

## The Development of Biodiesel

Case study #5 (21 October 2004)

Country: Austria

Market: fuel

### 1. Summary

The mineral oil supply crisis of the early 70ies triggered initiatives in Austria to search for potential alternative fuel supply opportunities from renewable sources, which focused on the development of rapeseed-oil-methyl-ester for the Diesel engine. In a kind of competitive position this strategy was investigated in 2 places in Austria and accelerated the development of efficient process technologies, of warranties for Diesel vehicles (initially agricultural tractors), of a quality assuring Biodiesel fuel standard (ON 1191), of Biodiesel's properties description (e.g. performance, emissions and other environmental parameters, macro- and microeconomic analysis), and of Biodiesel production at initially small farmers' cooperatives. Following supportive legislative measures (tax exemption) industrial scale Biodiesel plants were established, with production plants today in Bruck (25.000 t capacity), Zistersdorf (40.000 t), Arnoldstein (25.000 t) and Mureck (6.000 t). With the further development of process technology a broader scope of feedstock sources can be used today, which encompasses high quality virgin oils (e.g. rapeseed, sunflower, soy, palm, Jatropha), animal fats (beef tallow), and low quality recycled oils from households and restaurants as well as low quality animal fats from rendering operations with usually very high levels of FFA (free fatty acids). Present tax exemption is however not sufficient to assure sufficient Biodiesel application in Austria as most of the Biodiesel is exported to Germany and Italy, where higher margins can be gained.

### 2. Description of the case

#### **Reasons and triggers how and why the development started**

- The mineral oil supply crisis of the early 70ies and its deep psychological impact on public life has to be considered as the most important trigger for many initiatives to search for alternative energy sources. For the transport sector there were not many immediate options available and liquid biofuels (Biodiesel for the Diesel engine, Bioethanol for the petrol engine) appeared to be one of the best solutions with high probability for fast implementation. Bioethanol however, already well established in the USA (produced from maize) and Brazil (produced from sugarcane) as petrol extender, requires high investments and assured supply of large and low priced feedstock volumes. The established Bioethanol consortium "Austroprot" ceased its activities after the first steps of feasibility studies as it did not get the required political support in Austria and feedstock supply was not assured.

- Biodiesel however requires much simpler production steps (process reaction at ambient pressure and temperature, minimal energy input, glycerine as valuable side product), and is therefore low in investment volume. With favourable climatic conditions rapeseed qualified as an ideal feedstock for Biodiesel production and represented a welcomed plant in a broadened crop rotation. The development of Biodiesel appeared to be an alternative and sustainable way for producing a reliable fuel for Diesel engines from renewable resources such as vegetable oils, which idea was already described by Rudolf Diesel in his patent application and which was now revitalised.
- Early experiments were based on pure rapeseed following the initial work of Rudolf Diesel, who used neat peanut oil for his engine. These experiments failed as viscosity and carbon residues in the combustion engine were too high leading to failures within the engine caused by high levels of carbon residues and coking of nozzles and valves.
- The chemical reaction however of splitting one large oil-molecule (which is a triglyceride-molecule) into 3 smaller fatty-acid-methyl-ester molecules appeared to be a promising attempt and was developed in Austria in 2 places:
  1. The Federal Institute for Agricultural Engineering (BLT) in Wieselburg (Niederösterreich) and
  2. the Institute of Organic Chemistry (IOC) at the University of Graz together with the Weinbauschule Silberberg (Steiermark).
- An additional trigger was the evaluation of the energy balance. Evaluating total energy input for Biodiesel production (field-to-wheel) versus energy output the energy balance for Biodiesel resulted in a positive input-output ratio of 1 : 3,23 i.e. for 1 unit energy input Biodiesel produces 3,23 units of energy output - as Biodiesel is one form of free solar energy which is stored by the oilseed plant.

