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An Overview of Biofuels and Policies in the European Union

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Abstract *Biofuels are liquid or gaseous fuels made from plant matter and residues, such as agricultural crops, municipal wastes and agricultural and forestry by-products. The term biofuels can refer to fuels for direct combustion for electricity production, but is generally used for liquid fuels for transportation. Biofuels are made from biomass through biochemical or thermochemical processes. Currently much attention is focused on utilization of ethanol, methanol, biodiesel, biocrude, and methane as biofuels. The European Union is on the third rank of biofuel production world wide, behind Brazil and the United States. In Europe, Germany is the largest, and France the second largest producer of biofuels. Most biofuels in commercial production in Europe today are based on sugar beet, wheat and rapeseed, which are converted to bioethanol/ETBE and biodiesel. The European Commission has set as a goal that by the end of 2005, 2% of the energy used in transportation shall be biofuels. The use of biofuels is then to grow by 0.75% annually. The ambition is to have 5.75% biofuels in transportation by 2010.*

Keywords biofuels, environmental impacts, European Union, policies, production

Introduction

It can be expected that in the countries belonging to the European Union (EU), the increase in the consumption of energy within the next twenty years will force these countries to pay more attention to renewable energy sources—probably biomass will be the most attractive one. The most important biomass streams include wood wastes, straw, deposits from sewage treatment plants, paper, etc. They can be used as direct substitutes for fuels, or they can be processed into liquid fuels as oils and alcohol. Also, biogas formed on the dumping sides and during the fermentation process of various organic sludges can play a considerable role as an energy source (Slupek et al., 2000).

The term biofuels can refer to fuels for direct combustion for electricity production but is generally used for liquid fuels for transportation. These include alcohols, esters, ethers, and other chemicals made from biomass (DOE, 2002). Biofuels are made from biomass through biochemical or thermochemical processes (DOE, 2000). Biofuels are being investigated as potential substitutes for current high pollutant fuels obtained from the conventional sources (Nwafor, 2004). Biofuels are important because they replace petroleum fuels. There are many benefits the environment, economy and consumers in using

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biofuels. Beyond energy benefits, development of biofuels promotes rural economies that produce crops used for biofuels. Advantages of biofuels are the following (Puppan, 2002):

- Biofuels represent a carbon dioxide (CO_2)-cycle in combustion, most of them have better emissions, and they are biodegradable and contribute to sustainability.
- Biofuels have a considerable environmentally friendly potential.

The increase in biofuels utilization has also been accompanied over the past 3–4 years with policy decisions that encourage future growth of these fuels. In North America, policies which help grain-based ethanol compete in the market were extended, and additional policies to increase biodiesel utilization are being discussed. In Europe, guidelines to ensure motor fuels contain certain levels of alternate fuels have been established, and biofuels are expected to be the primary way these goals are met. In South America, Brazil also continued policies that mandate at least 22% ethanol on motor fuels and encourage the use of vehicles that use hydrous ethanol to replace gasoline (Stevens et al., 2004).

Biofuels are liquid or gaseous fuels made from plant matter and residues, such as agricultural crops, municipal wastes and agricultural and forestry by-products. They can substitute conventional fuels in vehicle engines—either totally or partially in a blend. The major types of biofuels and their conversion technologies are described below and are illustrated in the production process diagram (EC, 2004). Biofuels sector is in turn composed of two distinct sectors: ethanol, which after transformation into ETBE (ethyl-tertiary-butyl-ether), serves as an additive for carburettor type petrol engines; and biodiesel that serves as an additive for diesel engines (EC, 2005).

In the past decade, the use of biofuels has increased dramatically to a total volume of approximately 30 billion (30×10^9) liters in 2003. The increase in the use of biodiesel has been particularly rapid, growing from essentially zero in 1995 to more than 1.5 billion liters in 2003. The use of ethanol and ethanol-derived ETBE has also grown steadily, experiencing a nearly 3-fold increase in a decade (Stevens et al., 2004). Brazil and the United States have the largest programs promoting biofuels in the world. Brazil, one of the world's largest producers of sugarcane, successfully implemented a subsidized ProAlcohol program.

Before tax, biofuels are currently appreciably more expensive than conventional fuels. The explanatory memorandum to the originally proposed Biofuels Directive states that biodiesel costs approximately €0.50/liter to manufacture, while replacing 1 liter of conventional diesel requires 1.1 liter of biodiesel. Mineral diesel costs (net of tax) some €0.20–0.25/liter. These figures suggest that pure biodiesel is on the order of 120–175% more expensive (Jansen, 2003).

