non-approved engines or drive concepts and on the other hand varying biodiesel qualities. Also, different interpretations of life cycle assessments and economic analyses caused major insecurities.

To overcome these obstacles, various measures, activities, initiatives, programmes, and incentives have been implemented. Different competent stakeholders have been striving for joint actions in order to find effective solutions. These actions had various effects like the definition of a fuel norm and a quality assurance system, which paved the way to a further increase of biodiesel usage. Today, the 100 % tax exemption for all biofuels for transportation is certainly the most important incentive for the oncoming years.

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Annex

Abbreviations

a	Year
AGQM	Arbeitsgemeinschaft Qualitätsmanagement Biodiesel e. V. (Association for the Quality Management of Biodiesel)
BImSchV	Bundesimmissionsschutzverordung (Federal Immission Regulation)
CO_2 equiv.	Carbon dioxide equivalents, reference for the measurement of the greenhouse effect
DIN-NAGUS	Deutsches Institut für Normung e. V., Normenausschuss Grundlagen des Umweltschutzes (German Institute for Standardisation, Principles of Environmental Protection Standards Committee)
E85	Ethanol/petrol blend (85 % ethanol, 15 % petrol)
EtOH	Ethanol
ETBE	Ethyl tert butyl ether
FAME	Fatty-acid methyl ester
FNR	Fachagentur Nachwachsende Rohstoffe e. V. (Agency on Renewable Raw Materials)
ha	Hectare
km	Kilometre
L, l	Litre (0.001 m^3)
m^3	Cubic metre
MinöStG	Mineralölsteuergesetz (Mineral oil tax act)
MTBE	Methyl tert butyl ether
PJ	Petajoule (= 10^{15} J)
PO_4 equiv.	Phosphate equivalents, reference for the measurement of nutrient inputs
PPO	Pure plant oil
SO_2 equiv.	Sulfur dioxide equivalents, reference for the measurement of acidification
RME	Rapeseed oil methyl ester
t	Tonne (metric ton)
TJ	Terajoule (= 10^{12} J)
UBA	Umweltbundesamt (Federal Environmental Agency), Berlin
UFOP	Union zur Förderung von Oel- und Proteinpflanzen e. V. (Union for the Promotion of Oil Seeds and Protein Plants)
VDB	Verband deutscher Biodieselhersteller e. V. (Association of German Biodiesel Producers)

Table A-1. Specification of biodiesel in the old preliminary and the new European norm in Germany. Sources: /Brautsch 2004/, /Bockey 2004/, /BDI 2005/.

Property	Limit (DIN E 51606)	Limit (DIN EN 14214)
Density at 15 °C	875-900 kg/m³	860-900 kg/m³
Kinematic viscosity at 40 °C	3.5-5.0 mm²/s	3.5-5.0 mm²/s
Flash point	Min. 100 °C	Min. 120 °C
Cold filter plugging point (CFPP)	0 °C (summer time) -10 °C (transition) -20 °C (winter time)	0 °C (summer time) -10 °C (transition) -20 °C (winter time)
Sulfur content (mass ratio)	Max. 100 mg/kg	Max. 10 mg/kg
Coke residue (mass ratio)	Max. 0.3 %	Max. 0.3 %
Ignitability (cetane number)	Min. 49.0	Min. 51.0
Sulfate ash (mass ratio)	Max. 0.01 %	Max. 0.02 %
Water content (mass ratio)	Max. 300 mg/kg	Max. 500 mg/kg
Total contamination (mass ratio)	Max. 20 mg/kg	Max. 24 mg/kg
Copper corrosion	Max. 1	Max. 1
Oxidation stability (induction time)	(has to be specified)	Min. 6 h
Acid number	Max. 0.5 mg KOH/g	Max. 0.5 mg KOH/g
Methanol content	Max. 0.30 %	Max. 0.20 %
Monoglycerids	Max. 0.80 %	Max. 0.80 %
Diglycerids	Max. 0.10 %	Max. 0.20 %
Triglycerids	Max. 0.10 %	Max. 0.20 %
Free glycerol	Max. 0.020 %	Max. 0.020 %
Total glycerol	Max. 0.25 %	Max. 0.25 %
Iodine number	Max. 115 mg Iodine/kg	Max. 120 g Iodine/100g
Phosphorous content	Max. 10 mg/kg	Max. 10 mg/kg
Alkaline content (Na + K)	Max. 5 mg/kg	Max. 5 mg/kg
Earth alkaline content (Ca + Mg)		Max. 5 mg/kg

