Biodiesel

An Environmentally Friendly Form of Renewable Energy
A New Liquid Fuel for the Transport and the Heating Sector

Summary
of
A. Environmental Benefits
&
B. Macroeconomic Benefits

Having observed lengthy and sometimes fruitless discussions over pros and cons of single properties of Biodiesel as a new fuel the following summary tries to give a picture as complete as possible by compiling all the key differential advantages of Biodiesel which have been identified in a number of in-depth studies on Biodiesel in the past years in the European Union and in the USA.

Wherever possible those key features of Biodiesel were translated into product advantages in comparison to fossil Diesel which ultimately are resulting in an economic benefit for society.

In some cases a precisely defined price tag can be put to those benefits, in some other cases there is a clear indication of a financially measurable benefit but quantification needs further detailed work. With this compilation we hope to provide a number of arguments for more serious and balanced discussions about strengths and weaknesses of the new fuel Biodiesel.

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(Werner KÖRBITZ - Austrian Biofuels Institute) Vienna; 15. August 1998

A: Environmental & Health Benefits :

1. Less Greenhouse Effect - Global Pollution :

The potential threat of a climatic change triggered by an accumulation of greenhouse gases in the atmosphere is one of the great concerns of our society today (lit. # 19) which explains the great interest Biodiesel and the fuel's potential to contribute to a greenhouse gas reduction has found all over the world.

Very detailed cradle-to-grave research within complete life cycle analysis has come to the following conclusion about the reduction of CO_2 and CO_2 -equivalent gases (e.g. Methane, N_2O) when applying Biodiesel:

Production of CO_{2eq} per 1 kg DFE (Diesel Fuel Equivalent = 42,7 MJ):

- ***Biodiesel produces: 0,73 kg CO_{2eq} / 1 kg DFE***
- ***fossil Diesel produces: 3,63 kg CO_{2eq} / 1 kg DFE***

In a nearly closed photosynthesis cycle CO_2-emissions of Biodiesel are taken up again by the green oilseed plant which results in a reduction by 2,90 kg CO_{2eq} -emissions per 1 kg Biodiesel in average. (lit. # 6, 7)

Average costs for industrialised countries per ton of avoided CO_2 have been estimated with US$ 220 which translates into

avoiding CO_2-cost of US$ 0,64 per 1 kg Biodiesel.

as calculated by the German Fraunhofer Institute in a study financed by the European Commission. (lit. # 17)

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2. Less Local Air Pollution :

Caused by the constantly growing traffic in urban areas air quality and hence life quality has deteriorated, specifically for health risk groups. Because of those risks various initiatives have been taken to improve the health situation of urban population, e.g.:

- the EU Council Directive on Quality of Petrol and Diesel fuel (lit. # 18),
- the regulation and increasing restriction of certain harmful emissions (e.g. EURO 2),
- the Clean Air Act and related programmes (Clean City Networks) in the USA,
- the development of efficient exhaust emission treatment tools, such as the oxidation catalytic converter or „oxicat".

On the fuel side Biodiesel has an effect on the following emissions:

Type of emission	**Change of emissions for Biodiesel compared to fossil Diesel approx. in %**	**Comments** **type of engine in test: modern EURO 2 with oxicat**
SO_x Sulphur oxides	**- 99**	The new Council Directive for quality fuels has set a new limit of max. 350 mg/kg fossil Diesel. Biodiesel is meeting this requirement since the very beginning and has by nature only traces of sulphur of below 50 ppm.
CO Carbonmonoxide	**- 20**	
NO_x Nitrous oxides	**+ 1**	
NO_x *with optimised engine !*	**- 23**	Substantial reduction by a 5° delayed injection adjustment
PM Particulate matter	**- 39**	
HC Hydrocarbons	**- 32**	
Soot	**- 50**	Improvements up to three times under high load
Biodiesel has by nature an already „built-in" oxygen content of approx. 10 % in the molecule which results in improved combustion and less emissions.		