Biofuels in the European Union

The EU is on the third rank of biofuel production world wide, behind Brazil and the United States. In Europe, Germany is the largest, and France the second largest producer of biofuels (Brand, 2004). Liquid biofuels, such as wheat, sugar, root, rapeseed, and sunflower oil, are currently being used in some member states of the European Union like Austria, Belgium, France, Germany, Italy, and Spain.

The continued growth of biofuels in the EU will depend on a number of economic and technological factors, combined with the set-up of adequate government measures to support the growth of biofuel production. The gradual rise in EU biofuel production recorded over the last couple of years has only been possible because of the proactive measures, both fiscal and promotional, taken in the various Member States concerned. Fuel tax systems are very fragmented throughout the EU, and large differences exist among EU Member States with regard to specific tax exemptions given for different fuel specifications.

Biodiesel in the EU

In Europe the most important biofuel is biodiesel. In the EU biodiesel is by far the biggest biofuel and represents 82% of the biofuel production (USDA, 2005). Biodiesel production for 2003 in EU-25 was 1,504,000 tons from nine countries (Table 1). Germany led production followed by France and Italy. All these countries increased production during 2003, in particular Germany and Italy, where the impact of legislation favorable to biodiesel is helping to encourage take-up. According to the European Commission's 2004 figures, Germany produced an estimated 715,000 tons in 2003, France produced 357,000 tons, and Italy produced 273,000 tons (EC, 2004).

Pure biodiesel use is predominant in Germany. Germany produced over half of the EU's biodiesel. 1,088,000 tons of biofuel were produced in Germany in 2004, marking a 52% growth in production. France and Italy are also important biodiesel producers, while Spain is the EU's leading bioethanol producer. In France, biodiesel production started in 1992. In 2004, the production capacity was 520,000 tons, which makes France the second largest biodiesel producer in Europe. In contrast to Germany, French biodiesel is exclusively sold as a mix with either up to 5% or up to 30% biodiesel added to fossil diesel (Brand, 2004).

Biodiesel production uses around 1.4 million hectares (ha) of arable land in the EU. The most important biodiesel producer is Germany (with about 40% of the production). There are approximately 40 plants in the EU; however, the number of plants and the

Table 1
EU-25 biodiesel production (tons)

Country	2002	2003	2004[a]
Germany	450,000	715,000	1,088,000
France	366,000	357,000	502,000
Italy	210,000	273,000	419,000
Czech Republic	68,800	70,000	47,000
Denmark	10,000	41,000	44,000
Austria	25,000	32,000	100,000
United Kingdom	3,000	9,000	15,000
Spain	—	6,000	70,000
Sweden	1,000	1,000	8,000
Poland	—	—	1,200
Hungary	—	—	2,000
Total (EU-25)	1,133,800	1,504,000	2,296,200

[a]Estimates.
Source: EC, 2004; USDA, 2005.

Table 2
Cost and return scenario for a 60,000 ton biodiesel plant

	Million euros
Income	
60,000 tons biodiesel @ €617/ton	37.03
7,500 tons 80% glycerine @ €500/ton	3.75
Undetermined amount of free fatty acids sold as livestock feed	
Total income	40.78
Expenses	
60,900 tons vegetable oil @ €520/ton	31.67
6,000 tons methanol @ €265/ton	1.59
Undetermined amount of NaOH included in variable costs	
Undetermined amount of HCl included in variable costs	
€30 million investment amortized over 10 years at 10% interest	4.70
Variable costs equal to fixed costs	4.70
Total cost	42.66

Source: USDA, 2003.

crushing capacity is growing quite fast. The plants are mainly located in Germany, Italy, Austria, the Czech Republic, France, and Sweden (USDA, 2005).

Europe's biggest biodiesel plant is going to be completed early 2005 in Teesside, and a second plant one year later. The £ 21m plant, with the capacity to produce 250,000 tons of biodiesel a year, uses renewable vegetable oils such as oilseed rape, palm, and soy as raw materials. The project would use technology licensed from energea of Austria. This is based on continuous flow biodiesel production, expected to be significantly more efficient and cheaper than traditional batch processing (AMFI, 2004).

