BIODIESEL

Documentation of the World-Wide Status 1997

a report prepared by the

Austrian Biofuels Institute

for the

International Energy Agency (IEA)

commissioned by the

BLT-Federal Institute for Agricultural Engineering

in

Wieselburg, Austria

INDEX:

Introduction:

- The International Energy Agency (IEA) was founded in 1974 within the framework of the OECD. Under the IEA Office for Technology and R&D there are about 40 active lmplementing Agreements and the Bioenergy Agreement is one of them.

- Within the Bioenergy *Agreement* there is a specific *,,Activity" on Liquid Biofuels* with the intention to collect and disseminate information as well as to support the understanding of this type renewable energy in the form of liquid biofuels and their application as transport fuel.

- Having recognised a fast development for Biodiesel world-wide in the past few years the specific objective of this documentation is to compile all available information on Biodiesel and give a structured report concerning the motivational factors, existing or projected capacities, actual production figures, raw materials used, quality standards, taxation policies, marketing issues and perceived barriers and opportunities.

- The Austrian Biofuels Institute (ABI) is continuously observing the production and market development and published some basic studies in this field in earlier years. The ABI was therefore commissioned to complete this study and documentation including the latest developments by the BLT - Federal Institute for Agricultural Engineering in Wieselburg, Austria, which is the *IEA Activity* Leader.

Method:

The Austrian Biofuels Institute developed a detailed and well structured questionnaire together with the *,,JETZT"*- team of the Sociology Department at the University of Vienna with the goal of covering both quantitative and qualitative aspects, as well as providing an easy interview. In total 135 questionnaires were mailed to Biodiesel producing companies and supportive institutions.

The action covered 28 countries around the world, in which Biodiesel activities have been reported in the past 15 years. Furthermore potential multipliers such as university institutes, commercial production and consulting companies and trade associations were asked to support additional distribution of this questionnaire.

The data from the returned questionnaires were screened and statistically evaluated by using the SPSS-Programme, then cross-checked with published data and literature from sources available in the library of the Austrian Biofuels Institute, in the NTB-Net documentation or completed via personal phone and internet checks and finally compiled in the following format covering both hard facts and personal judgements.

EXECUTIVE SUMMARY:

- Investigated period:

  This study concentrated on the development of Biodiesel throughout the past 15 years in those 28 countries in which Biodiesel activities have been reported.

- World-wide activities

  In these years Biodiesel has steadily emerged from a trial production in back-yard type pilot plants to full industrial type production and marketing with wide and increasing acceptance by the Diesel vehicle industry, the fuel trade, and the end-user in a wide variety of market segments.
  In 21 out of the researched 28 countries Biodiesel was produced and tested within the period of the last 6 years.
  Those activities have led or most probably will lead to commercial projects in countries with different structure e.g. Austria, Czechia, France, Germany, Italy, Malaysia, Nicaragua, Sweden, and the USA.

- Motivational factors:

  The strongest motivation in the past was the concern about the vulnerable supply security of liquid fuels for the transport sector, as experienced world-wide by the oil supply shocks of the 70s and the Gulf war.
  As this coincided with an expensive agricultural overproduction in Europe, Biodiesel became the flagship of all non-food projects utilising set-aside land for energy production, which is today the second strongest reason; similarly the surplus in soybeanoil is the driving force in the US.
  Today however, environmental concerns about global and local pollution have taken the lead as a motivational factor.
  But with the burden of high unemployment levels, the creation of additional jobs through local production of energy as liquid fuel has gained in weight significantly.

- Raw materials:

  Oil from rapeseed was the raw material of choice in the early days and is still leading with a share of over 80 % as a raw material source with highly suitable properties; sunfloweroil takes second place with over 10 %, followed by soy*beanoil,* mostly in the USA. Other raw materials used are palmoil, linseedoil, beef tallow, used frying oil (UFO).

- Capacity and production:

  In total, *85* Biodiesel production plants were identified, of which there were recorded a number of pilot plants, over 40 small capacity (mostly farmers' co-operative) plants in the range of 500 - 3.000 tons, and big scale industrial plants in the capacity range of approx. 5.000 - 120.000 tons.

Production capacity rose from 75.000 tons in 1991 to 1,286.OOO tons in 1996, while actual production developed from 10.000 tons to 591.000 tons in the same period.

There are further existing capacities available for methyl-ester production, which are however mostly dedicated for producing oleochemials.

By far the largest quantities are produced and marketed within the European Union, the strongest increase of capacity in 1997 was observed in the USA.

- Quality management:

The assurance for high quality was a key issue for developing customer confidence. Austria developed the first standard ON C 1190 for Biodiesel, followed by others in Czechia, France, Italy, leading into the German DIN E 51606 as the probably most elaborate standard for Fatty-acid-methyl-ester (FAME) today.

- Marketing strategy:

Local levels of taxation and national tax exemptions led to different marketing decisions e.g., use as heating oil in Italy, a 5 %-blend to fossil Diesel in France, a 20 %-blend and 100 % neat in the USA and the 100 % use in Austria and Germany targeting the environmentally sensitive areas such as water protection areas or smog-risk cities.

- Barriers and measures for improvement:

High cost of raw materials is today the strongest barrier and sufficient detaxation of well-founded internalisation of all the external cost (environment, supply security, renewable energy, new jobs, etc.) is seen as an effective tool.

New raw materials e.g., UFO or waste animal fats stand a good chance to lower the cost.

1. Investigated period:

This study concentrated on the development of Biodiesel throughout the past 15 years in those 28 countries in which Biodiesel activities from early research to present industrial production have been reported.
It is going back as far as 1982, with 2 reports, one from R.E.H. Sims in New Zealand on tallow esters and one from M. Mittelbach & M. Wörgetter in Austria on rapeseedoil-methyl-ester (RME) in the same year, and in 1983 from G. Vellguth in Germany.
It describes the start with pilot plants around 1989, followed by the fast growth in the mid-90s, finally giving a forecast for the years ahead.

2. Highlights:

In these past 15 years Biodiesel has steadily emerged with remarkable speed from a trial production in backyard type pilot plants to full industrial production and professional marketing with wide and increasing acceptance of this new liquid transport fuel by

- the Diesel vehicle industry e.g. **AUDI,** BMW, ISEKI, JOHN DEERE, **KUBOTA,** MERCEDES-BENZ, **NISSAN,** PEUGEOT, RENAULT, SAME, **SEAT, SKODA, Valmet** and VOLKSWAGEN,
- the fuel trade e.g. **ELF,** HYDRO-TEXACO, **SHELL** and TOTAL and
- the end-user e.g. bus companies, taxi fleets, forestry enterprises and boat owners.

In 28 countries all over the world Biodiesel was at least tested and in 21 out of those researched countries Biodiesel was produced within a period of the last 6 years.
Those activities have led, or probably will lead to commercial projects in countries with often quite different background in economies and kinds of motivation e.g., Austria, Belgium, China, Czechia, France, Germany, Italy, Malaysia, Nicaragua, Slovakia, Sweden, the United Kingdom, the USA and Yugoslavia.

This study identified in total 85 Biodiesel production sites as quite an impressive number, of which there were recorded a few pilot plants and commercial production plants with a capacity range between 500 to 120.000 tons per annum.

3. Motivational factors:

The questionnaire offered 11 different criteria to be selected as the key motivational factors as shown in the figure 1 and the evaluation came up with the following ranking:

1. Renewable energy:
   It appears that the strongest motive for most of the Biodiesel producers is that it is as a renewable form of energy, especially when it has become obvious that fossil resources are finite and supply security of mineral oils is an increasing risk. 92 % of the answers rated this point as “high + very high”.

2. Environmental benefits:
   Obviously all the environmental benefits (less greenhouse effect, less local air pollution, less contamination for water and soil, less health risks) are seen as convincing motivational factors with some variation by country. The rating showed a result of 86 % voting for the category ,,high + very high“.

3. Utilisation of agricultural surpluses:
   Increased production of agricultural crops for non-food purposes has offered the opportunity to utilise land, which otherwise would be set-aside as an unexploited resource. It is no surprise that this argument it seen as a strong motive in favour of Biodiesel. It found its expression in a 79 % vote for the same category.

4. Creation of a pioneer image:
   Developing a new challenging idea and the related positive image can be a strong driving force, and is represented as such by a ,,high + very high”-rating of 76 %.

5. Scientific interest
   for this new research & development field in renewable energy was mentioned by 69 % for the same category.

6. Political reasons
   were seen as a strong motive by 68 %.

7. State incentives
   were mentioned by 58 % as being a ,,high + very high” motive, although, interesting enough, 21 % classified this criteria as ,,not at all“ important.