Above figures can vary according to engine type and test cycle. (lit. # 8, 13, 16)

Cost to society can be demonstrated by the example of the city of Paris (lit. # 20) where during a smog period in October 1997 all vehicles with even/uneven numbers were banned intermittently and public transport was free at a

cost of approx. 1 mill GB £ per day to the city budget.

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3. No Acute Toxicity :

Biodiesel as a natural plant oil derivative exhibits a low toxicity similar to food oil, i.e. in feeding tests on rats no toxic effect was noted up to the maximum possible feeding ration.

The toxicological results are, that the

- ***acute oral LD_{50} : is beyond 2.000 mg / kg body weight,***
- ***acute dermal LD_{50} : is beyond 2.000 mg / kg body weight,***

(LD_{50}: lethal dose through which 50 % of a tested rat population die)

i.e. no toxic effects were observed. It has to be mentioned that fossil Diesel contains poly-cyclic aromatic hydrocarbons of higher toxicity e.g. Benz[a]pyren, which is considered to be a carcinogen (lit. # 21).

The benefit is that with accidental swallowing of or skin exposure to Biodiesel one can expect ***minimal health risks.*** (lit. # 1)

4. High Flash Point :

The flash point describes the inflammability, i.e. how quick a fuel can catch fire during accidents or caused by carelessness. Fuels with a flash point of lower than 100 °C require special safety equipment for transport and storage.

The requirements by fuel standards according to Biodiesel - DIN E 51606 and fossil Diesel - EN 590 (lit. # 15) are for

Biodiesel: > 110 ° C

fossil Diesel: > 55 ° C

Due to the real flash point of up to 170°C Biodiesel is by nature a *very safe fuel* and hence

reduces cost for security investments in transport and storage.

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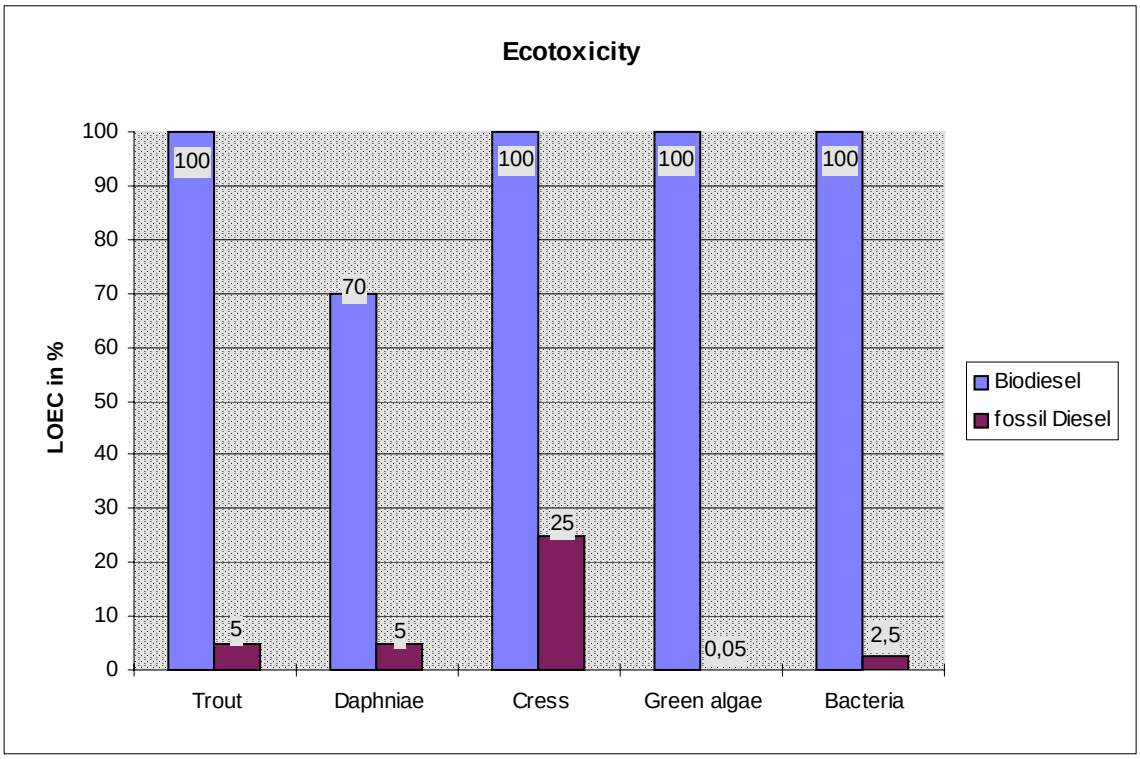
5. Less Risk for Water Organisms :

