Rapeseed for bio diesel production – international legal requirements and environmental benefits

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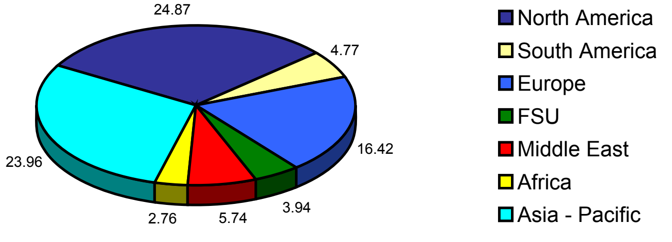
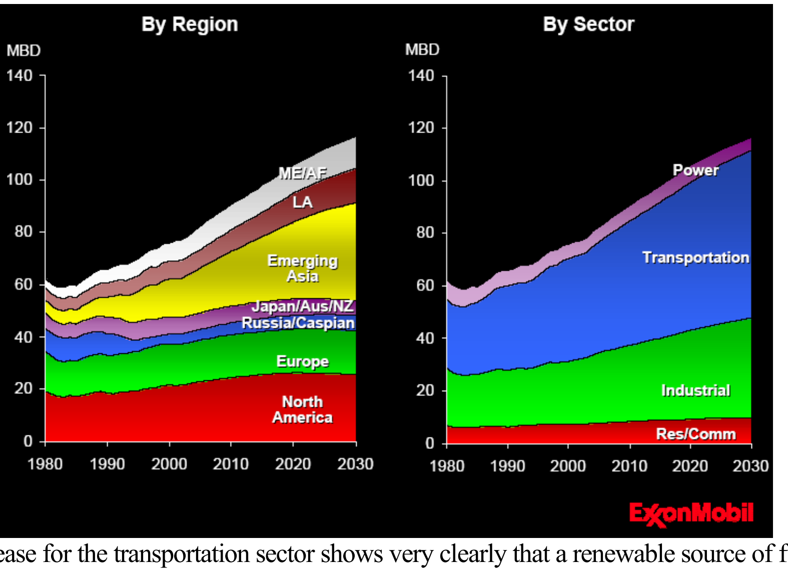
The earth contains a wide variety of carbon reservoirs that can be harnessed to meet society's power requirements, in the form of gaseous, liquid and solid fuels with liquid fuels having the most importance. The modern world has come to rely, almost exclusively, on fossil based reserves, a non-renewable resource, for the production of liquid fuels. The total consumption in 2005 was 82.46 m bbl/d with the following distribution between the different regions (source BP Energy Review 2006):



Asia will face a strong increase in its demand in the future and especially the transportation sector will increase dramatically.



The predicted increase for the transportation sector shows very clearly that a renewable source of fuel is required in order to meet the future energy needs of the world. The first generation of bio fuels replacing fossil fuels are bio ethanol and bio diesel.

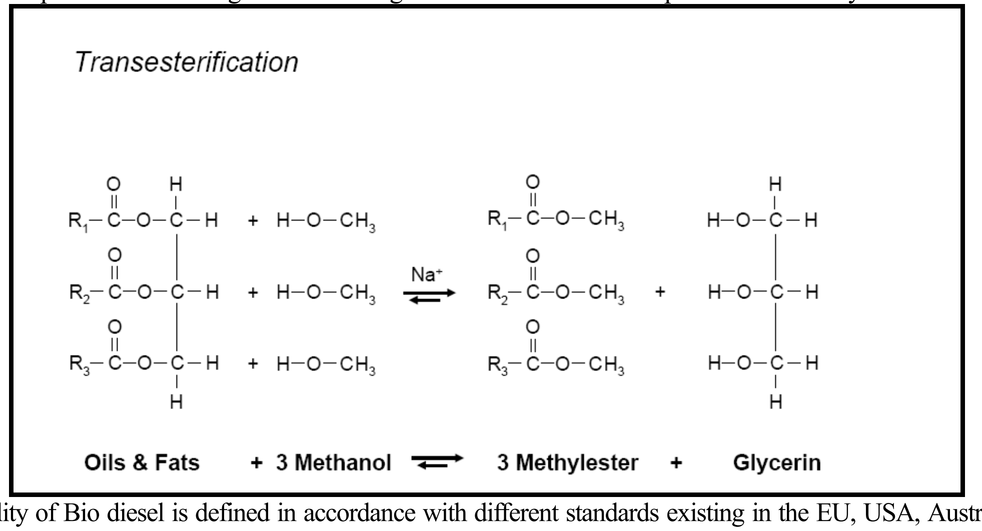
Bio diesel is a renewable liquid fuel source that can be used as an alternative to petroleum diesel fuel. Bio diesel is 100 % soluble in fossil diesel and can be used in blends without any modifications of engines. The commercial bio diesel industry is a relatively new industry and the commercial market for bio diesel a young market.