   Other criteria offered for rating showed less significant weight such as:

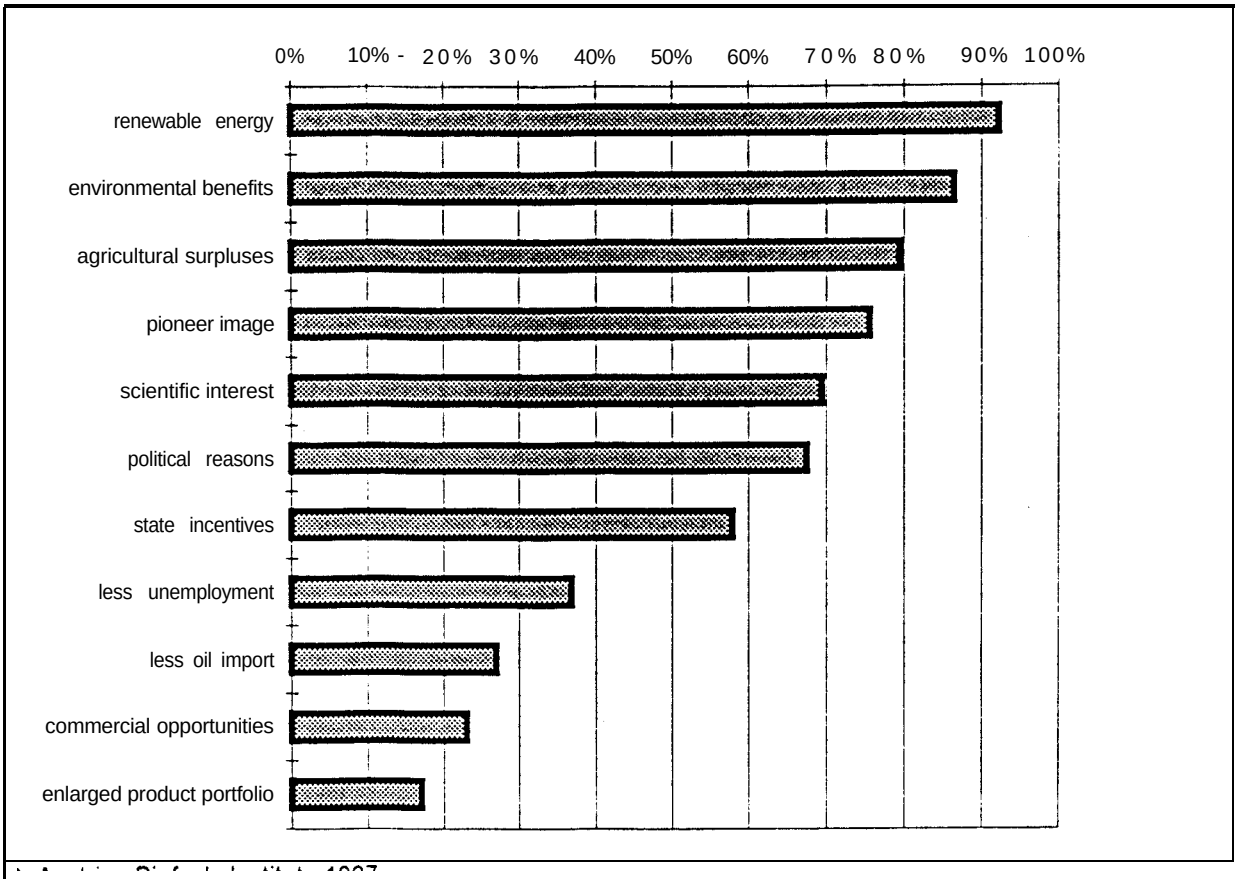
- Creating additional employment: rated by 34 % as being of ,,high”-importance, but regarded by another 53 % as of low“-importance,

- reduced import dependency: evaluated by 54 % as being of ,,low“-importance,

- commercial opportunities: rated by 46 % as being ,,low”-importance, and

- enlarged fuel product portfolio as the most unimportant criteria for decision-making.

Figure 1: **Motivational factors**



4. Raw materials:

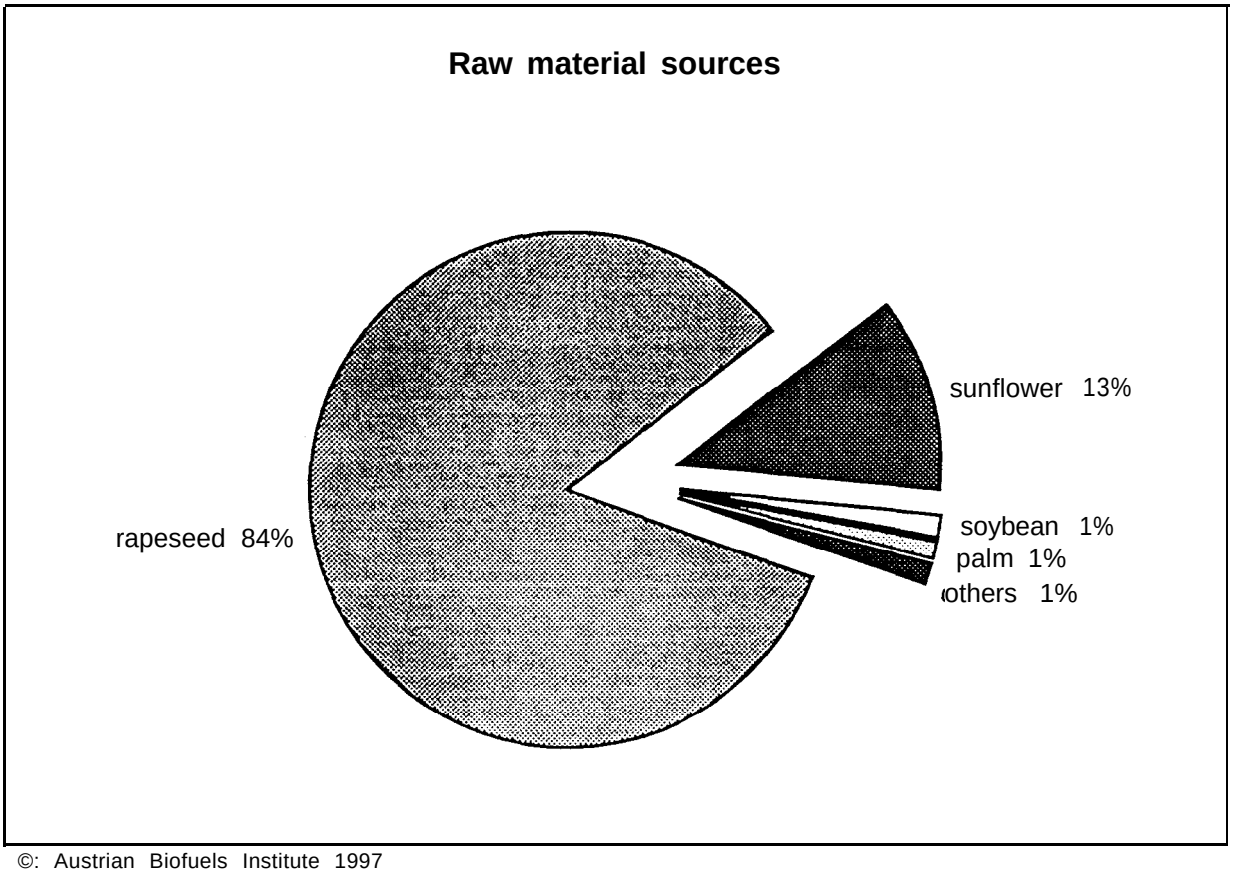
Rapeseed was the raw material of choice (figure 2) in the early days and is still leading with a share of over 80 % as raw material source with excellent properties, as it has a high content of the monounsaturated oleic acid, assuring satisfactory oil stability and winter operability. Biodiesel produced from rapeseed oil meets the German standard requirements of Iodine number < 115.

Sunfloweroil takes second place with over 10 %, mostly used in Italy and Southern France, followed by soybeanoil as preferred in the USA, both with an Iodine number of > 115 as an indication for a higher level of unsaturated fatty acids.

Other raw materials mentioned are palmoil in Malaysia, linseedoil, olive oil in Spain, cotton seed oil in Greece, beef tallow in Ireland, lard, used frying oil (UFO) in Austria and other waste oils and fats in the USA, but also other oil types e.g. from the locally grown Jatropha-nut in Nicaragua, and from the oily berry-bearing tree called Guang-Pi in China, all of them however of so far insignificant volumes.

There is a clear trend towards a multitude of raw materials, which is also reflected in changing the names from Rapeseedoil-methyl-ester (RME) to the more flexible and correct name of Fatty-acid-methyl-ester (FAME), which covers all raw materials.

Figure 2:



With all the different options available the challenge is to produce a Biodiesel fuel of consistent high quality along a strictly defined standard from a clever blend of low cost raw materials, which may vary by climatic requirements.