Table A-2. Effects of violating limits of the AGQM standard. Source: /Bockey 2004/.

Property	Effect / evaluation
Cinematic viscosity at 40 °C	Pumping problems (fuel pump, injection pump)
Flash point	May cause classification as a dangerous good
Cold filter plugging point (CFPP)	Problems in cold periods (also autumn!)
Water content (mass ratio)	Corrosion, clouding (mixtures diesel fuel/FAME)
Total contamination (mass ratio)	Filter plugging, also harmful for injection pump
Oxidation stability (induction time)	Filter plugging, deposition of polymers (for mixtures diesel/FAME)
Acid number	Corrosion
Free glycerol	Formation of coke (also in case of glycerids)
Alkaline content (Na + K)	Filter plugging
Earth alkaline content (Ca + Mg)	Filter plugging (effect higher than alkaline!)

Table A-3. Members of AGQM as of 2004. Source: /Bockey 2004/.

Type of member	Number of companies	Characteristics
Biodiesel producers	16	total capacity: 988,000 t/a (of about 1,200,000 t/a in Germany)
Biodiesel traders	30	traders operating locally and nationwide
Sponsors	11	e.g. constructors, producers of additives and supplies
Labelled filling stations	486 (contractual partners)	1,333 licensed filling stations (of total 1,717 biodiesel filling stations)

Table A-4. German manufacturers' approval of biodiesel use in Diesel vehicles in Germany. Source: /UFOP 2005/

Manufacturer	Model	Biodiesel approval
Audi	A2 (8Z), A3 (8L), A4 (8E, 8E2, 8E5) except 85 kW A4 Cabriolet (8H) A6 (4B), Allroad (4B)	approval for RME, possible malfunctioning of the auxiliary heating system or exclusion of its use
Audi	A3 (8P)	no general approval (only specific models)
Audi	A4 (8E) only 85 KW A4 (8EC und 8ED) A6 (4F) A8 (4E)	no approval
BMW		no approval
DaimlerChrysler		no approval ex works
Deutz	all engines except for 909, 910, 1015, 2015	approval if biodiesel according to EN 14214, comply technical circular
Fendt	all tractors	approval, comply service information
EvoBus Setra	OM 457HLA/LA, OM 501/502 LA, OM 906 LA buses	approval possible on request
Linde	all forklifts from 1.2 to 8 t load	approval, comply conditions
MAN	engines with Common-Rail system	no approval
MAN	others	approval if RME according to EN 14214, comply service information
Neoplan Bus	engines with Common-Rail system	no approval
Neoplan Bus	others	no general approval, only biodiesel according to EN 14214, comply service information
Opel		no general approval
Still Gabelstapler	Model R 70 (different loads)	approval
VW	Polo Diesel (A03) (except Post Polo), Golf (A4), Golf Vento (A3), Golf Ecomatic (A3), Passat (B4), Passat (B5) without particulate filter, Sharan, T4, T5, LT – 2, Caddy II Wirbel-kammer and SDI, TDI, Polo Classic, Lupo, Bora, Beetle, Phaeton V10 TDI, Touareg R5 TDI and V10 TDI	approval if RME according to EN 14214
VW	Golf (A5)	approval only if ordering optional RME version
VW	Touran	no approval

Table A-5. Biodiesel production plants in Germany. Source: /IFEU 2005/ on basis of different sources.