### **Description of the development and the outcome**

- Having these reasons in mind the Ministry for Agriculture initiated basic R&D at the Federal Institute for Agricultural Engineering (BLT) in Wieselburg in 1973 and the production of FAME from rapeseed oil in a new pilot plant of 700 litre volume in 1982, which was supported by the coal and oil trading company Gaskoks Ges.m.b.H. in Vienna.
- BLT tested the new fuel in Diesel engine bench tests and in real practice in a number of tractor trials with success in 1988 leading to a large number of company warranties for the most agricultural tractors and machinery available on the market were issued (e.g. Claas, Deutz, Ferguson, Ford, John Deere, Lamborghini, Massey-Ferguson, Same, Steyr, Zetor, etc.), and set the scene for Volkswagen's pace-setting general warranty for all cars from 1996 onwards.
- The Institute of Organic Chemistry at the University of Graz defined the chemical properties and analytical methods and together with the Weinbauschule Silberberg Biodiesel was produced as well in another pilot plant there. This was supported by the company Vogel & Noot A.G. in Wartberg.

- Initial commercial production was started independently in small farmers' cooperatives between 200 t up to 500 t production capacity/year: e.g. Asperhofen (1989), followed by Güssing, Mureck, Schönkirchen, Starrein – most of them built with Vogel & Noot technology. In this model Biodiesel was produced from rapeseed as grown by cooperative members, while the Biodiesel and the protein-rich rapeseed cake was used for farmers' purposes only in a closed cycle, at least in the beginning.
- As a next step an industrial plant with 10.000 t capacity was started in 1990 in Aschach at the Danube (built with Gaskoks process technology). The marketing model was different as Biodiesel was sold at the public fuel pumps of the Gaskoks owned company Austria and of the Raiffeisen organisation. The plant had to close down in 1992, because of low profitability caused by high cost levels in feedstock, waste streams and personal.
- The next step in scaling up was a plant with 15.000 t capacity in 1992 closely linked to the existing oil mill company Ölmühle Bruck Ges.m.b.H. in Bruck a.d. Leitha, which is crushing rapeseed and sunflower seeds. This Biodiesel plant was built with Vogel & Noot process technology and has increased its Biodiesel output to 25.000 t today by de-bottlenecking of the process chain. Biodiesel was sold to a few Raiffeisen fuel pumps, to discounters (e.g. AWI, AVIA) and directly to large truck companies, which are using an individual blend with fossil Diesel.
- While most of the small farmers' cooperatives had a difficult stand and reduced or closed production, especially during the period of very low mineral oil prices (lowest crude oil process at approx. 9,-US\$ per barrel in 1997/98), the cooperative in Mureck survived, because of an expansion to 6.000 t capacity Biodiesel and of the use of cheap recycled oil from e.g. McDonalds and other restaurants as feedstock.
- This development of an integrated recycled oil collection system from restaurants and households as a feedstock source for Biodiesel producers took place:
  1. in the city of Graz in a joint effort with the cooperative in Mureck, then spreading to other communities, and
  2. in Tyrol as an initiative of the waste treatment association, which developed the very efficient and clean collection system under the trademark "ÖLI", and which was licensed further to other areas (Upper Austria, Lower, Austria, Salzburg, the city of Vienna and communities in Southern Bavaria). This system was developed within an ALTENER-project together with the Austrian Biodiesel Institute.
- In 2003 the overall capacity in Austria has been enlarged by 2 additional companies: "Bioraffinerie Ges.m.b.H." in Zistersdorf (40.000 t) and "Biodiesel Kärnten Ges.m.b.H." in Arnoldstein (25.000 t; - with the option to be expanded to 50.000 t Biodiesel). Both of them are using recycled oils and fats of vegetable and animal origin as cheap feedstock sources.

### **Analysis of influencing factors and key players**

- As Biodiesel is a fuel with proven environmental advantages (reduction of toxic exhaust emissions, greenhouse gas savings, fast biodegradability, lowest acute and dermal

toxicity, high and safe flashpoint) and can be positioned as an environmentally friendly product for very good reasons.