Vegetable oil, the raw material that bio diesel is made from, is stored solar energy in a high density and bio diesel has approximately 90% of the energy potential of petroleum diesel. The chemical formula is on average $C_{60}H_{120}O_6$.

From environmental performance standpoint bio diesel contents no heavy metals or sulphur and burns much more cleanly than petroleum diesel with reductions in most pollutant levels noted (carbon black: up to 50 %, PAH: up to 80%). Bio diesel has a nearly closed CO_2 cycle, since the combustion of bio diesel produces as much CO_2 as the plant consumes during growing. Global climate change is one of the key concerns of the 21st century with serious implications for societies, environment and economies. The replacement of fossil fuel through bio diesel can help to avoid a lot of greenhouse gas emissions. Furthermore, in the case of a spill, bio diesel is a fairly environmentally benign chemical that is fully biodegradable. Conversely, petroleum diesel releases into the environmental are a serious threat to the ecosystems receiving these chemicals because many of the components of petroleum diesel are carcinogenic and persistent. Bio diesel is a promising alternative to petroleum diesel.

Additionally bio diesel can support the agricultural development in rural areas and is an important income for this profession.

Bio diesel is produced out of vegetable oil through transesterification in the presence of a catalyst.



The quality of Bio diesel is defined in accordance with different standards existing in the EU, USA, Australia, Canada, Indian, Korean and Brazil. Many other states are at the moment working on their standards and legal framework conditions for their respective countries.

The tables in annex I show a comparison of existing Bio diesel standards and their different quality criteria:

Rapeseed-oil represents, by far, the leading feedstock in Europe used for the constantly increasing Bio diesel production and this position has become even stronger with the further expansion of the European Union into the EU-25. Rapeseed-oil is the most important feedstock in Europe due to its following favourable properties:

- relatively high oxidation stability
- acceptable winter operability
- high yields of up to 2 t rapeseed oil/ha

Bio diesel out of rapeseed oil has very excellent cold flow properties. Therefore especially in countries with cold winters rapeseed is at the moment the most favourable feedstock, fulfilling all standards and the demand for rapeseed will continue to increase in the coming years.

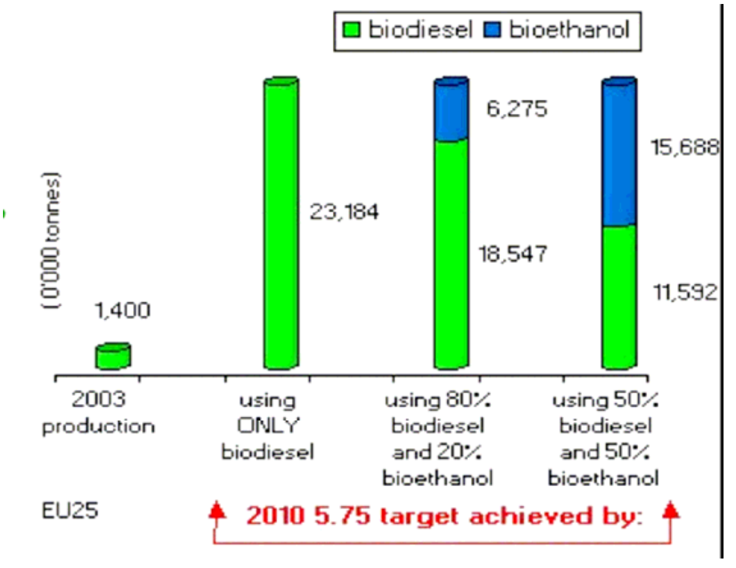
Internationally there are different regulations for the implementation of bio fuels. The EU uses the mechanism to define market share targets for their member states. The EU member states use in their countries different national legislation for implementation like:

- Fuel tax breaks for biofuels
- Quota systems
- Substitution requirement for fuel suppliers/distributors
- Incentives to R&D in the field of biofuels
- Public procurement
- Tax reduction and incentives
- Capital grants for biofuel production facilities
- Awareness raising actions

Other systems are for example in USA where feedstock usage is subsidized and Australia where renewable energy usage is requirerd. Many countries are at the moment working on similar directives like the EU or thinking about possible regulations.

The EU released a directive for the use of bio fuels in May 2003, EU Directive 2003/30/EC "Promotion of the use of bio fuels or other renewable fuels for transport". This directive sets out national targets for bio fuels. Since October 2005 2% of the complete fuel consumption in the EU has to be substituted by bio fuels. The EU-directive regulates a continuous increase of substitution up to 5.75% in 2010. The market share shall be calculated on the basis of the energy content of all petrol and diesel used for transport purposes.

This fact will lead to a continuous increase in the demand for bio diesel in Europe. The EBB–European Biodiesel Board (source R. Garofalo, National Biodiesel Conference 2006, San Diego) estimates the following demand for bio fuels in Europe at 2010 to fulfil the EU Directive 2003/30/EC:



Region/Country	European Standard EN 14214			US Biodiesel Standard ASTM D6751			Canadian Biodiesel Standard
Criteria	Test method	Unit	Treshhold value	Test method	Unit	Treshhold value	
Ester Content	EN14103	% (m/m)	> 96,5				Canadian General Standards Board
Cetane Number	EN ISO 5165		> 51	D613		⩾47	supports ASTM D6751 or the
Density (15°C)	EN ISO 3675, EN ISO 12185	kg/m3	860 - 900				European biodiesel standard EN 14214.
Sulphur Content	EN ISO 20846, EN ISO 20884	mg/kg	⩽10.0	D5453	mg/kg	⩽0.15	
Flashpoint	EN ISO 3679	°C	⩾120	D93	°C	130	
Cloud Point	EN 23015	°C	⩽-2	D2500	°C	Report	
Pour Point	ISO 3016	°C	⩽-9				
Linolenic acid methylester content	EN 14103	% (m/m)	⩽12.0				
Viscosity (40°C)	EN ISO 3104	mm2/s	3.50 – 5.00	D445	mm2/s	1.9-6.0	
Oxidation stability (110°C)	EN 14112	h	⩾6.0				
Copper strip corrosion (3h at 50°C)	EN ISO 2160		⩾class 1	D130		⩽No. 3	
Carbon residue (on 10% distillation)	EN ISO 10370	% (m/m)	⩽0.30				
Carbon residue (on 100% distillation)				D4530	% mass	⩽0.05	
Sulphated ash	ISO 3987	% (m/m)	⩽0.02	D874	% mass	⩽0.02	
Water content	EN ISO 12937	mg/kg	⩽300	D2709	% volume	⩽0.05	
Total contamination	EN 12662	mg/kg	⩽24				
Acid value	EN 14104	mg KOH/g	⩽0.50	D664	mg KOH/g	⩽0.80	
Iodine value	EN 14111	g Iodine/100 g	⩽120				
Polyunsaturated methyl ester (⩾4 double bonds)	EN 14103	% (m/m)	⩽1.0				
Methanol content	EN 14110	% (m/m)	⩽0.20				
Monoglycerid content	EN 14105	% (m/m)	⩽0.80				
Diglycerid content	EN 14105	% (m/m)	⩽0.20				
Triglycerid content	EN 14105	% (m/m)	⩽0.20				
Free glycerin content	EN 14105, EN 14106	% (m/m)	⩽0.02	D6584	% mass	⩽0.02	
Total glycerin	EN 14105	% (m/m)	⩽0.25	D6584	% mass	⩽0.24	
Alkaline metals group I (Na + K)	EN 14108, EN 14109	mg/kg	⩽5.0				
Alkaline metals group II (Ca + Mg)	EN 14538	mg/kg	⩽5.0				
Phosphorous content	EN 14107	mg/kg	⩽10.0	D4951	mg/kg	⩽10.0	
Distillation temperature, atmospheric equivalent temperature, 90% recovered				D1160	°C	⩽360	
Lubricity (50°C)							
Cold-filter plugging point			Regional specific				
Source:				G. Knothe (2004): The Biodiesel Handbook. AOCS Press			Canadian Renewable Fuels Association