Production plant	Location		Capacity today [t/a]	Start-up
MUW Mitteldeutsche Umesterungswerke Bitterfeld	Bitterfeld / Sachsen-Anhalt		150,000	9/2001
ADM Oelmühle Hamburg AG	Hamburg		120,000	9/2001
ADM Oelmühle Leer Connemann GmbH & Co.	Leer / Niedersachsen		100,000	9/1995
NEW Natural Energy West GmbH	Marl / Nordrhein-Westfalen		100,000	4/2002
Biodiesel Schwarzheide GmbH	Schwarzheide / Brandenburg		100,000	10/2002
RBE Rheinische Bioester GmbH	Neuss / Nordrhein-Westfalen		100,000	12/2002
Campa Biodiesel GmbH	Ochsenfurt / Bayern		75,000	1/2000
Biodiesel Wittenberge GmbH	Wittenberge / Brandenburg		100,000	8/1999
Bio-Ölwerk Magdeburg GmbH	Magdeburg / Sachsen-Anhalt		75,000	3/2003
TME Thüringer-Methylesterwerke GmbH & Co. KG	Harth-Pöllnitz / Thüringen		45,000	1/2002
Rapsveredelung Vorpommern GmbH	Malchin / Mecklenburg-Vorpommern		36,000	5/2004
Petrotec GmbH	Südlohn / NRW		35,000	5/2002
EOP Elbe Oel Prignitz AG	Falkenhagen / Brandenburg		30,000	12/2002
Biodiesel Kyritz GmbH	Kyritz / Brandenburg		30,000	3/2003
KFS-Biodiesel GmbH	Cloppenburg / Niedersachsen		30,000	8/2004
BioWerk Sohland GmbH	Sohland / Sachsen		15,000	7/2002
SARIA Bio-Industries GmbH & Co. Verw. KG	Malchin / Mecklenburg-Vorpommern		12,000	10/2001
Kartoffelverwertungsgesellschaft Cordes & Stoltenburg GmbH & Co.	Schleswig/Schleswig-Holstein		12,000	5/2003
HHV Hallertauer Hopfen-Verwertungsgesellschaft	Mainburg / Bayern		8,000	4/1995
Biodiesel Bokel GmbH	Bokel / Niedersachsen		8,000	9/2002
Landwirtschaftliche Produkt-Verarbeitungs GmbH	Henningsleben / Thüringen		5,000	4/1998
PPM Umwelttechnik GmbH	Oranienburg / Brandenburg		5,000	11/2001
BioWerk Kleisthöhe GmbH	Uckerland / Brandenburg		5,000	12/2002
Delitzscher Rapsöl GmbH & Co. KG	Wiedemar/Sachsen		5,000	4/2002
BKK Biodiesel GmbH	Rudolstadt/Thüringen		4,000	12/2001
Vogtland Kraftstoff GmbH	Großfriesen / Sachsen		2,000	1996
		Sum	1,207,000	
ADM Oelmühle Hamburg AG	Hamburg		+ 180,000	end 2005
Nordbrandenburger Bioenergie GmbH	Brandenburg		150,000	under constr.
Marina Biodiesel GmbH & Co. KG	Brunsbüttel / Schleswig-Holstein		144,000	end 2005
Rapsveredelung Mecklenburg	Sternberg / Mecklenburg-Vorpommern		100,000	under constr.
NEW Natural Energie West GmbH	Marl / Nordrhein-Westfalen		100,000	mid 2005
J.C. Neckermann GmbH & Co. KG	Halle / Sachsen-Anhalt		57,000	2005
RBE Rheinische BioEster GmbH	Neuss / Nordrhein-Westfalen		+ 50,000	mid 2005
Biodiesel Schwarzheide	Schwarzheide / Brandenburg		+ 50,000	2005
HHV Hallertauer Hopfen-Verwertungsgesellschaft	Mainburg / Bayern		+ 5,000	4/1995
		Sum	836,000	