- Surprisingly Biodiesel could be used in the existing types of Diesel engine with very minor modification (e.g. a few rubber parts) even as a 100 % pure fuel at the same performance, so market introduction appeared to be quite simple.
- By chance 2 competence centres for Biodiesel development emerged independently in Austria working in a friendly but competitive climate, which may have contributed to accelerated and ambitious efforts in R & D and commercial implementation between 2 clusters:
  1. The Federal Institute for Agricultural Engineering (BLT) in Wieselburg running a new pilot plant, which was supported by the coal and oil trading company Gaskoks Ges.m.b.H. in Vienna, and
  2. the Institute of Organic Chemistry at the University of Graz together with the Weinbauschule Silberberg, which was supported by the company Vogel & Noot A.G. in Wartberg.
- The Biodiesel project found also strong support at the FICHTE (Research Institute for Chemistry and Technology of Mineral-oil-products) located within the University of Technology in Vienna, which contributed with its know-how about fuel chemistry and initiated the development of a Biodiesel fuel standard for quality control reasons. FICHTE played the key role in initiating and coordinating with all stakeholders the formulation of the world-wide first Biodiesel fuel standard ON C 1190 for RME (Rapeseed-oil-Methyl-Ester) in 1991, and later on the pace-setting ON C 1191 for FAME (Fatty-Acid-Methyl-Ester) in 1997, which became the foundation for the European standard EN 14214 published in 2003 and represents today the most advanced Biodiesel fuel standard as the required basis for quality control, customer confidence and market acceptance.
- The Austrian Biodiesel Institute (ABI is the author of this report) was founded in 1995 with the intention to establish a competence platform, which is a place for open communication and cooperation for all the many players in R&D, process technology, production and marketing, who may want to take advantage of so far unexploited synergies. The criterion for membership is evidence of competence in one of the many fields of activity for Biodiesel, there is no national limitation. The ABI has supported the development of the European Biodiesel standard EN 14214 and has worked in many European ALTENER-projects for dissemination and further demonstration of Biodiesel always in multi-national teams. The most recent reports as commissioned by the International Energy Agency-Bioenergy are: "World-wide Review of Commercial Biodiesel Production" and "Best Case Biodiesel Production Plants in Europe", which are going to be published in March 2004.

### **Main barriers**

- Governmental supportive actions: As a supportive action the Austrian government exempted Biodiesel from the mineral oil tax at an early stage in order to acknowledge the environmental benefits and to improve the competitive position. Tax exemption is

however even higher in the neighbouring countries Germany and Italy and therefore a higher margin can be achieved by exporting Austrian Biodiesel to those countries today, but with very limited remaining sales and shrinking product publicity in Austria itself. Facing the challenge to meet the European target of obligatory market share of 2 % by 2005 and 5,75 % by 2010 the Austrian government has to reconsider its present unsatisfactory policy and will have to develop a framework, by which these targets can be met.

Comparison with neighbouring countries:

Country:	Comparison: mineral oil taxation
2003	€ / 1.000 ltr Diesel
Austria	289,59
Germany	470,40
Italy	403,21

Progressive development of the mineral oil tax by adding a greenhouse tax on top:

- **Feedstock availability:** Because of a rather limited acreage, in which oilseeds and in specific rapeseed can be grown satisfactorily, the supply of sufficient oil seeds from Austrian farmers to local oil mills remained very limited and feedstock availability is therefore insufficient. This is in obvious contrast to Germany, where the rapeseed acreage and the yields were continuously increased by systematic application of promotion, training and education as organised by the Union zur Förderung von Öl- und Proteinpflanzen (UFOP), through which the so far neglected rapeseed cultivation became a recognised parts for farmers' income.
- **Marketing strategy:** After initial attempts to position Biodiesel as a high priced speciality with significant and proven environmental advantages the actual applied marketing strategy was to sell the product only as a cheap fuel at a lower price than fossil Diesel. Previous studies of the Austrian Biofuels Institute have however identified typical market niches, in which the differential advantages of Biodiesel are valued and needed most, e.g. personal and commercial goods transport in the city (bus, taxi, bakeries, breweries, etc.), forestry machinery, waterway transport, skiing slope bachers in the Alps, etc.)