5. Capacity and production:

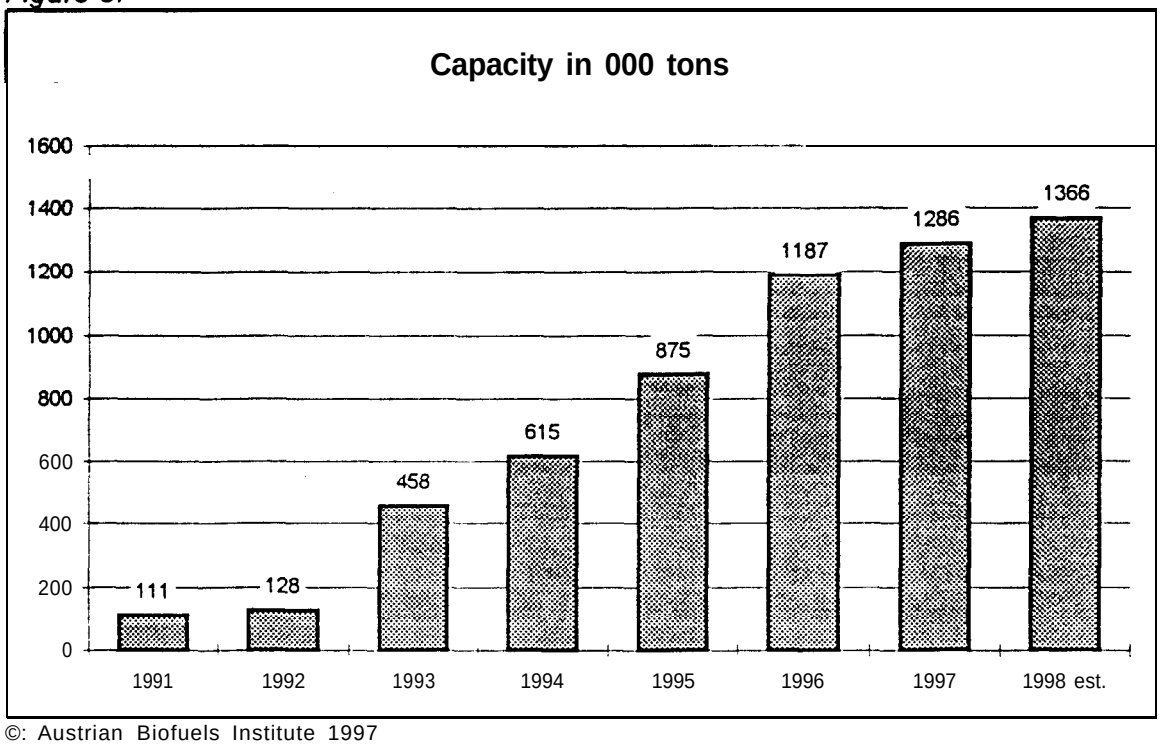
In total 85 biodiesel production plants were identified, of which there were recorded a few pilot plants, over 30 small capacity plants in the range of 500 - 3.000 tons mostly with a farmers' co-operative as owner, and several big scale industrial plants in the capacity range of 10.000 - 120.000 tons.

Regional split in number of Biodiesel plants regardless of capacity size by area:

- 44 plants in Western Europe, with Italy being the leading country with 11 plants,
- 29 plants in Eastern Europe, with Czechia being the leading country there with 16 Biodiesel plants,
- 8 plants in North America, and
- 4 in the rest of the world.

Overall capacity grew from 111.000 tons in 1991 continuously to 1,286.000 tons in 1997 (figure 3) with a forecast of 1,366.000 tons for 1998 world-wide.

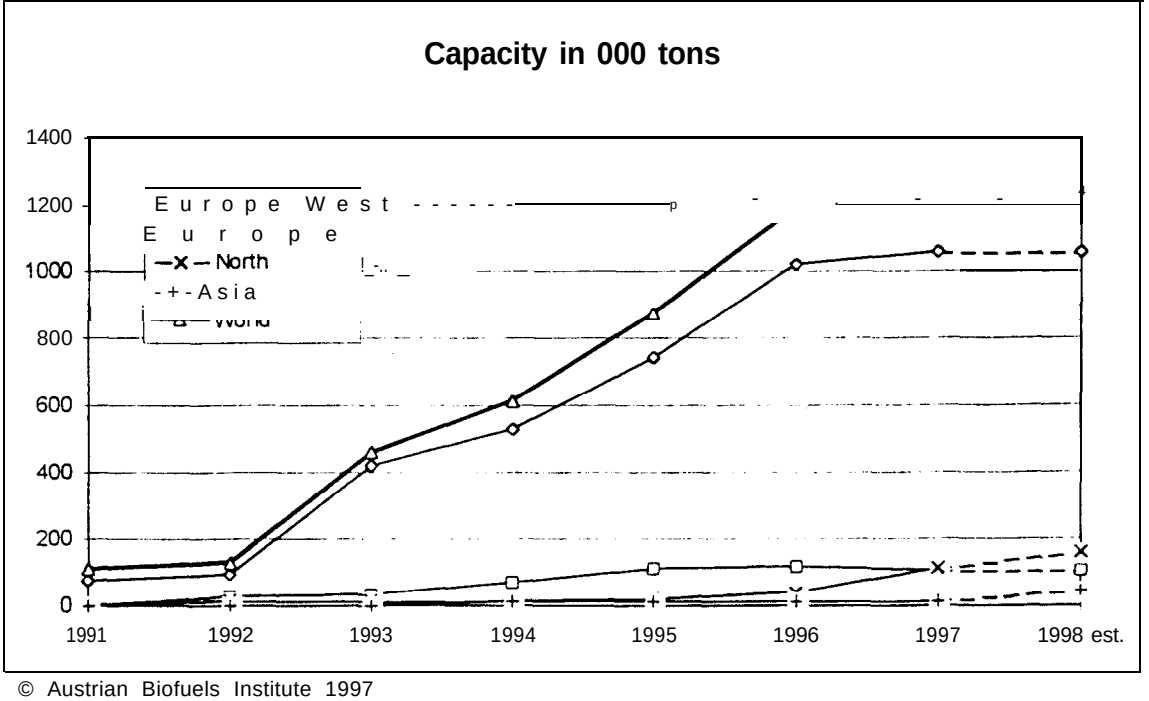
Figure 3:



Western Europe represents by far the largest volume potential (figure 4), followed by Eastern Europe until 1997, but the strongest increase of capacity development in 1997 and for the 1998 estimate however, can be observed in the USA as the fastest growing newcomer and a number of new companies emerging there.

In near future there might be additional capacity installed in Japan and in the leading palmoil countries like e.g. Malaysia and Indonesia.

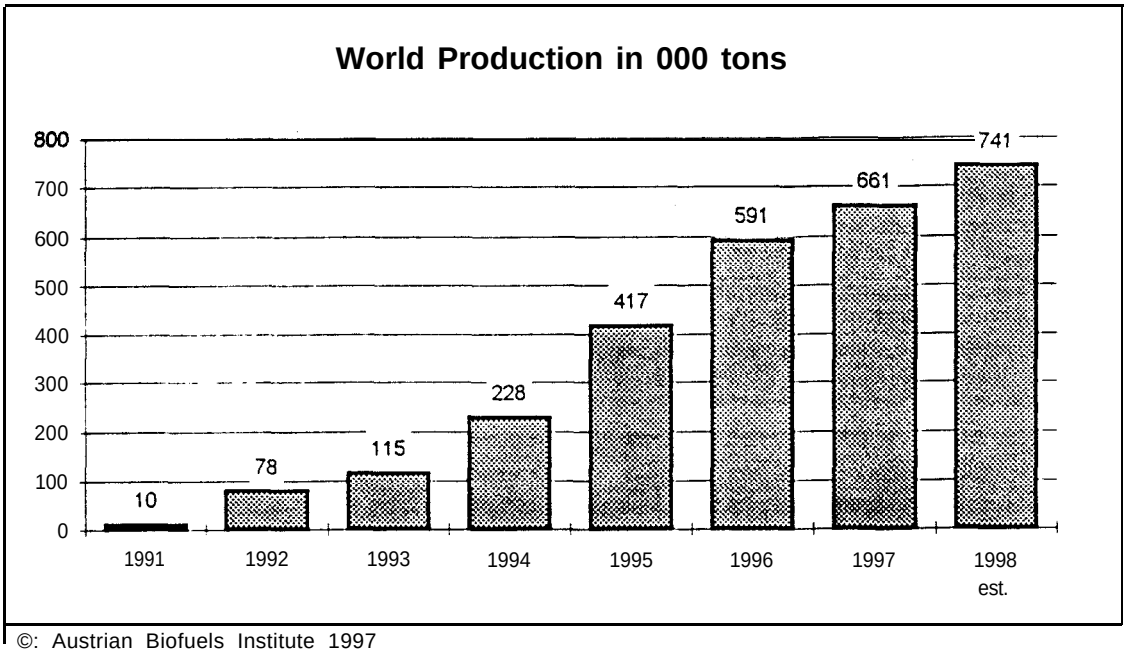
Figure 4:



There are further existing capacities available for methyl-ester production, which are however mostly dedicated for producing oleochemicals by companies like **ARHUS OLJE, FINA, HENKEL, PROCTER & GAMBLE or Sisas.**

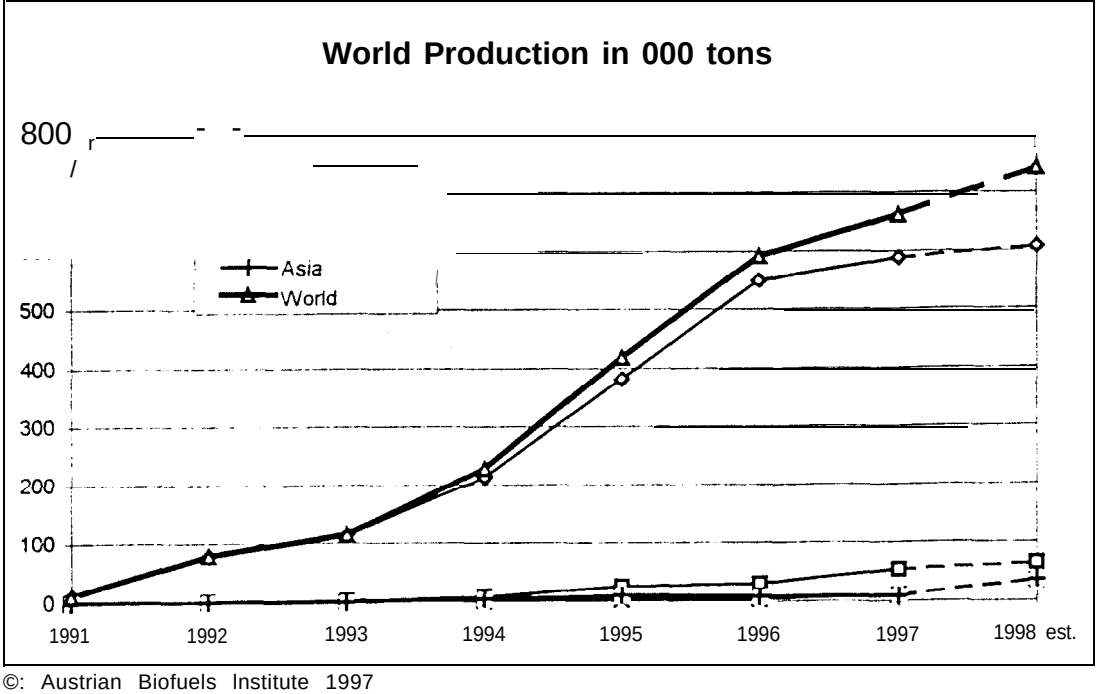
While capacity rose from 75.000 tons in 1991 to 1,286.000 tons in 1996, actual production developed from 10.000 tons to 591.000 tons in the same period (figure **5).**

Figure 5:



The largest quantities of Biodiesel are presently produced and marketed within the European Union today (figure 6) with Eastern Europe being second.