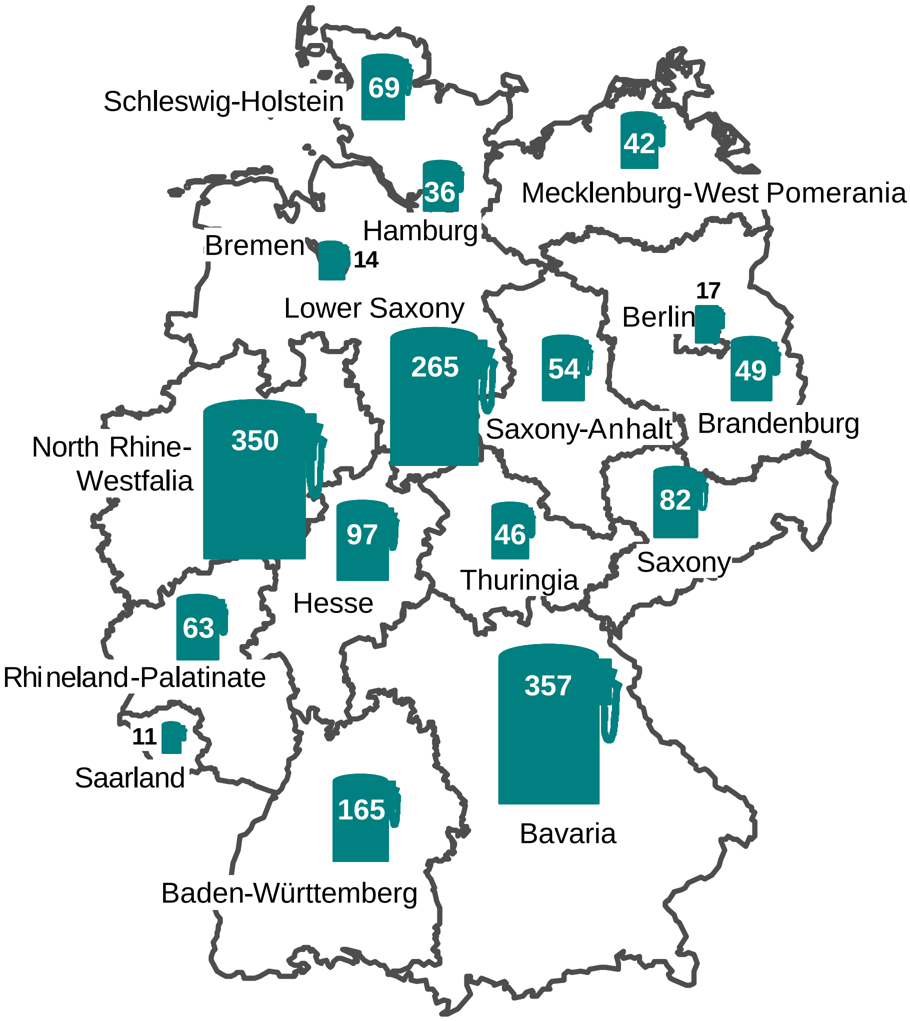

Fig A-1. Biodiesel filling stations in Germany as of 2004. Source: /Bockey 2004/

Table A-6. Distances between certified AGQM filling stations as of 2004. Source: /Bockey 2004/

German Land	Distance [km]
Baden-Württemberg	25
Bavaria	24
Berlin/Brandenburg	28
Hamburg	25
Hesse	22
Lower Saxony	20
Mecklenburg-West Pomerania	47
North Rhine-Westfalia	21
Rhineland-Palatinate	25
Saarland	20
Saxony	31
Saxony-Anhalt	41
Schleswig-Holstein	24
Thuringia	26

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