Region/Country	Provisional Brazilian Biodiesel Standard ANP 255 (2003)			Indian Biodiesel Standard IS 15607			Korean Biodiesel Standard		
Criteria	Test method	Unit	Treshhold value	Test method	Unit	Treshhold value	Test method	Unit	Treshhold value
Ester Content					% (m/m)	> 96,5	EN 14078	% (m/m)	> 96,5
Cetane Number	EN ISO 5165		> 45			> 51			
Density (15°C)					kg/m3	860 - 900	KS M 2002	kg/m3	860 - 900
Sulphur Content	D5453	mg/kg	⩽ 0.10		mg/kg	⩽ 50.0	EN ISO 20846, EN ISO 20884	mg/kg	⩽ 10.0
Flashpoint	ISO/CD 3679	°C	⩾100		°C	⩾ 120	EN ISO 3679	°C	⩾ 120
Cloud Point					°C	⩽ -2			
Pour Point					°C	⩽ -9			
Linolenic acid methylester content					% (m/m)	⩽ 12.0			
Viscosity (40°C)					mm2/s	2.50 – 6.00	KS M2014	mm2/s	1.9-5.5
Oxidation stability (110°C)	EN 14112	h	⩾ 6.0		h	⩾ 6.0	EN 14112	h	⩾ 6.0
Copper strip corrosion (3h at 50°C)	EN ISO 2160		⩾ class 1			⩾ class 1	KS M 2018		⩽ class 1
Carbon residue (on 10% distillation)	EN ISO 10370	% mass	⩽ 0.50		% (m/m)	⩽ 0.05	EN ISO 10370	% (m/m)	⩽ 0.10
Carbon residue (on 100% distillation)									
Sulphated ash	D874, ISO3 987	% (m/m)	⩽ 0.02		% (m/m)	⩽ 0.02			
Water content	D2709		⩽ 0.20		mg/kg	⩽ 300	KS M 2115	% volume	⩽ 0.50
Total contamination					mg/kg	⩽ 24			
Acid value	EN 14104	mg KOH/g	⩽ 0.80		mg KOH/g	⩽ 0.50	KS M ISO 6618	mg KOH/g	⩽ 0.50
Iodine value	EN 14111	g Iodine/100g	⩽ 120			to report		no specification	
Polyunsaturated methyl ester (⩾4 double bonds)									
Methanol content	EN 14110	% (m/m)	⩽ 0.50		% (m/m)	⩽ 0.20	EN 14110	% (m/m)	⩽ 0.20
Monoglycerid content	EN 14105	% (m/m)	⩽ 1.00		% (m/m)	⩽ 0.80			
Diglycerid content	EN 14105	% (m/m)	⩽ 0.25		% (m/m)	⩽ 0.20			
Triglycerid content	EN 14105	% (m/m)	⩽ 0.25		% (m/m)	⩽ 0.20			
Free glycerin content	EN 14105, EN 14106	% (m/m)	⩽ 0.02		% (m/m)	⩽ 0.02			
Total glycerin	EN 14105	% (m/m)	⩽ 0.38		% (m/m)	⩽ 0.25	KS M 2412	% (m/m)	⩽ 0.24
Alkaline metals group I (Na + K)	EN 14108, EN 14109	mg/kg	⩽ 10.0			to report	EN 14108, EN 14109	mg/kg	⩽ 5.0
Alkaline metals group II (Ca + Mg)						to report	EN 14538	mg/kg	⩽ 5.0
Phosphorous content	EN 14107	mg/kg	⩽ 10.0		mg/kg	⩽ 10.0	EN 14107	mg/kg	⩽ 10.0
Distillation temperature, atmospheric equivalent temperature, 90% recovered									
Lubricity (50°C)							KS M ISO 12156-1Na	µm	⩽ 460
Cold-filter plugging point								no specification	
Source:	G. Knothe (2004): The Biodiesel Handbook. AOCS Press						Korea Petroleum Quality Institute		

The EU countries handle the implementation of this directive in different ways. The most effective way is to support bio diesel by compensating its higher cost (in comparison to fossil diesel) by removing the fuel tax, levied on fossil diesel, from bio diesel. At the moment this or the addition of additional taxes on fossil fuels that contain no bio diesel appears to be the most popular in Europe. Increasing fossil oil prices and the more economic production of bio diesel will lead to a more competitive price for bio diesel in the future.