Figure 6:



Ranked by volume the leading EU-15 countries are:

- France (227.000 tons in 1996),
- Italy (141.000 tons),
- Germany (63.000 tons) and
- Austria (17.000 tons); for Eastern Europe it is
- Czechia (22.000 tons in 1996), followed by Slovakia.

6. Quality management and standardisation:

The assurance for consistently high quality of the fuel was a key issue for developing confidence in Biodiesel among all customer groups, specifically the Diesel engine and vehicle producer. Besides existing criteria applied to fossil Diesel like Cetane number and CCR (Conradson Carbon Residue), new criteria and analytical methods had to be developed like for Mono-, Di- and Triglyceride levels.

In 1994 Austria published the first final standard ON C 1190 for Biodiesel, then only for Rapeseedoil-methyl-ester (RME), followed by ON C 1191 for Fatty-acid-methyl-ester (FAME) in 1997, thus allowing a broader scope of raw materials to be used for Biodiesel production.

Other standards followed in Czechia (CSN 65 6507), France (by decree), Italy (CUNA NC 635-01), Sweden (SS 15 54 36) and the German DIN E 51606 as the probably most elaborate standard today. With the objective to create a European standard a European Commission mandate for this work was given to the CEN **(COMITE EUROPEEN DE NORMALISATION),** which has started this work by end of 1997 in several working groups of the TC 19.

The **AMERICAN SOCIETY FOR TESTING AND MATERIALS** (ASTM) has also started its work to develop a Biodiesel standard for the USA.

7. Market positioning:

Local levels of taxation, national tax exemptions and desired speed of market penetration led to different marketing decisions, e.g. use as heating oil in Italy, as blends to fossil Diesel with 5 % in France and with 20 % in the USA, and as 100 % in Austria and Germany targeting the environmentally sensitive areas such as water protection areas or smog endangered cities.

The questionnaire offered 5 different reasons to select as the key criteria for product positioning in specific market segments as shown in the figure 7 below, and the evaluation came up with the following ranking:

1. Reduction of the greenhouse effect was seen by 52 % as a highly important argument to demonstrate an advantage for Biodiesel as compared to fossil Diesel i.e. an average 3,0 kg saving of CO2- and CO2-equivalent greenhouse gases per litre.

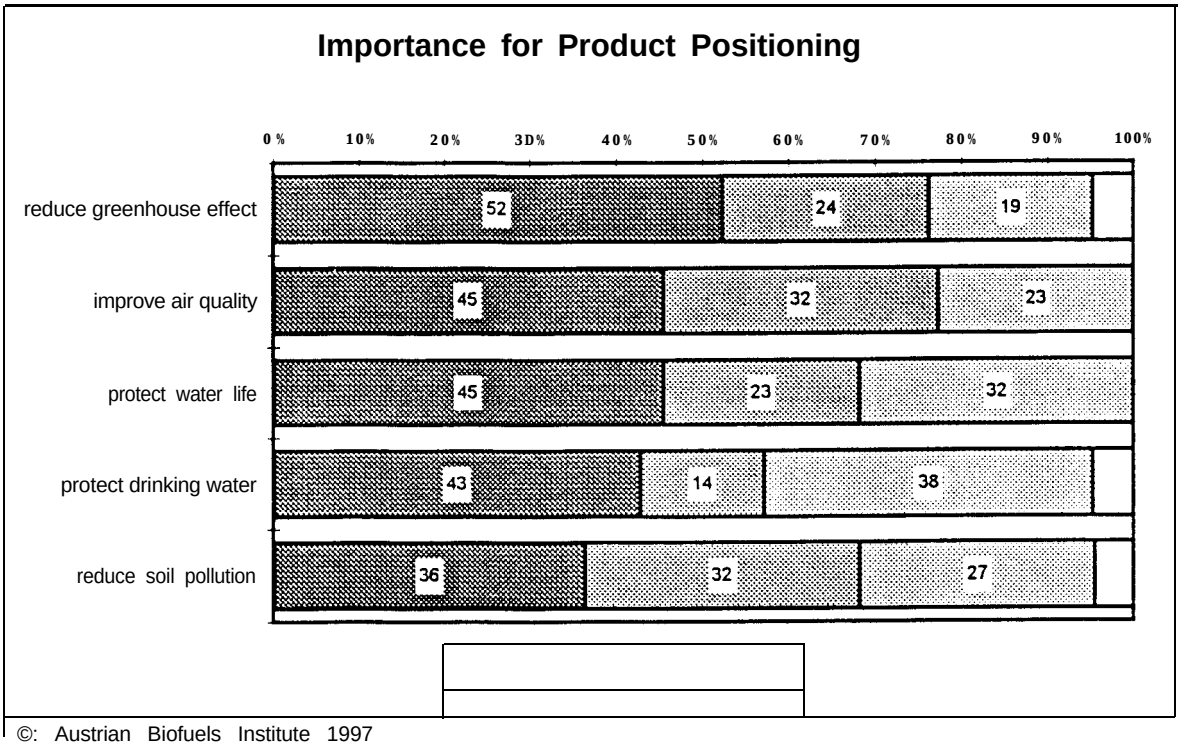
2. Improvement of local air *quality* appeared to be the second strongest marketing argument by 45 %, offering reductions of harmful emissions such as particulate matter, soot, hydrocarbons, carbonmonoxide, specifically in combination with the oxidation catalytic converter in congested city traffic, the urban bus system, or community vehicles.

3. Protection of water life was rated at the same level of 45 % having in mind the reductions of potential risks by Diesel fuelled engines used in the marine sector and the possibility of accidental spillage into surface water systems causing a risk to valuable water life such as trout and daphnia.

4. Protection of drinking water resources was regarded as highly important by 43 % of all voters.

5. Reduction of soil pollution was regarded as highly important by only 36 % of all voters.

Figure 7:



Additional positioning arguments mentioned were: fuel lubricity improvement for low sulphur fossil Diesel (by 3 participants) and renewable form of energy.

8. Barriers and measures for improvement:

High cost of raw materials is perceived today as the strongest barrier by 79 % of the participants (figure 8). Cheap raw materials e.g. UFO (used frying oil) or animal fats stand a good chance to lower those cost. Related to this strongest barrier 50 % regarded Biodiesel as not competitive to fossil Diesel.

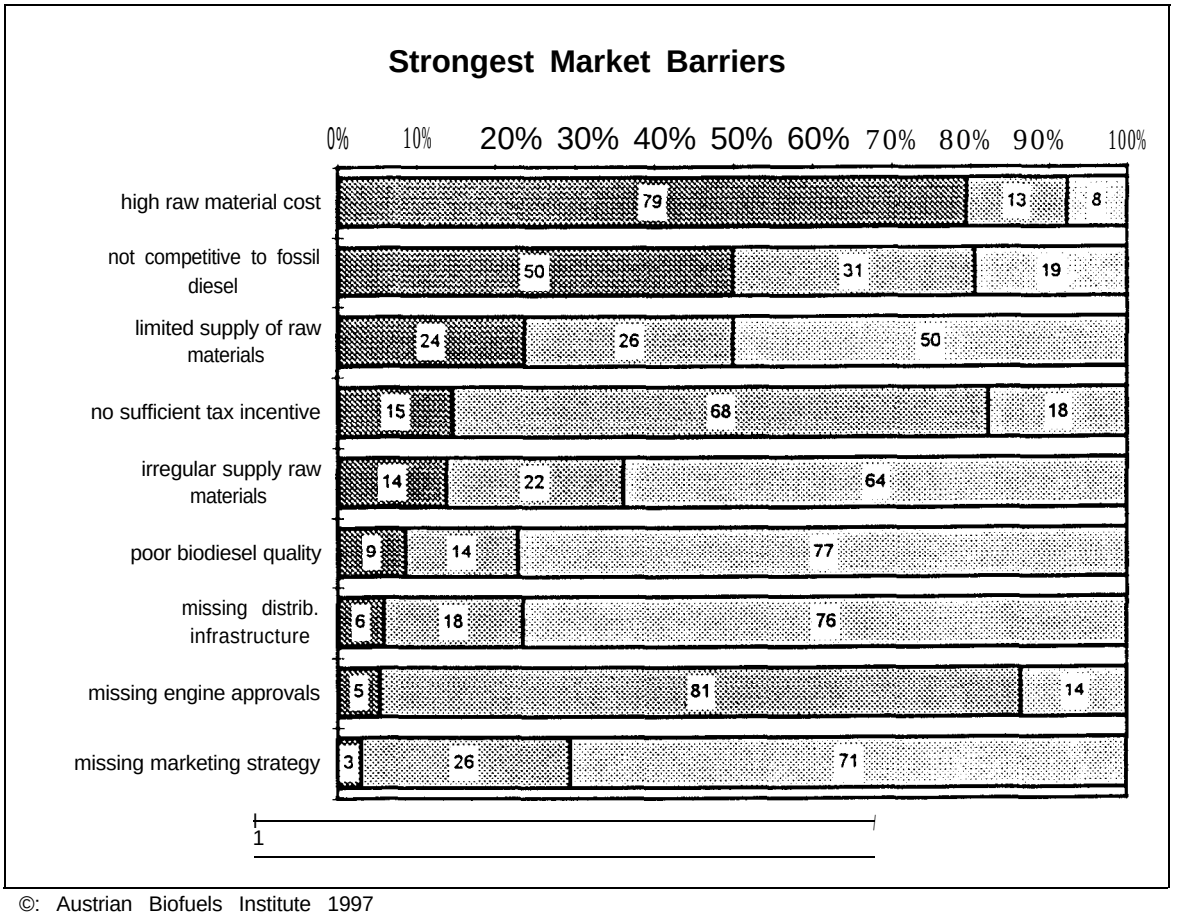
The limited supply of raw materials was seen only by 24 % as a strong, but by another 26 % as a considerable barrier. This may have become a stronger factor in the last three months according to latest phone-checks.