The cost of biodiesel is higher than diesel fuel. Currently, there are seven producers of biodiesel in the United States. Pure biodiesel (100%) sells for about \$1.50 to \$2.00 per gallon before taxes. Fuel taxes will add approximately \$0.50 per gallon. A mix of 20% biodiesel and 80% diesel will cost about 15¢ to 20¢ more per gallon over the cost of 100% diesel (Hofman, 2003). Cost of biodiesel production is a generally accepted view of the industry in Europe that biodiesel production is not profitable without fiscal support. Table 2 shows cost and return scenario for a 60,000 ton biodiesel plant (USDA, 2003).

Bioethanol in the EU

Brazil's bioethanol production in 2003 was 9.9 million tons—over 20 times European production. All petrol sold in Brazil contains around 25% bioethanol (EC, 2004). The United States has used bioethanol produced from maize in fuel blends since the 1980s. The United States ethanol production, with corn as the primary feedstock, totaled 2,821 million gallons in 2003 and is projected to increase to 4,544 million gallons in 2025 (EIA, 2005).

In 2004, 3.4 billion gallons of fuel ethanol were produced from over 10% of the corn crop. Ethanol demand is expected to more than double in the next ten years. For the supply to be available to meet this demand, new technologies must be moved from

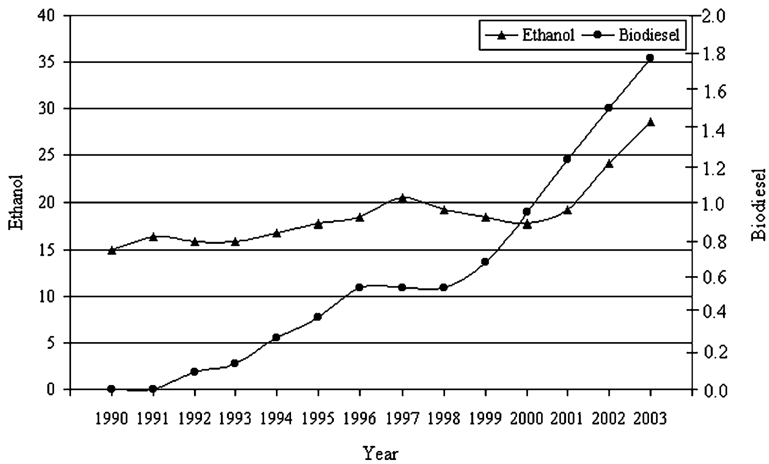

Figure 1. Fuel ethanol and biodiesel production, world total, 1990–2003 (billion liters). (*Source*: Fulton et al., 2004.)

the laboratories to commercial reality (Bothast, 2005). Figure 1 shows world ethanol and biodiesel production in 1990–2003.

Bioethanol production for 2003 was 446,140 tons in EU-25 (Table 3). Only five countries produced bioethanol. Spain is the largest producer with 180,000 tons in 2003. Spain is the leading bioethanol producer followed by Poland, France, Sweden, and the Czech Republic. The use of bioethanol as a direct blend in petrol is increasing. At present, France, Spain, and Poland convert most or all their bioethanol production into ETBE; Sweden and the Czech Republic use their bioethanol production directly (EC, 2004) via a chemical process ethanol can be transformed to ETBE, which can be added to petrol to up to 15%. ETBE consists of 47% ethanol and 53% fossil fuel (Brand, 2004). ETBE

Table 3
EU-25 bioethanol production in 2003

Country	Bioethanol (tons)
Germany	—
France	77,200
Italy	—
Czech Republic	5,000
Denmark	—
Austria	—
United Kingdom	—
Spain	180,000
Sweden	52,300
Poland	131,640
Total (EU-25)	446,140

Source: EC, 2004.

Table 4
ETBE production in EU in 2002

Country	ETBE production (tons)
Spain	375,500
France	192,500
Total	568,000

Source: EC, 2005.

production for 2002 in the EU was 568,000 tons from two countries. Table 4 shows ETBE production in the EU (EC, 2005).

In France ethanol transformation into ETBE started in 1993. Today the three existing facilities have a capacity of 219,000 tons/year. Around 800,000 tons of ethanol are currently produced in France, 75% of which are made of sugar beet and 25% of cereals. The high share of sugar beet is also due to the fact that 1 ha of sugar beet can produce 5.5 tons of ethanol whereas one hectare of wheat only brings 2.5 tons of ethanol. Eighty-five thousand to 100,000 tons of ethanol are used for ETBE production. Only 14,000 ha of the 440,000 ha of sugar beet produced in France every year are used for ethanol production (Brand, 2004).