In case of accidental spillage of fuels into open waterways damage can occur to water organisms. Comparative toxicity trials with Biodiesel and fossil Diesel have given following results:



LOEC: **L**owest **O**bserved **E**ffect **C**oncentration in % of stock solution, when organisms show the first signs of being affected by a compound, e.g. 100 % of the stock solution with Biodiesel has no effect on trout, whereas already 5 % of the same solution with fossil Diesel has shown negative effects. (lit. # 3,4,14)

The benefit is that in case of accidental spillage of Biodiesel into rivers and lakes

the risk to fish and other animals and plants is significantly reduced.

This is correspondingly confirmed by the ***German Water Hazard Classification*** („Wassergefährdungsklasse“ = WGK) where Biodiesel is in ***class 1*** and the more toxic fossil Diesel is in class 2.

Latest research indicates a repositioning of Biodiesel into WGK-class 0 in near future. (lit. # 5)

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6. Rapid and Full Biodegradability :

The degradation of a compound through microbial activity in soils is called the biodegradability. The result according to the standard test is for

- ***Biodiesel : more than 95 % are degraded after 21 days,***
- ***fossil Diesel : about 72 % after 21 days.***

Biodiesel as a natural product is perceived as a food substance by soil microbes. Although fossil Diesel fuel is not considered as a very toxic compound its biodegradability is much lower and remaining residual (and more toxic) compounds have a much longer persistence in the soil.(lit. # 2)

The benefit is that in case of accidental soil pollution Biodiesel is degraded rather rapidly by biological activity while fossil Diesel on the contrary usually contains polycyclic aromatic hydrocarbons (e.g. Benz[a]pyren) of higher toxicity and of much lower degradability therefore showing a higher persistence in the soil.

The risk for soil contamination is significantly reduced - as are the cost for decontamination.

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B. Macro - Economic Benefits :

Beyond the direct environmental benefits of Biodiesel there are also significant macro-economic benefits to society such as:

1. Fossil Energy Saving Effect :

Every applied litre of ***Biodiesel saves 0,91 - 0,76 kg mineral-oil*** as a finite source of fossil energy, i.e. it extends the possible utilisation of valuable mineral oil sources for later years and for more important usage than just burning. (lit. # 6) Certainly mineral oils will not decline in value in the coming years.

While there are efforts to switch more and more to renewable forms of energy are continuously increasing world-wide the financially *quantified benefit of* ***the factor renewability*** (e.g. as a factor of increased energy supply security) is not fully explored, but most probably represents the by far leading benefit above anything else.

2. Energy Balance:

Evaluating energy input for Biodiesel production versus energy output the energy balance for Biodiesel is

positive with an 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. (lit. # 16)

3. Strategic Cost to Assure Security in Energy Supply:

Example U.S.A.:

More than 60 % of known mineral oil reserves are located in the politically unstable area of Near East. The needed presence of strategic forces on the spot is a cost directly related to the protection of mineral oil supplies from there.

A strategic study (lit. # 12) evaluated all these costs of generating and sustaining US military forces in peacetime in the Persian Gulf with US $ 60 billion which in relation to total US imports of 6,2 billion barrels (1992) results in

US national security cost of US$ 9,70 per barrel mineral oil.