Not sufficient detaxation of well-founded internalisation of all the external cost, is regarded by 15 % as a strong and by 68 % as a considerable barrier.

There is one more barrier seen as considerable by 81 %, which are the missing approvals and warranties from the Diesel engine and vehicle producers.

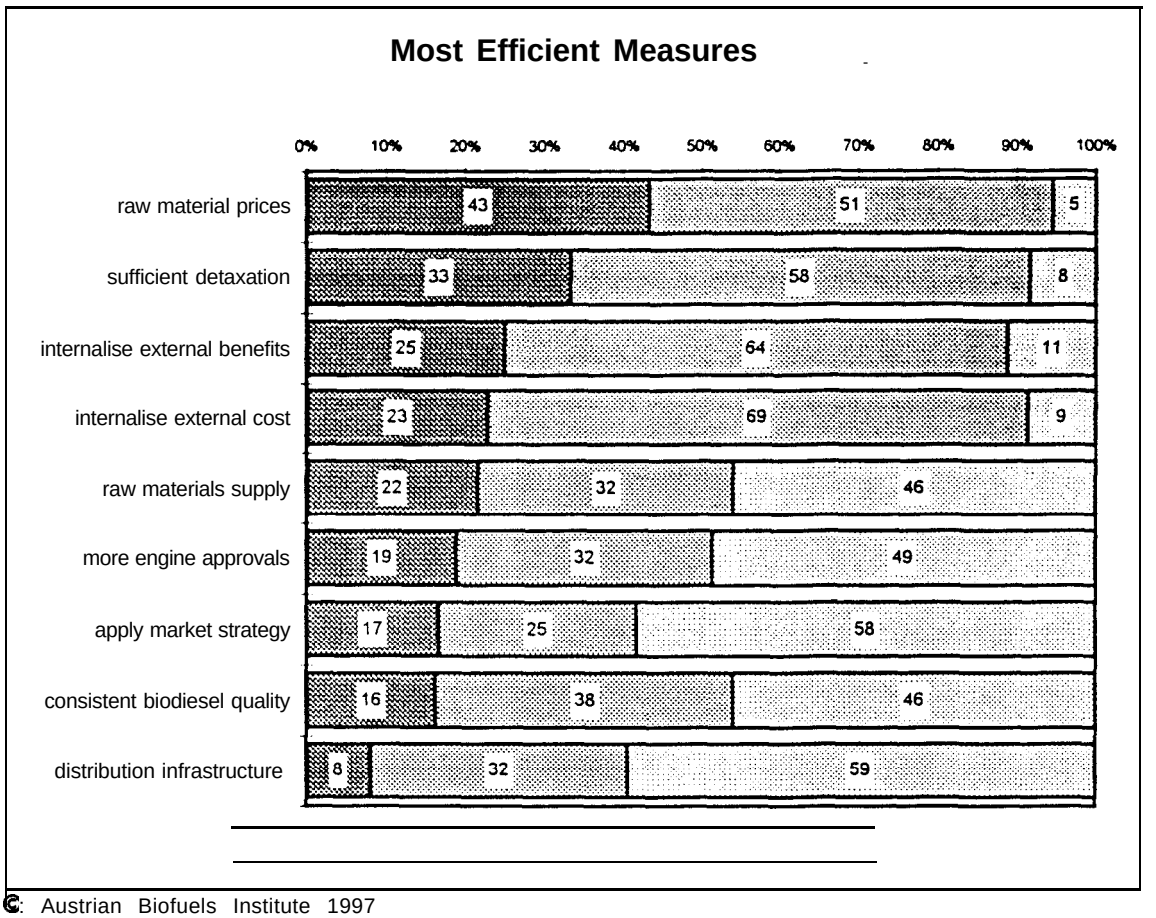
Other barriers mentioned like poor Biodiesel quality, weak distribution infra-structure and lack of effective marketing strategies are not perceived as strong barriers for the market introduction of Biodiesel.

Figure 8:



Correspondingly lower raw material cost is seen by 43 % of the participants as the most efficient measure to improve the economy of Biodiesel production. Sufficient detaxation is perceived as the second most important tool, together with measures, which assure the internalisation of all the external cost of fossil Diesel and external benefits of Biodiesel not yet expressed in a differentiated fuel prices at the pump.

Figure 9:



Both risen raw material prices for standard oilseeds such as rapeseed and limited supply in volume because of declined set-aside percentages in the EU have triggered an intensive search for cheap raw materials.

The Biodiesel plant in Mureck, Austria may serve as a model how to overcome the mentioned barriers by using used frying oil collected in the surrounding communities. Both types of Biodiesel - one derived from rapeseed and another from used frying oil - are sold at the pump.

New process technology can process today any type of waste oil and fat in any composition with highest yield output and assured high Biodiesel quality according to the most stringent standards.

1. Austria:

- In 1982 the first test were made with pure rapeseedoil in a Diesel engine in the Federal Institute for Agricultural Engineering in Wieselburg. The decision was made then to adapt the pure oil by transesterification for the unmodified Diesel engine. Pilot plants were established in Wieselburg and at the agricultural school in Silberberg, followed by a third one in Margarethen, all in competition to each other.

- Capacity:
  There are 2 different models implemented, which is the small size farmers' co-operative plant (5 plants in the range of 1.000 - 3.000 tons capacity) and the industrial scale plant (2 plants with 10.000 and 17.000 tons capacity at the ÖLMÜHLE BRUCK). Additionally the 3 pilot plants are still in action.

- Production:
  In 1991 the world-wide first industrial scale and dedicated Biodiesel plant went into production processing rapeseedoil as 2 other small scale plants, of which one processed also sunfloweroil to a minor share. Since 1994 the multifeed-stock plant built by BDI in Mureck produces also Biodiesel in commercial scale on the basis of used frying oil (UFO), which is collected within the region through own logistic services. It is used as a 100% pure and high quality Bio-diesel in community vehicles.

Austria	**1991**	***1992***	***1993***	***1994***	***1995***	**1996**	est. **1997**	est. ***1998***
capacity	11	13	30	33	35	38	40	33
production	6	8	9	14	18	17	22	25

- Taxation:
  Austria implemented a tax exemption policy ahead of and in line with the draft of the Scrivener-directive by allowing a 95 % tax reduction for Biodiesel when applied as a 100 % fuel for Diesel engines. The farmers enjoy a complete de-taxation when using Biodiesel derived from their own crop for their own purposes on the farm.

- Marketing:
  While farmers Biodiesel production is going back to farm application for agricultural machinery in a closed-loop model, one can observe a sophisticated marketing strategy for the industrially produced Biodiesel, targeting the big bus and distribution fleets, the taxi and community services in big cities, but also Diesel vehicles in environmentally sensitive areas.

- Quality:
  Austria was first in developing and publishing a Biodiesel standard ON C 1190 for Raps-Methyl-Ester (RME) as the basis for warranties given by many Diesel engine companies thereafter, followed by another standards ON C 1191 for Fatty-Acid-Methyl-Ester (FAME) thus allowing a wider scope of raw materials to be used.

2. Belgium:

- In Belgium a pilot plant was built by the company DE SMET in 1992, furthermore 2 large scale plants with the capacity to produce methyl-esters exist, which are however not dedicated Biodiesel production plants.

- Capacity:
  One is owned by the mineral oil company **FINA,** which was offering Biodiesel under the trademark FINAGREEN for some time, but has ceased those commercial activities now. The other one is run by **SISAS** in Feluy - Belgium, with headquarters in Milano - Italy, and has a capacity of over 200.000 tons for methyl-ester, of which a large share is utilised for oleochemicals.

- Production:
  SISAS has produced approx. 12.000 tons in 1994 and has developed the production up to 20.000 tons in 1997, estimating 30.000 tons for 1998. It is processing only degummed rapeseed oil.

- Taxation:
  There is no specific tax policy known for the time being. For some time Belgium was opposing directive drafts of the European Commission - e.g. the Scrivener-initiative - calling for an unanimous decision for tax exemptions in favour of biofuels, which attitude has changed recently.