### 3. Results

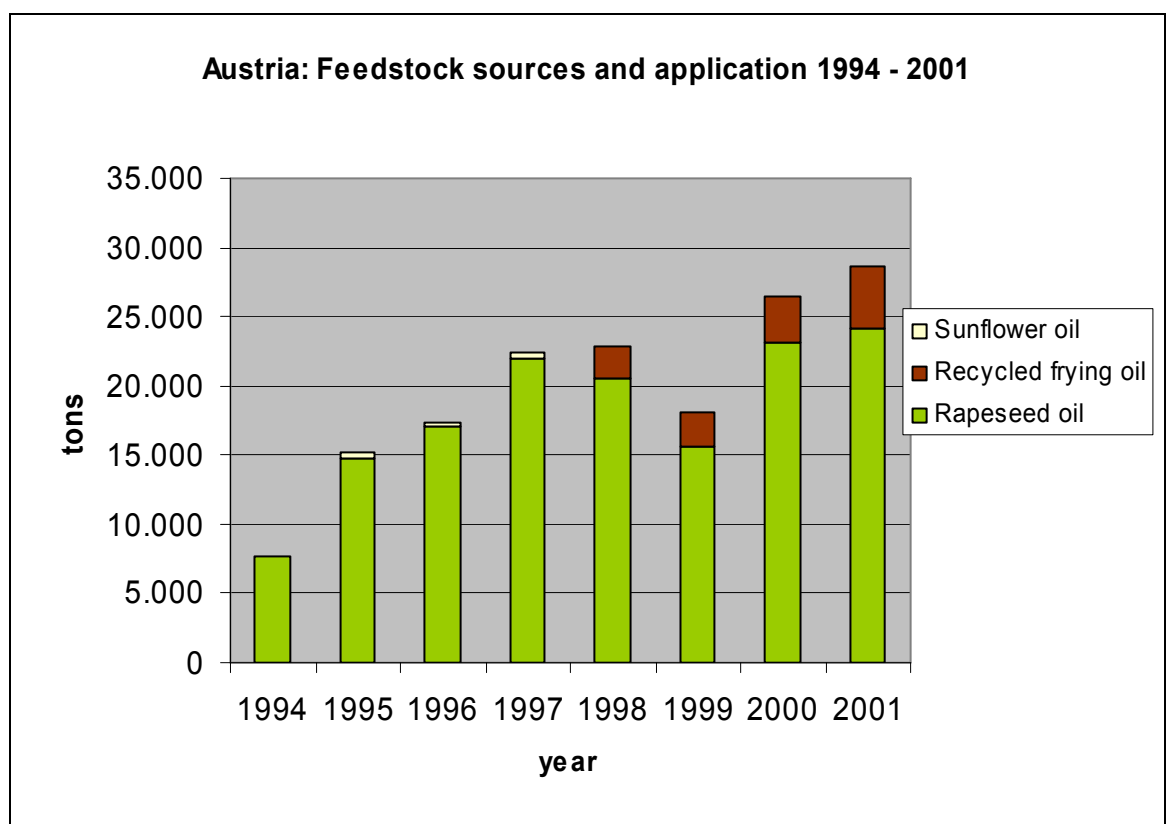
#### **Volume growth**

In the Biodiesel growth development one can observe 3 phases:

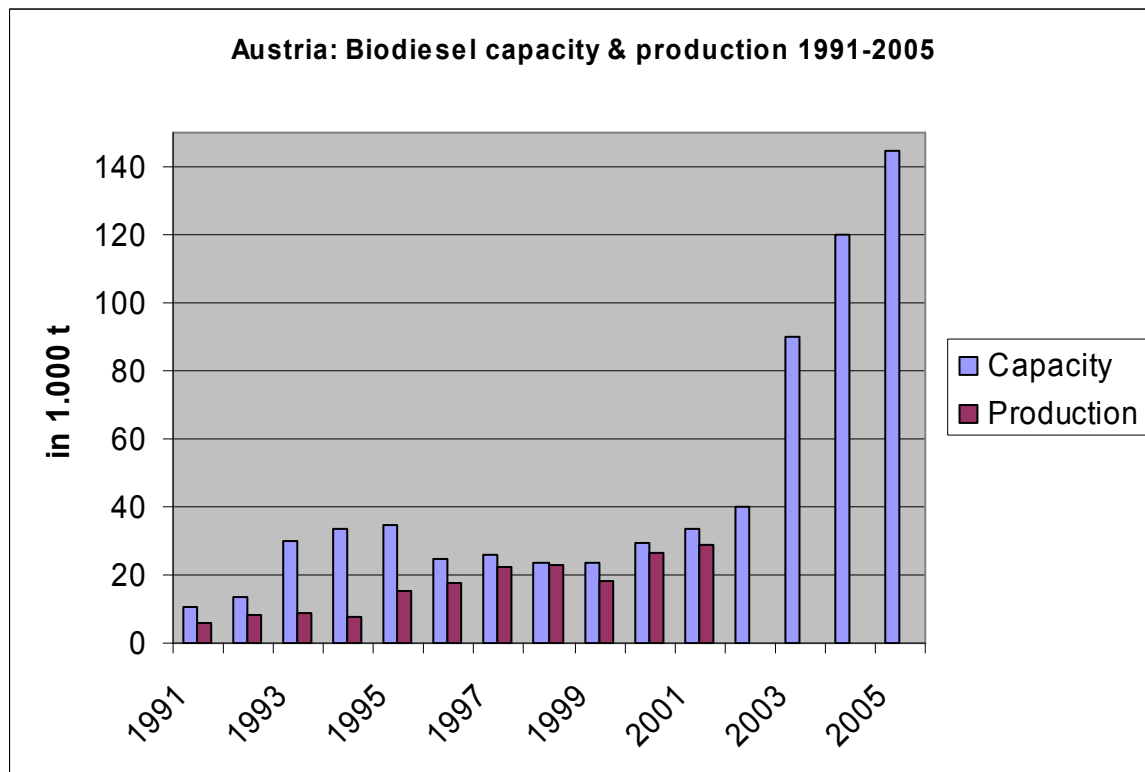
1. The small scale farmers' cooperative model in the initial phase: the Biodiesel plants at Asperhofen (1989) using rapeseed- and sunfloweroil, followed by Güssing, Mureck, Schönkirchen, Starrein (with a capacity range of 200 – 500 t/year). However only the 2 Biodiesel plants in Mureck (expansion to 6.000 t and usage of low cost recycled oils) and in Starrein (expansion to 1.000 t Biodiesel) survived.

2. The larger scale Biodiesel plant integrated into an oil mill: the plants in Aschach in 1990 (10.000 t) and Bruck a.d. Leitha in 1992 (initially 15.000 t, now extended to 25.000 t/year by de-bottle-necking)
3. The large scale plant with recycled oil as the main feedstock source as the most recent model: the plant in Zistersdorf in 2002 (40.000 t) and in Arnoldstein in 2003 (25.000 t, with the option to double capacity to 50.000 t in the next years.)

The following graphs are illustrating the development of the feedstock sources used and the production capacity:



Assuming the possible extension from 25.000 t to intended 50.000 t at the Biodiesel production plant in Arnoldstein within the next 2 years an total Biodiesel production capacity of over 140.000 t could be reached:



### Technology improvement

Austria has become the leading country in providing modern and efficient process technology, engineering and construction services on a world-wide scope. The companies involved:

1. BDI - BioDiesel International Ges.m.b.H. in Grambach near Graz with reference plants in Austria (Mureck, Bruck a.d. Leitha, Arnoldstein), in the Czech Republic (MILO Olomouc), in Germany (Malchin, Niederpöllnitz), in Spain (Barcelona), in the United Kingdom (Argent in Scotland) and in the USA (Griffin Industries).
2. Energea Umwelttechnologie Ges.m.b.H. in Klosterneuburg with reference plants in Austria (Zistersdorf), in Australia (Perth - in negotiation) and in the United Kingdom (Teesside - in negotiation).
3. ENA-Biodiesel Ges.m.b.H., now integrated into the Christof Group in Graz with reference plants in Austria (Starrein) and Germany (Falkenhagen).