This cost is a daily fact to the US tax payer, - it is however not paid at the fuel station pump but out of the general public budget with no transparency at all to the US citizen and Diesel fuel customer. (1 barrel = 159 litre)

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4. Employment Effect:

Example Germany:

In a recent input-output-study of the IFO-Institute in Munich / Germany (lit. # 9) evaluating the macro-economic impacts of a 300.000 to/year Biodiesel production resulted in a

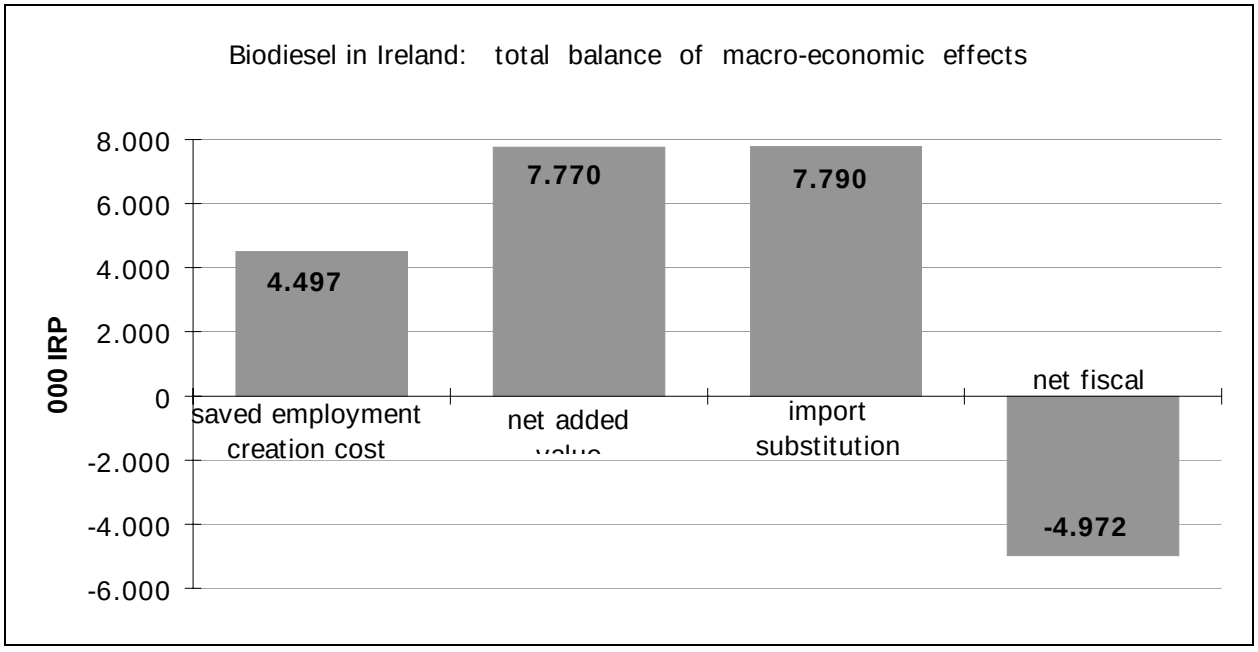
total employment effect for 4.830 employed persons.

Those jobs are located in rural areas, in the industry and in the trade, - mostly in small and medium sized enterprises as the key motor of any national economy.

5. Impact on Macro - Economics:

Example Ireland:

Domestic production of Biodiesel reduces costs for energy imports at the same time as it saves protein meal imports. Furthermore the effect on the national gross product is positive due to a better valorisation of domestic resources. (lit. # 10, 11)



Biodiesel saves employment creation cost for 324 persons (assuming 30.000 to of Biodiesel production) thus ***saving the state budget 4,5 mill Irish £.***

Assuming full detaxation the total balance ends up with

a benefit for the state budget of 15,0 mill Irish £.

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