- Marketing:
  Main market targets are export countries e.g. France, Germany and especially Italy, where SISAS holds a share of 17.500 tons within the state regulated quota.

- Quality:
  The Biodiesel fuel standards for Germany, Italy and Sweden are met.

3. Canada:

- Canadian scientist especially at the University of Saskatoon, (the home of ,,Canola", the basic 00-rapeseed variety since 25 years), showed an early interest in the development of Biodiesel, low market prices for fossil fuels however did not allow any other work than laboratory scale production so far. The Saskatchewan Canola Development Commission is supporting now the start-up of a Canadian Biodiesel production.

- Capacity & Production: For 1997 a production is estimated with approx. 1.OOO tons, but an increase up to 20.000 tons is in the forecast for 1998.

- Taxation: No tax exemption policy is reported.

- Marketing: As target markets ideas exist to establish customer contacts with e.g. the boat traffic in the Vancouver district, with the Rocky Mountain train system and the underground mining sector. Biodiesel may be applied *as* a 100 % pure, as a 2 %-blend fuel and as a Diesel fuel lubricity improver.

- Quality: The Biodiesel standard as defined by the Austrian ON C 1191 is used.

4. China:

- The Liaoning Province Research Institute of Energy Resources reports about trials with pure vegetable oil as well as transesterified oil in the years 1991 to 1994. As raw material source Chinese researchers focus on an oily beny-bearing tree called Guang-Pi grown on marginal land.
  In January 1998 a project will be started together with the Austrian Biofuels Institute, which partially financed by the European Commission.

5. Czechia:

- Based on intensive contacts to Austrian Biodiesel groups the concept of the farmers' co-operative small scale plant was adopted and quickly set into practise. Beside agricultural motives all the environmental reasons were taken to support the establishment of an initially Czechoslovakian, then Czech Biodiesel industry.
  The tractor company **ZETOR** with the probably best tractors of the East European region completed in-depth tests, which led to warranties for **ZETOR** tractors. There was a Biodiesel Producer Association founded in Prague, supported by the Institute for Agricultural Engineering (VOZT).

- Capacity & Production:
  In 1996 the list of production plants were led by MILO in Olomouc with a 30.000 tons capacity, followed by a plant in Mydlovary with 12.000 tons, another plant in Jihlava with 3.000 tons (with a 80/20 % share for rapeseed/soybean) and 13 small scale plants with less than 1.000 tons capacity each.
  This is in total 16 Biodiesel plants, which makes Czechia the world-wide leader in number of plants by country.

Czechia	***1991***	***1992***	***1993***	***1994***	***1995***	***1996***	*est.* ***1997***	*est.* ***1998***
capacity	0	0	2	34	58	63	63	69
production	0	0	1	4	17	22	45	55

- Taxation:
  There is full detaxation for Biodiesel given on environmental reasons, which is also valid in blends with linear alpha olefins, additionally the VAT-level is reduced for Biodiesel down to only 5 %.

- Marketing:
  After an initial phase of a 100 % application there are several blends in practise today: A 30 %-blend with fossil Diesel and all kind of blends with biodegradable linear alpha olefins became a common practise.
  Diesel engine warranties were obtained by local producers e.g. **SKODA** personal **car** (owned now by **VOLKSWAGEN)** for RME, - for the 30 %-blend warranties were given for all models by **SKODA-LIAZ** trucks and **ZETOR** tractors.

- Quality:
  In co-operation with Austria the CSN 65 6507 standard was developed.

6. Denmark:

- Some years ago initial tests were run with the HT-bus company of Copenhagen. The family owned oilmill **EMMELEV MOLLE** on the island of Fyn prepared for some time a Biodiesel plant project linked to the oilmill, but did not obtain the needed political support.
  A recent report completed and published by the Danish Technological Institute DTI showed very encouraging results and opportunities for emission reduction.

- Capacity & Production:
  As observed in other places there is a methyl-ester production capacity installed at **ARHUS OLJE** A/S, which however is not a dedicated Biodiesel plant. Arhus has provided in the early days trial quantities of methyl-ester for trial purposes.

- Taxation
  There is no tax incentive in place. Denmark is one of the last but strongest opponents for a common European regulation for tax exemptions on biofuels.

7. France:

- France has certainly put the strongest political support behind the implementation of the biofuels idea within the European Union, developing both Biodiesel and Bioethanol for the market.
  Powerful agricultural groups e.g. **SOFIPROTEOL** and **ONIDOL** together with the French mineral oil industry e.g. **ELF** and **TOTAL** joined forces and set a production and marketing plan efficiently into practice.
  Further support came from **PEUGEOT** and **RENAULT** - bus and truck division, as well as from the efficient governmental Agency for Environment and Energy **(ADEME).**

- Capacity & Production:

  Initially Biodiesel was produced in existing methyl-ester plants as the one owned by **CASTROL** in Peronne and the other by **SIDOBRE-SINOVA (a HENKEL affiliate)** in Boussens.

  But starting off with a small scale pilot plant in Compiegne built with the technology as developed by the well known INSTITUTE FRANCAIS DU **PETROLE** (IFP) the first dedicated plant owned by the company **ROBBE** went into commercial production on the same location in 1993.

  Further expansions took place in 1995, when the Italian based company NOVAOL added **70.000** tons capacity in Verdun at an adapted chemical plant and when the Biodiesel plant in Rouen started its production with a capacity of 120.000 tons, the so far biggest dedicated Biodiesel plant in the world.

  This plant is a joint venture between **SOFIPROTEOL** and VAMO MILLS, (at closing of this report VAMO MILLS had sold its shares to the French sugar- and starch company ERIDANIA BEGHIN-SAY).

  A further industrial scale project as developed by the group **J.SOUFFLET** S.A. in Nogent-sur-Seine may take shape in near future.

France	***1991***	***1992***	***1993***	***1994***	***1995***	***1996***	***est. 1997***	***est. 1998***
capacity	0	10	***80***	***85***	***235***	***310***	***315***	***315***
production	0	1	***8***	***60***	***133***	***227***	***250***	***260***

- Taxation:

  There is full tax exemption however for a limited quantity of 235.000 m^3 only, similar to the Italian practise of having established a state quota.

- Marketing:

  Overall marketing of Biodiesel is managed by 2 groups, which is the DIESTER INDUSTRY (for the 3 plants in Rouen, Boussens and Compiegne) and **NOVAOL** (for the 2 plants in Verdun and Peronne).

  Most of the Biodiesel is taken to 7 (out of a total of 13) refineries for blending and enters the market as a 5 %-blend to fossil Diesel.

  As an interesting marketing concept the ,,Club de Ville" was founded as an association of cities, which support the utilisation of Biodiesel in their bus fleets, mostly as a 30 %-blend in order to reduce local emission levels.

  The **INSTITUTE FRANCAIS DU PETROLE** (IFP) investigated also the application of Biodiesel as a lubricant additive for fossil Diesel with very low sulphur levels in order to assure adequate lubricity in injection pumps.

- Quality:

  Standards are regulated in the French Decree of 20 December 1993.

8. Germany:

- Initial supplies of Rapeseed-methyl-ester for Biodiesel trials in Austria and Germany were produced by **HENKEL** in Dusseldorf in the non dedicated plant, but in the mean time all the existing and sizeable capacity is used for the production of oleochemicals.

- Capacity & Production:
  Other plants came soon on stream such as the pilot plant at the oilmill **CONNEMANN** located at the coast of the North Sea, followed soon by the industrial scale plant with a capacity of then 60.000 tons at the same location in 1994.
  Additionally 2 small scale plants went into operation in 1995, one in Bavaria and one as a farmers' co-operative in Plauen I Thuringia with markets in the agricultural and the city bus sector. All of them are processing rapeseedoil.
  A further project for about 60.000 tons may be implemented at the location of Wittenberge.

Germany	***1991***	***1992***	***1993***	***1994***	***1995***	***1996***	***est. 1997***	***est. 1998***
capacity	***64***	***68***	***68***	***68***	***110***	***287***	***292***	***293***
production	***4***	***9***	***10***	***45***	***51***	***63***	***83***	***105***

- Taxation:
  There is full tax exemption for Biodiesel when it is sold and applied as a 100 %-fuel.

- Marketing:
  Following an impressive and very professional effort of UFOP (the ,,Union for Oil- and Proteinplants") Biodiesel was promoted by many ways.
  As one result there are now more than 600 Biodiesel pump stations available all over Germany, and Biodiesel is well accepted by different customer groups such as city bus fleets, taxi fleets, construction companies, driving schools, agricultural co-operatives, etc.
  All major German car producer have now issued engine warranties e.g. **MERCEDES-BENZ** for personal cars and trucks, **VOLKSWAGEN, AUDI** and recently also BMW for the new 5-serie.

- Quality:
  Taking the Austrian standard ON C 1190 and later on the ON C 1191 as a model the German standardisation group developed the DIN E 51606 for Fatty-acid-methyl-ester (FAME), probably the most elaborate Biodiesel standard today.

9. Greece:

- Early investigations about availability and feasibility of various raw materials are in the early phase of completion.
  This may include low qualities of cottonseed oil, grape-seed oil as well as olive oil and other waste oils and fats.

10. Hungary:

- Some years ago a Biodiesel plant with an intended capacity for 18.000 tons was built close to the city of Gyor in Western Hungary, but did not manage to get into production, because of non-technical obstacles.
  In this area sunflower would be the oilseed of choice, but presently no forecast can be made.