The EU imports a large proportion of the ethanol it uses. The biggest exporter of ethanol to the EU is Pakistan, followed by Brazil and Guatemala. The reason for which Pakistan is a big supplier of ethanol is that due to the Generalized System of Preferences (GSP) Pakistan can sell ethanol to the EU with no taxes. This is an agreement that has been made because Pakistan is actively working against the production of narcotics in the country. This GSP has been prolonged until the end of 2006. Italy and the Netherlands are the biggest importers of ethanol in the EU. In the EU ethanol is subject to an import duty of €10.2 per hectoliter denatured alcohol and €19.2 per hectoliter undenatured alcohol. However, the EU has a number of free trade agreements with a number of third countries, and the EU has been negotiating an unprecedented free trade agreement with the Mercosur countries, including the biggest world alcohol producer Brazil (USDA, 2005).

Biogas in the EU

During the year 2002, the total production of crude biogas of the countries of the EU amounted to 2,762 ktoe (thousands of tons oil equivalent). European production took a 6.4% leap forward compared with the figures for 2001 (Table 5) (EC, 2005). However, biogas production used for heat or electricity stood at 2,304 ktoe in 2000 (Jansen, 2003).

The United Kingdom is the number one country in Europe with 952 ktoe produced in 2002. Biogas is one sector that has really been able to take advantage of the liberal framework established in Britain. Germany is found in second place position with 659 ktoe, recording a 9.8% advance with respect to 2001. As in the case of many other renewable energy sectors, Germany reaffirmed a strong will to diversify its energy panel. France holds an interesting third place position reinforced by a 13.2% growth rate with respect to 2001. This can be explained by several new sites that were put into service. The other member countries of the EU have clearly lower production figures. Nonetheless, the efforts made by Spain, which increased its production by 25.4% in one year, should be cited. Biogas sector valorizes different types of waste deposits. Biogas can be used

Table 5
Crude biogas production in 2002 in EU
(thousands of tons oil equivalent)

Country	2001	2002	Growth, %
United Kingdom	904	952	5.3
Germany	600	659	9.8
France	276	310	12.3
Spain	134	168	25.4
Italy	153	155	1.3
The Netherlands	161	134	−16.8
Sweden	112	115	2.7
Denmark	73	62	−15.1
Austria	56	59	5.4
Belgium	45	56	24.4
Greece	33	42	27.3
Ireland	28	28	0.0
Finland	18	18	0.0
Luxemburg	2	2	0.0
Portugal	1	2	100.0
Total	2,596	2,762	6.4

Source: EC, 2005.

as a source of energy to produce electricity, heat or a fuel gas. Overall, the EU counts from 4,190 to 4,390 units that make up its biogas installations. These figures represent an increase in the region of 7% in the number of installations with respect to the year 2000. Distribution of European biogas production per type of deposit is given Table 6 (EC, 2005).

The most important reason for the failure of biogas technology is that the initial cost is often prohibitive for most rural households. The typical cost of a simple, unheated biogas plant, excluding the cost of land, is between \$50 and \$75 per cubic meter capacity (IEA, 2001).

Table 6
Distribution of European biogas production per type of deposit

Deposits	Units	Production share, %
Landfill	450	38
Urban sewage	1600–1700	33
Industrial sewage	420	24
Agricultural biogas	1600–1700	2
Mechanization units of municipal waste	65	2
Collective co-digestion units	55	1

Source: EC, 2005.

European Biofuel Policy

The general EU policy objectives considered most relevant to the design of energy policy are: (1) competitiveness of the EU economy, (2) security of energy supply, and (3) environmental protection. All renewable energy policies should be measured by the contributions they make to these goals. Current EU policies on alternative motor fuels focus on the promotion of biofuels. In a proposed biofuels directive, the introduction of a mandatory share scheme for biofuels, including as from 2009 minimum blending shares, is presented in the Commission's view mandating, the use of biofuels will: (i) improve energy supply security; (ii) reduce greenhouse gas (GHG) emissions; and (iii) boost rural incomes and employment. Current regulations would preclude a notable negative impact on the rural environment (Jansen, 2003).

Elements of the European biofuels policy (EC, 2003):

- A Communication presenting the action plan for the promotion of biofuels and other alternative fuels in road transport.
- The Directive on the promotion of biofuels for transport which requires an increasing proportion of all diesel and gasoline sold in the Member States to be biofuel.
- The biofuels taxation, which is part of the large draft Directive on the taxation of energy products and electricity, proposing to allow Member States to apply differentiated tax rates in favour of biofuels.