Conclusion

Bio diesel like other bio fuels will show an increased demand in the coming years. Driving factors are the environmental benefits of bio diesel as well as the increase in demand and prices of fossil diesel. Bio diesel out of rapeseed shows favorable properties and is therefore especially in Europe widely used. Due to this fact the demand for rapeseed increased during the last years and can support the agricultural development in rural areas and is an important income for this profession.

Region/Country	Australian Biodiesel Standard 2003			New Zealand Biodiesel Standard NZS 7500:2500			Japan Biodiesel Standard	China Biodiesel Standard
Criteria	Test method	Unit	Treshhold value	Test method	Unit	Treshhold value		
Ester Content	EN 14103	% (m/m)	> 96,5		% mass	> 96,5	No Standard	No Standard
Cetane Number	EN ISO 5165		> 51			> 51		
Density (15°C)	ASTM D1298	kg/m3	860-890		kg/m3	860 - 900		
Sulphur Content	ASTM D5453, EN ISO 3675	mg/kg	⩽ 10.0		mg/kg	⩽ 50.0		
Flashpoint	ASTM D93	°C	⩾120		°C	⩾ 100		
Cloud Point								
Pour Point								
Linolenic acid methylester content								
Viscosity (40°C)	ASTM D445	mm2/s	3.5-5.0		mm2/s	2.0-6.0		
Oxidation stability (110°C)	EN 14112	h	⩾ 6.0		h	⩾ 6.0		
Copper strip corrosion (3h at 50°C)	ASTM DD130		⩽ No. 3			⩽ class 1		
Carbon residue (on 10% distillation)	EN ISO 10370	% mass	⩽ 0.30		% mass	⩽ 0.10		
Carbon residue (on 100% distillation)	ASTM D4530	% mass	⩽ 0.05		% mass	⩽ 0.05		
Sulphated ash	ASTM D874	% mass	⩽ 0.02		% mass	⩽ 0.02		
Water content	ASTM D2709	% volume	⩽ 0.50		mg/kg	⩽ 500		
Total contamination	EN 12662	mg/kg	⩽ 24		mg/kg	⩽ 24		
Acid value	ASTM D664	mg KOH/g	⩽ 0.80		mg KOH/g	⩽ 0.50		
Iodine value					g Iodine/100g	⩽ 120		
Polyunsaturated methyl ester (⩾4 double bonds)					% mass	⩽ 12.0		
Methanol content					% mass	⩽ 0.20		
Monoglycerid content					% mass	⩽ 0.80		
Diglycerid content								
Triglycerid content								
Free glycerin content					% mass	⩽ 0.02		
Total glycerin					% mass	⩽ 0.24		
Alkaline metals group I (Na + K)	EN 14108, EN 14109	mg/kg	⩽ 5.0		mg/kg	⩽ 5.0		
Alkaline metals group II (Ca + Mg)	EN 14538	mg/kg	⩽ 5.0		mg/kg	⩽ 5.0		
Phosphorous content	ASTM D4951	mg/kg	⩽ 10.0		mg/kg	⩽ 10.0		
Distillation temperature, atmospheric equivalent temperature, 90% recovered								
Lubricity (50°C)					µm	⩽ 460		
Cold-filter plugging point	TBA				no specification			
Source:	G. Knothe (2004): The Biodiesel Handbook. AOCS Press			B. Blackett (2006): Biodiesel developments in Auckland. Presentation at the "EECA Bio fuels Conference"			M. Shibuya (2005): A Study of Fuel Standards and Testing Methods for Biodiesel Fuel, presentation at "The First Japan-Korea Petroleum Technology Seminar"	