11. Ireland:

- Some interesting preparatory work has been completed in the Republic of Ireland such as feasibility and macroeconomic studies, assuming different raw materials.
  As Ireland does not have an oilmill for rapeseed also other oils and fats such as used frying oil (UFO) and waste beef tallow were taken into consideration. The oil of ***Camelina*** *sativa,* another Cruciferae plant similar to rapeseed, was tested as well.
  Related chemical and machinery trial work was completed by **TEAGASC'S** Oak Park Research Institute in Carlow in co-operation with the Austrian Biofuels Institute. With large quantities of beef tallow produced Biodiesel may become a safe outlet for this type of fat in times of BSE-fears, however winter operability of Biodiesel has to be assured even in the moderate climate of Ireland, which may be achieved by blending with UFO as raw material.

- Capacity & Production:
  So far only small scale laboratory production for trial purposes was completed.

- Taxation:
  An option for tax exemption was installed during a previous parliament period for the government, which could implement the option whenever reasons are given.

- Marketing:
  Initial investigations have identified tourist boats on the river Shannon and the city bus system in the smog burdened city of Dublin as attractive market segments.

12. Italy:

- Italian companies took part in a joint venture GEIE-project partially financed. by the European Commission with the objective to develop a Biodiesel industry, starting in 1992.
  NOVAOL (then named **NOVAMONT)** and **ESTERECO** took part for the Italian side, real capacity and production development however went into other directions as described below.

- Capacity & Production:
  Italy started production with some smaller existing but non-dedicated methyl-ester plants in Northern Italy, followed by the big scale dedicated plant in the harbour of Livorno as built by **NOVAOL,** processing both rapeseed and sunflow-eroil of fully refined quality.
  In total there appear 10 companies as having taken a share of the total state quota of 125.000 tons, of which the biggest in rank of reported volume pro-duced are:
  BAKELITE in Solbiate, OLEIFICI in Bari, IGS in Milano, DEFILU in Milano, Fox **PETROLI in Ancona, COMLUBE in Castelnedolo and ESTERECO in** CM di Castello; - the other mentioned companies like **BITOLEA and DISTILLERI PALMA in** Napoli seem to have ceased their formerly existing production.

Italy	*1991*	*1992*	*1993*	*1994*	*1995*	*1996*	*est. 1997*	*est. 1998*
capacity	0	*60*	150	166	189	199	211	211
production	0	59	95	122	135	141	109	107

- Taxation:
  Both transport fuels and heating oil is taxed at a rather high level with the same percentage. Full tax exemption is given to both application forms, however for a quota of 125.000 tons per annum only.

- Marketing:
  With efforts of some emission burdened cities to reduce those risks a market for heating oil light was created and takes about 45 % of the total production. Another 45 % are marketed as lubricity improving additive for low-sulphur fossil Diesel.

- Quality:
  The Italian CUNA standard is taken as reference, for export markets fuels of the locally required standard are supplied.

13. Japan:

- Only a few reports have been identified, in which the utilisation of used frying oil (UFO) as raw material for Biodiesel production and its use in urban areas was mentioned, e.g. in the city of Kyoto. The Japanese Oleo-Chemical Society has published a similar report.

14. Malaysia:

- Always looking for new applications of palmoil it was a logic step for the Malaysian palmoil industry to try Biodiesel on the basis of locally grown oil.
  The initial pilot plant of the Palm-Oil Research Institute Malaysia (PORIM) produced sufficient quantities of Biodiesel for entering detailed trial work with city buses together with **MERCEDES-BENZ,** which resulted in interesting and detailed trial reports.
  Although being high in saturated fatty acids and therefore getting solid at already moderate temperatures palmoil-Biodiesel worked fine under local high temperatures.

- Capacity & Production:
  Beside the mentioned pilot plant with an estimated capacity of 10.000 tons there is no dedicated Biodiesel production plant known, but surplus from other plants producing methyl-ester for oleochemical or other purposes may enter the international Biodiesel market sooner or later.

15. Nicaragua:

- Supported by an Austrian development programme the locally grown bush Jatropha cufcas was identified as an interesting oilseed crop. This bush, which is usually found in the wild, but can also be grown in plantations, produces a nut which is rich in oil, but not suitable for human or animal consumption, however applicable for Biodiesel production.

- Capacity & Production:
  A Biodiesel plant with a capacity of 3.000 tons together with a quality control laboratory was recently installed and should be in full production by now.

- Quality:
  The Biodiesel fuel standard as defined by the Austrian ON C 1191 will be used at the laboratory.

16. Norway:

- As a Scandinavian country a strong environmental consciousness can be recognised also in Norway, which is not yet a Biodiesel producer, but imports Biodiesel for distribution through the **HYDRO-TEXACO** fuel company.

Being the second biggest mineral oil exporting country in the world after Saudi-Arabia, Norway considers however to become a country with a Biodiesel production in the region of Hadeland **(HABIOL** AS in Jaren) on the basis of rapeseedoil and UFO, which could be collected in the Greater Oslo region.

- Marketing:
  As one interesting point there is an existing engine warranty given by NISSAN for the Terrano II model.

- Taxation:
  Presently there is no tax on Biodiesel.

17. Poland:

- Although being one of the traditional big rapeseed growing countries in Europe and having encouraging examples in the neighbouring countries there is only a small pilot plant production existing in Mochelek near Bydgoszcz, which was built by IBMER-Institute of Warsawa.
  It went into production in 1996 and was financed by the Polish Committee for Scientific Research.

- Capacity & Production:
  Although there exists only a small pilot production IBMER forecasts a production capacity of 296.000 tons by the year 1998, growing together with significant increases of rapeseed production up to 690.000 tons by the year 2020.

- Taxation:
  Presently there is full tax exemption given.

- Marketing:
  A 10 %-blend is seen as the most promising marketing route.

- Quality:
  The Austrian standard ON C 1191 is taken as the reference and analytical tests are completed in the Institute for Aviation in Warsawa.

18. Slovakia:

Initially started under the Czechoslovakian Biodiesel programme a first small scale plant was built in what is today the state of Slovakia by a group of technicians of the company ZTS-MARTIN, formerly known as a producer of heavy weapons and tanks, supported also by other initiatives for process development and quality control at the University of Bratislava.
There is a Slovak Biomass Association with a subsection for MERO (methylesters of rapeseedoil) with members of most of the producers.

- Capacity & Production:
  The first small scale plant went into operation in 1992, followed step by step by 9 additional plants with capacities in the range of 500 to 1.500 tons each, resulting in a total capacity of 7.100 tons today.
  Most of the plants process rapeseed with a minor share of sunflower as well. Most of the process equipment was provided by the company MDT (MARTIN **DAVOZ** TRADING).

- Taxation:
  Full detaxation exists up till now for Biodiesel and for heating oil applications.

- Marketing:
  Overall conditions are similar to what is mentioned for Czechia, like marketing of 30 %-blends with aliphatic hydrocarbons (N-alkenes).

- Quality:
  The CSN 65 6507 standard - originally developed as a Czechoslovakian standard - is taken as basis for quality assurance, and was renamed to PN 010395 or also PN 7601.

19. Spain:

- There had been several projects in consideration, two of those were located in the Catalonian region, which were so far not yet realised. There are reports about a pilot plant in Bilbao in the Bask region, production start is however not confirmed.

20. Sweden:

- Southern Sweden offers ideal growing conditions for rapeseed and has tried already many routes of emission reduction for the transport sector, mostly however with Ethanol-blended fuels.

- Capacity & Production:
  SVENSKA ECOBRANSLE AB is the biggest producer with 8.000 tons in 1997 and intentions to increase capacity to 18.000 tons in future.
  Rapeseed is by far the standard raw material, but trials are made also with linseed, lard and UFO.
  Three other plants are mentioned in reports which appear to have been involved in Biodiesel production in the past.

- Taxation:
  Full tax exemption is given for a quota of 30.000 tons maximum with a time limit up to the year 2001.

- Marketing:
  About 80 % of the production is applied as 100 % pure Biodiesel and 15 % as a 2 %-blend with fossil Diesel. A small part is used as chemical for paints. Market targets are widely spread and cover all kind of transport.
  Ecobransle provides a long list of engine and vehicle warranties, of which one can find beside the well known companies e.g. VOLKSWAGEN, etc., also some new warranties given by CLAAS (with **MERCEDES-** or PERKINS-engine), FORD tractor and personal car (from 1997 onwards), **HOLDER** tractors, **ISEKI, KUBOTA,** MERCEDES-Unimog, **NISSAN** trucks, **OPEL** personal car (from 1997 onwards), PEUGEOT personal cars (only for 10 %-blends by late 1997), RENAULT tractors (with MWM- or air-cooled **DEUTZ-engines), - VOLVO** is still hesitating although the AUDI AG-engine is used, which is warranted by **AUDI.**

- Quality:
  The Swedish standard SS 1554 36 is the basis for quality assurance

21. Switzerland:

- Swiss institutes e.g. FAT in Tänikon and the EMPA in Dübendorf were involved in Biodiesel research in the early 90s and contributed with interesting results, including from a city bus trial in Zurich.

- Capacity & Production:
  Since 1996 there is now a small scale Biodiesel production plant in Etoy (province Vaudois) in action with a capacity of 2.000 tons and processing both rapeseed and sunflowerseed in 80/20 %-share.

- Taxation:
  Biodiesel is fully taxed, but farmers get a full tax refund.

- Marketing:
  Biodiesel is used in the 100 % form in agricultural machinery, where many tractor companies have issued warranties for their models, e.g. **CASE, DEUTZ-FAHR, FENDT, FIAT, FORD, JOHN DEERE, LAMBORGHINI, LANDINI, SAME, STEYR,** ZETOR.