In Europe, energy security coupled with rural development is a clear priority and the main driver for its renewable fuels policy. Another important driver in Europe is its commitment to the Kyoto Protocol and the need to cut GHG emissions from the transport sector. However, this argument has been disputed by the European Green Party and most environmental organizations who claim that the possible CO_2 benefits from biofuels are negligible and do not counterbalance the negative environmental impacts from intensive biofuel farming techniques (ACFA, 2004).

In the White Paper for a Community Strategy and Action Plan, entitled "Energy for the Future: Renewable Sources of Energy" (1997), the need for increasing the share of liquid biofuels has already been mentioned. It is stated that, at present, biofuels are not competitive due to the relatively low price of crude oil. Still, it is important to secure an increasing part of alternative fuels on the market because of unpredictable oil prices and long-term fossil resource depletion. The first priority that is identified in the White Paper is a decrease of production costs of biofuels. Other focus areas of focus are tax exemption and subsidized biomass growing initiatives. The first proposals by the Commission for making large-scale tax exemption measures possible date from this time. The small-scale incentives that are in force to stimulate pilot projects seem to be too limiting; market initiatives tend to go beyond the experimental stage. Whereas most activities in the biofuel sector took place in France, Austria, and Germany, the explicit goal has been to promote biofuels in all Member States. To this end, the White Paper announces to release additional directives in the years to come (Thuijl et al., 2003).

The Green Paper called "Towards a European Strategy for the Security of Energy Supply" (2000) stresses the importance of biomass in relation to supply security. Whereas the entire energy supply is at stake, all usage is promoted: generation of heat and electricity using biomass and the production of biofuels. It is stated that "the enormous potential of forest and agricultural residues has so far not been exploited." Advantages concern the emission of greenhouse gases ("between 40 and 80% less than fossil fuels"), local

Table 7
The targets for biofuels consumption stated in the initial Commission proposal for a Biofuels Directive

Year	%	Of which as a minimum in the form of blending, %
2005	2	—
2006	2.75	—
2007	3.5	—
2008	4.25	—
2009	5	1
2010	5.75	1.75

Source: Jansen, 2003.

environment ("less particulate and carbon monoxide and hydroxide"), and social aspects ("job creation in rural areas"). It is also stressed that intense agricultural production forms are undesirable (Thuijl et al., 2003).

The European Council meeting at Gothenburg on 15 and 16 June 2001 agreed on a Community strategy for sustainable development consisting in a set of measures, which include the development of biofuels. As a result of technological advances, most vehicles currently in circulation in the EU are capable of using a low biofuel blend without any problem. The most recent technological developments make it possible to use higher percentages of biofuel in the blend. Some countries are already using biofuel blends of 10% and higher. Captive fleets offer the potential of using a higher concentration of biofuels. In some cities captive fleets are already operating on pure biofuels and, in some cases, this has helped to improve air quality in urban areas. Bioethanol and biodiesel, when used for vehicles in pure form or as a blend, should comply with the quality standards laid down to ensure optimum engine performance. It is noted that in the case of biodiesel for diesel engines, where the processing option is esterification, the standard prEN 14214 of the European Committee for Standardization (CEN) on fatty acid methyl esters (FAME) could be applied. Accordingly, the CEN should establish appropriate standards for other transport biofuel products in the EU (EU, 2002).

The European Commission has set as a goal that by the end of 2005, 2% of the energy used in transportation shall be biofuels. The use of biofuels is then to grow by 0.75% annually. The ambition is to have 5.75% biofuels in transportation by 2010. The actual share of biofuels in European consumption today is estimated to be 1%. These goals are part of the main energy policy target of the EU which is to double the share of Renewable Energy Sources (RES) in gross inland consumption from 5.4% in 1997 to 12.0% by 2010 (USDA, 2005). The targets for biofuels consumption stated in the initial Commission proposal for a Biofuels Directive is given Table 7.

Biofuel Fields

In 2001–2002, 5.6 million ha of land not required for food production was set aside under compulsory or voluntary programs. This land could be used to grow biofuel crops.

Table 8
Land use requirements for different biofuel-crop combinations to meet the target

Biofuel-crop combination	EU-15, %	EU-25, %
All rapeseed	10.0–11.1	8.4–9.4
Half rapeseed, half wheat	9.0–15.5	7.6–13.1
Half sugar beet, half wheat	5.6–11.8	4.7–10.0
Half sugar beet, half woody biomass	4.8–6.4	4.1–5.4
All woody biomass	6.5–9.1	5.5–7.7

Source: USDA, 2005.