### Market penetration

While the Biodiesel production capacity as installed in Austria would be sufficient to cover the demand as required by the Directive on the Promotion of the Use of Biofuels with a market share of 2 % by 2005, there is however a much lower consumption in Austria as the main share is exported to countries, which offer higher profit margins (Germany, Italy). Early initiatives for detailed market research and targeted market segmentation leading then to a differentiating marketing strategy with exactly defined market positions for Biodiesel as an environmentally friendly fuel (see below table) were never implemented:

Biodiesel Marketing Strategy - Austria (proposal)	
Target market niches:	
"Areas of high risk to the environment"	
	Volume
Identified market niches:	t
Skiing slope bachers	16.000
Forestry machinery	17.000
Ship traffic	7.000
Alpine areas	3.000
Public buses (>30.000 inhabitants)	15.000
Other niches	6.000
<b>Total Biodiesel - demand</b>	<b>64.000</b>
Total Diesel-consumption (2001)	4.400.000
Total Biodiesel-demand in niches	64.000
Market share in niches	1,45%
Required market share (EU Directive 2005)	2,00%
Required Biodiesel volume (2005)	88.000
Present Biodiesel-capacity (2004)	90.000

### Energy savings

Although there is sufficient production capacity installed in Austria, it is highly questionable to reach the intended market share of 2 % and the adequate replacement of fossil Diesel fuel by 2005 for the time being because of the export of major volumes to Germany and Italy.

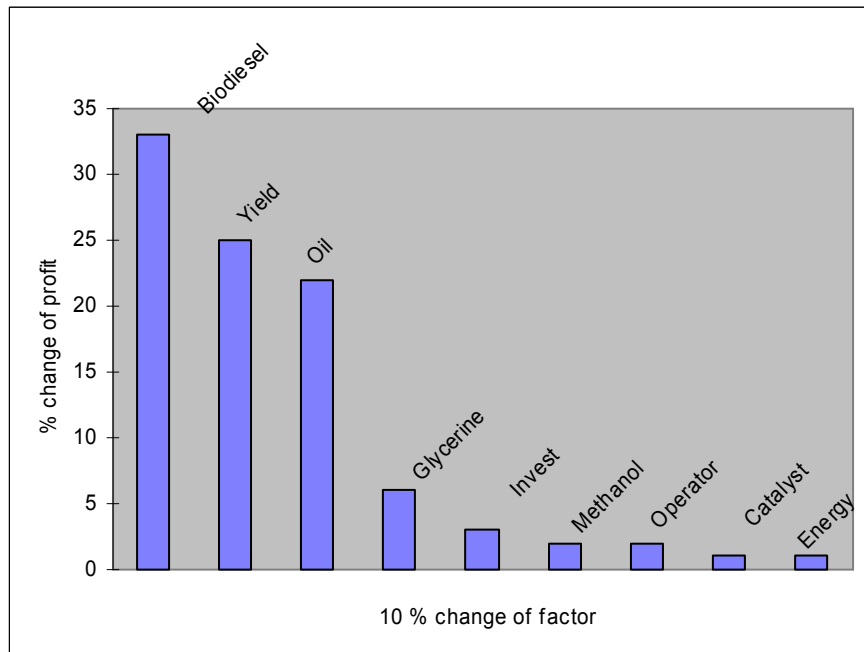
### Economics

With the advanced process technology as developed by Austrian technology companies the production of Biodiesel has reached a high level of competitiveness, as the new technologies can process:

- "dirty" and therefore cheap feedstock (all recycled oils and fats in addition to virgin oils and fats of vegetable and animal origin, even animal fats from rendering facilities with very high content of free fatty acids),
- while obtaining highest possible yield levels,
- at lowest processing cost in energy, personal cost and minimal waste streams,
- while also fulfilling strictest environmental and security regulations,
- and always achieving the required high quality of standardised Biodiesel according to EN 14214.

The key elements influencing profitability are highlighted in the following graph, showing that e.g. energy cost are at a very low level as the process needs only minor energy inputs (e.g. pumps, stirrer), but that Biodiesel selling price, feedstock cost and yield (measured as ratio of

turning triglyceride and free fatty acid molecules into Fatty-Acid-Methyl-Ester molecules) have a decisive impact:



### Achieved objectives

While several companies and institutes have developed themselves to recognised leaders in Biodiesel processing technology and Biodiesel know-how, there is a gap in sustainable Biodiesel marketing. The objectives to establish a well defined marketing strategy and a satisfactory market penetration have not been achieved so far and would need satisfactory legislative support measures.