- Quality:
  The institute FAT in Tänikon functions as the quality control laboratory applying the German DIN V 51606 as standard.

22. United Kingdom:

Following a visit to Austria in November 1992 the British Association **for Biofu-**els and Oils (BABFO) was founded soon after as a Biodiesel promoting agency.
There was interest expressed by **CARGILL** to produce Biodiesel at one of their oilmills located in Hull.

Other companies giving support were **PERKINS** Diesel with engine warranties **e.g. for the MASSEY-FERGUSON** tractors, **LUBRIZOL** by having developed an efficient additive to assure winter operability of Biodiesel, and the seed industry **e.g. SEMUNDO and DALGETY** Oilseeds.
The Scottish Agricultural College (SAC) in Aberdeen provided substantial know-how in growing oilseedrape. Offering one of the best conditions in Europe to grow rapeseed and having a highly efficient agriculture Biodiesel would have had an ideal background to start, but government policy was so far strictly negative.

- Capacity & Production:
  Small trial quantities were produced by **CHEMOXY** Ltd. in Northern England and applied in small scale local trials in trucks there. Some of this British Biodiesel was exported to Ireland and tested in a bus trial in the City of Cork.

- Taxation:
  There is no tax exemption in place.

23. USA:

- Based on some initial work at the University of Idaho in Moscow and the University of Missouri in Columbia the **UNITED SOYBEAN BOARD** (USB) took an interest in an American Biodiesel project and founded the **NATIONAL SOYDIESEL DEVELOPMENT BOARD** in 1992, which was succeeded by the **NATIONAL BIODIESEL BOARD** (NBB) located in Jefferson City later on, which works now as a very professional Biodiesel development and promotion agency.
  Most of the activities are financed by soybean-checkoff Dollars as a very efficient tool to push new research and development.
  Further supportive organisations are the **NATIONAL RENEWABLE ENERGY LABORATORY** (NREL) in Golden, also because of the programme to develop oil from microalgae there, the **FAT AND PROTEIN RESEARCH FOUNDATION** (FPRF), and the **NATIONAL RENDERERS ASSOCIATION** (NRA) with the interest to create a new and profitable outlet for waste oils and fats of animal or plant origin.

- Capacity & Production:
  Some indications show that first quantities of Biodiesel were produced in non dedicated plants e.g. by **PROCTER & GAMBLE** in Kansas City as early as 1992 and by **TWIN RIVERS TECHNOLOGIES** in Quincy, MA in 1994.
  In 1996 a small scale Biodiesel plant built **by PACIFIC BIODIESEL** went into operation in the city of Kahului on Hawaii with UFO as raw material, only for blends with fossil Diesel.
  Furthermore there are strong intentions to build dedicated plants by:
  * N0PEC in Lakeland, FL (73.000 tons),
  * AG-ENVIRONMENTAL PROCESSING in Lenexa. KS (18.000 tons),
  * COLUMBUS FOODS in Chicago (33.300 tons),
  * INTERWEST in Ralston and by
    CHEMOL in Greensboro, NC.

U.S.A.	1991	1992	1993	1994	1995	1996	est. 1997	est. 1998
capacity	10	10	10	11	16	38	107	136
production	0	0	1	2	3	5	8	13

- Taxation & Regulations:
  No direct tax exemption is in place, however there exist specific regulations, which are forming new market segments with different competitive rules, in which alternative fuels have a strong chance to succeed, e.g.:
  The Clean Air Act with the objective to reduce emission levels, the Clean City Programme to develop additionally the alternative fuel markets, the Alternative Fuelled Vehicles (AFV) regulation, which is encouraging governmental and larger private fleet owners to run a certain share of their vehicles on alternative fuels.

- Marketing:
  A large number of various initiatives can be observed focusing e.g. on city bus systems, the marine sector, underground mining, federal and single state government fleets, national park and even army vehicles with 20 %-blends and pure 100 %.

- Quality:
  Already in 1994 the **AMERICAN SOCIETY OF AGRICULTURAL ENGINEERS** issued an Engineering Practice (ASAE EP X552) as a first orientation for a Biodiesel quality standard.
  Further standardisation work is presently on the way at the **AMERICAN SOCIETY FOR TESTING AND MATERIALS** (ASTM).

24. Yugoslavia:

- Yugoslavia is a specific and interesting case concerning motivational factors as the Biodiesel development was triggered by the embargo for mineral oil products during the Balkan war.
  The immediate cut in supplies and extremely painful shortage of liquid fuel for transport and agriculture led to a slightly desperate rush into Biodiesel production of mostly not satisfactory quality.
  This case may lead to the conclusion, that a basic level of Biodiesel production can at least ease supply shocks and assure energy supply for the most crucial and strategic production sectors during a supply crisis.

- Capacity & Production:
  The non-dedicated production plant of **PRVA ISKRA** was in place with a capacity of initially 26.000 tons but was increased to 36.000 tons by 1995.
  A second new plant was added by **JUGOINSPEKT** in Novi Sad in the year 1994 with a capacity of 13.200 tons, processing rapeseed and sunflower as 50/50 %-

share. Total production found its peak in 1995 with 5.500 tons Biodiesel but returned to zero after the lift of the embargo in 1996.

- Taxation:
  Full detaxation was allowed for a maximum quantity of 50.000 tons.

- Marketing:
  In times of shortage no specific marketing activities were necessary.

- Quality:
  The Austrian standards ON C 1191 was taken for orientation; quality control investigations and technical support was given by the Agricultural Faculty at the University in Novi Sad.

CONCLUSION & PROSPECTS:

Since the very first tests in a number of small pilot plants a significant Biodiesel production development has taken place during a rather short time, showing the great interest into the Biodiesel-idea, although economic background varied by country and by area substantially, but motivational triggers seems to be quite common, such as concerns for a clean environment and a high energy supply security.

Coming from this early days a ,,Biodiesel-world" had developed today, represented by scientists in all the different fields, by farmers and plant breeders, by engineers for Diesel engine construction and process technology, by Biodiesel producers and marketers, and by Diesel engine and vehicle companies, last but not least by motivated customers, whether it is a city bus company, a taxi fleet owner, a tourist boat manager, a farmer with his tractor and combine, a personal car driver.

Prospects however don't look too promising for the time being, as raw material supply from agriculture is not assured at reasonable prices and non-food markets are seen as a secondary priority by agricultural institutions, also by the European Commission with the Agenda 2000, while pressures from the World Trade Organisation (WTO) for ,,real" cost are continuing, which are however not reflecting externalities.

Being highly dependent on huge imports of fossil oil - as a finite energy source anyway - the European Union has to face today again an increasing risk in security of energy supply for the transport sector caused by the following issues as emphasised by the International Energy Agency (IEA):

- the production-demand gap of fossil oil is declining world-wide,
- North Sea oil will be finished by the year 2010 latest, and
- the energy demand of the non-OECD world is growing dramatically (e.g. China).

According to the IEA there will be a need for all alternative fuels for the transport sector, and Biodiesel will be one of them (European Commission, October 1996). The FORUM-scenario of the European Commission describes a 12 % market share as possible for biofuels by the year 2020.

As far as environmental•damage is concerned, the transport sector has a clear responsibility.
Within the last 10 years its part in global warming potential has increased from less than 20 % to more than 25 %; it is now bigger than those of the domestic and industrial sector, while its contribution to acid pollution constitutes 75 % of total emissions of this pollution type.
As one reaction the European Commission has developed a fuel quality directive asking for new environmental fuel specifications aiming at the reduction of exhaust and evaporative emissions (European Commission, September 1996).

The future agricultural policy will have to take into consideration, that with the enlargement of the EU-15 by the Countries of Central Europe (CCE) tremendous opportunities for Biodiesel production are opening up, as

- those countries have presently double the acreage per citizen compared to the EU-15,
- they will represent 55 % of the total agricultural land within the new EU-25,
- there is an enormous unexploited potential in agro-productivity, as does Russia and the Ukraine.

This challenge of integration can lead to a significant impulse in production of a number of renewable non-food raw materials in general, and of Biodiesel in specific.

The last 6 years have shown an impressive growth for Biodiesel; together with the above mentioned strong arguments for the sectors of energy, environment and agriculture, all closely linked with a job-creation effect, Biodiesel may become increasingly attractive for politicians, the business world and last but not least the public.

Acknowledgements:

- Mr. Dieter Bockey, UFOP, Bonn, Germany
- Mr. Joosten Connemann, ÖLMüHLE LEER, Leer, Germany
- Mr. Alastair Fraser, NOVAOL, Milano, Italy
- Mr. Klaus Grosser, VOLKSWAGEN, Wolfsburg, Germany
- Mr. Zdenek Pokomý, VOZT, Prague, Czechia
- Mr. Heinz Prankl, BLT, Wieselburg, Austria
- Mr. R.E. Sims, Massey University, New Zealand
- Mr. Frederic Staat, DIESTER INDUSTRIES, Paris, France
- Mr. Nick Tapp, BABFO, St. Nicholas, England
- Mrs. Anna Theil-Gangl, Olmuhle Bruck, Bruck, Austria
- Mr. Manfred Wargetter, BLT, Wieselburg, Austria
- BDI - BioDiesel International GmbH, Graz, Austria
- EUROPEAN BIODIESEL BOARD, Brussels, Belgium
- JETZT-team, Vienna, Austria
- NATIONAL BIODIESEL BOARD, Jefferson City, USA

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