## 4. Evaluation: Main elements of success and problems

From the actors' perspective:

### Policies

- The very early introduced mineral oil tax exemption provided initially a basis for successful establishing of Biodiesel plants in Austria.
- As Biodiesel has now become a product, which is produced and traded all over Europe this tax exemption provides no longer a framework for competitive Biodiesel marketing in Austria, and a new framework is urgently needed, if Austria wants to meet the European 2 % market share goal in 2005.

### Market

- The driving force for marketing a product is the achievable margin, which is higher in the neighbouring countries than in Austria.

- As the role of competitors - e.g. in the Italian market- is weak, there are good market opportunities there for Austrian producers.

#### **Role of technology performance, development, competition**

- The role of Biodiesel production technology performance is in the mean time very well recognised by the professional investor and producer. It is defined by high feedstock flexibility, high processing yields, Biodiesel fuel quality higher than the standard EN 14214, and lowest possible cost in energy consumption, personal and waste streams.
- The Austrian Biodiesel process technology companies have obtained a very good image of being reliable, consistent in quality and customer-oriented with e.g. online services into the production plant.

#### **Utilisation of the potential**

- The utilisation of the potential of the recycled feedstock segment (recycled oils and fats from households, restaurants, rendering plants, etc.) has reached a very high level and the logistics systems itself have become an export product ("OLLIE").
- There is certainly not the optimum achieved in exploiting all the potentials and opportunities in oil seed cropping in Austria, and new Biodiesel plants will have to rely on imports from e.g. the countries located along the Danube (Hungary, Romania, Bulgaria, possibly also the Ukraine.)

## 5. Objectives for further development

#### **Current situation**

- The current situation is unsatisfactory as most of the Biodiesel is exported and not used within Austria. This has to be changed in order to reach the target of the European Directive on the Promotion of the Use of Biofuels with 2 % market share by 2005 and 5,75 % by 2010 and a new legislation framework is needed immediately.

#### **Targets**

- While the 2 % market share could be reached by the presently existing Biodiesel production plants further capacities are needed in order to reach the 5,75 % goal.
- This could be reached by e.g. the investment into a 200.00 t Biodiesel production plant at an Austrian Danube harbour with feedstock supply (oil from rapeseed, sunflower, soy) from the Southeast of Europe.

#### **Planned policies**

- Suggested policies can be implemented along the 2 following strategies:
  1. Blending of Biodiesel up to 5 % into fossil Diesel at petrochemical refineries with the 2 options to sell this blend with an anonymised Biodiesel within the fossil diesel (e.g. France) or to create a new branded product (e.g. United Kingdom: "Bio-Plus", GlobalDiesel", or in the USA: "Soygold", "EnviroDiesel".)
  2. Marketing of pure 100 % Biodiesel in the identified market niches ideally at a premium price (as mentioned under "3. Results: market penetration").

**Economics** (conflicts with established interests)

- As the mineral oil industry perceives Biodiesel as a broadening of their product portfolio no special conflicts are envisaged.

## 6. Conclusions

**Lessons learned**






- While Austrian institutes, companies and individual persons engaged themselves very successfully in the sectors of basic and broad product knowledge, broadening of suitable feedstock sources, efficient process technology, engine performance, quality management and dissemination, there appeared gaps in applied marketing strategy of Biodiesel producers and in needed political accompanying measures such as timely tax exemption or obligatory usage legislation.
- It appears to be a clear advantage of having an open and active platform for communication with and between all the different stakeholders in order to coordinate common formulation of required policy steps, to assure fast flow of beneficial information and to avoid duplication of mistakes.

**Useful hints for other countries for dissemination**

- In those countries, which start from scratch, one can observe the typical symptom, that not just all inventions but also all mistakes are repeated at a cost again and again. The recommendation is made therefore to install a national study group, which carefully screens all existing experience made in other countries thus saving significantly in time and money.



## 7. Contact information

Name	Details
ABÖ - Arbeitsgemeinschaft der Biodiesel-Hersteller Österreichs	Founded in 2001 by 5 national Biodiesel producers (Bruck, Zistersdorf, Mureck, Starrein, Güssing) with action areas in quality management, public relation, lobbying.
 Austrian Energy Agency	Energy research and policy institution. Its mission is to promote rational use of energy and to stimulate renewable energy.  Website: <a href="http://www.eva.wsr.ac.at/">http://www.eva.wsr.ac.at/</a>
 Austrian Biofuels Institute	International competence centre for liquid biofuels: R&D, demonstration, dissemination, specific studies. Co-ordinator for biofuels projects within the ALTENER-program. International consulting for Biodiesel investment projects world-wide.  Website: <a href="http://www.biodiesel.at">http://www.biodiesel.at</a>

R & D institutions	
 Federal Institute of Agricultural Engineering in Wieselburg	R&D in the field of agricultural engineering; trial production of innovative Biodiesel from a large variety of feedstock sources in a batch process pilot plant; diesel engine performance and emission tests; quality control and chemical analysis.  Website: <a href="http://www.blb.bmf.gv.at">http://www.blb.bmf.gv.at</a>
 University of Graz, Institute for Chemistry	The Institute of Organic Chemistry has more than 20 years of extensive R&D experience in feedstock analysis, quality control and in the development of Biodiesel fuel standards.  Website: <a href="http://www.kfunigraz.ac.at">http://www.kfunigraz.ac.at</a> <a href="http://www-och.uni-graz.at/">http://www-och.uni-graz.at/</a>
 TU Graz, Institute for Combustion Engines and Thermodynamics	Diesel engine tests with a variety of different Biodiesel fuels (rapeseed, sunflower, recycling oils etc.) in stationary and transient cycle tests. Tests in heavy duty diesel engine (6 cylinder, 12 m <sup>3</sup> volume, common rail fuel injection equipment), with electronically optimized fuel injection timing.  Website: <a href="http://fvkma.tu-graz.ac.at/">http://fvkma.tu-graz.ac.at/</a>
 IMU - Institute for Mineral-oil and Environmental Analysis in Vienna	Involved in the development of the Austrian and the European fuel standard for Biodiesel (ON C 1190 & ON C 1191, EN 14214). Quality management for both fossil and Biodiesel.  Website: <a href="http://www.imu.at">http://www.imu.at</a>
 Joanneum Research in Graz	Research on greenhouse gas emissions and transportation systems.  Website: <a href="http://www.joanneum.at">http://www.joanneum.at</a>


- **Production Development**

Presently there are 6 commercial production plants (ranked by capacity):

Name	Details
 Biodiesel Raffinerie GmbH	Capacity: 40 000 t/a Feedstock: Multi-feedstock, mainly recycled oil and fat  Website: <a href="http://www.energea.at">http://www.energea.at</a>
	Capacity: 25 000 t/a (after initial 15 000 t at start-up) Start up: 10/1992 Feedstock: rapeseed oil, recycled frying oils Branch of Novaol recently acquired by Bunge

<p>Ölmühle Bruck Ges.m.b.H.</p>	<p>Website: <a href="http://www.novaol.it/english">http://www.novaol.it/english</a></p>
 <p>Biodiesel Kärnten GmbH</p>	<p>Capacity: initially 25 000 t/a, to be increased to 50 000 t/a Start: June 2003 Feedstock: Multi-feedstock, mainly recycled oils  Website: <a href="http://www.biodiesel-kaernten.com/">http://www.biodiesel-kaernten.com/</a></p>
 <p>Südsteirische Energie- und Eiweißherzeugungsgenossenschaft</p>	<p>Capacity: 6 000 t/a; Feedstock: rapeseed oil and recycled frying oil Farmers' co-operative  Website: <a href="http://www.seeg.at/">http://www.seeg.at/</a></p>
<p>RME Treib- &amp; Heizstoffherzeugung, Starrein</p>	<p>Capacity: 1 500 t/a Feedstock: rapeseed oil Farmers' co-operative A-2084 Starrein</p>
 <p>BAG Güssing</p>	<p>Capacity: 1 000 t/a Feedstock: rapeseed oil Farmers' co-operative  Website: <a href="http://www.bag-guessing.at">http://www.bag-guessing.at</a></p>

One further processing plant is in the start-up phase:

Name	Details
	<p>Capacity: 20 000 t/a In the start-up phase Website: <a href="http://www.bioenergy.co.at/">http://www.bioenergy.co.at/</a></p>