It represents a potential of 7–14 million metric tons per year of renewable biofuels for typical yields of 2–3 metric tons/ha for ethanol and 1–1.5 metric tons/ha for biodiesel, or the equivalent of 2.5–5% of the automotive fuel (gasoline or diesel used for transportation in Europe). Table 8 shows land use requirements for different biofuel-crop combinations to meet the target (USDA, 2005).

The projections about the average transport biofuel yield per crops assessed in EU-15 over the period 2005–2010 are presented in Figure 2. Figure 2 shows that the bioethanol yield in EU-15 normally is higher than the biodiesel yield. Under prevailing conditions, the average yields from biofuel crops in New Acceding Countries (NAC) and Candidate Countries (CC) are projected to be significantly lower, compared to those in EU-15 (Figure 3). Whilst for oilseeds, the average yields in NAC and CC will represent about 70% of the EU-15 average; for cereals (wheat), this proportion decreases to less than 60%. For this reason, the highest biodiesel yield per hectare in NAC and CC, in contrast with EU-15, is larger than the bioethanol revenue from the lowest ethanol-yielding crop—wheat (Kavalov, 2004).

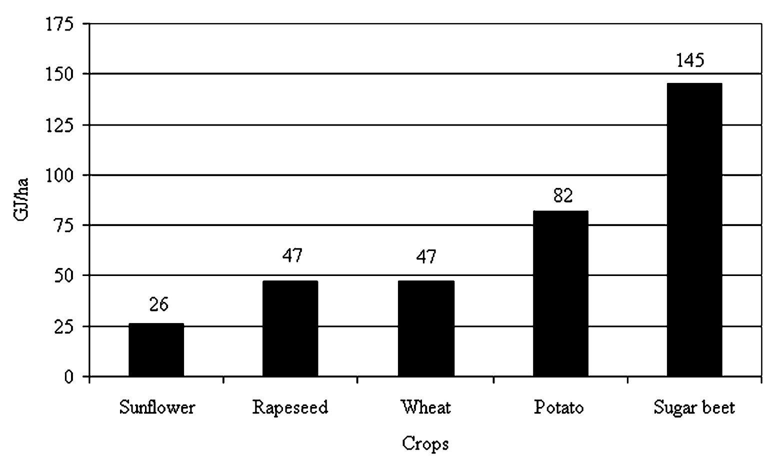

Figure 2. Prospective average biofuel yield from different crops in EU-15 over 2005–2010 (GJ/ha). (*Source*: Kavalov, 2004.)

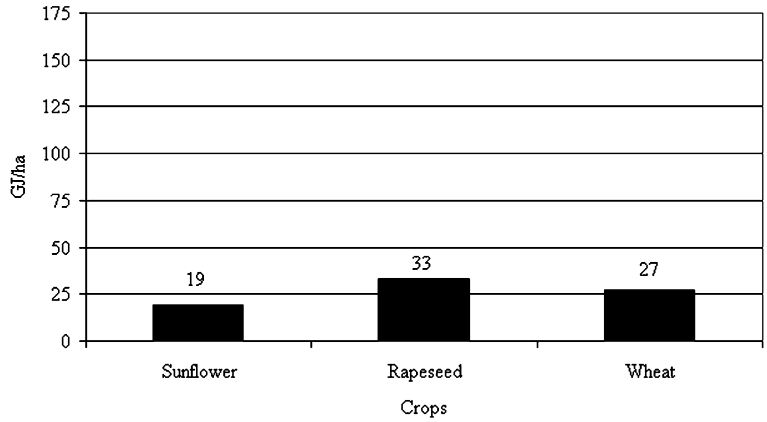

Figure 3. Prospective average biofuel yield from different crops in NAC and CC over 2005–2009 (GJ/ha). (*Source*: Kavalov, 2004.)

All together, it could be roughly considered that under most optimistic estimates, the average yields from sunflower and rapeseed in NAC and CC over the 2005–2010 period could reach 90% of the EU-15 average yields. For wheat, potato and sugar beet, this proportion could reach 70%. The corresponding approximate absolute biofuel yields by crops in NAC and CC, taken on average for the period 2005–2010, are presented in Figure 4. Figure 4 shows that the bioethanol yield in the OTP scenarios for NAC and CC normally would be larger than the biodiesel yield—a situation, similar to the EU-15 one (Kavalov, 2004).

Environmental Impacts

Producing and using biofuels for transportation offers alternatives to fossil fuels that can help provide solutions to many environmental problems. Using biofuels in motor vehicles

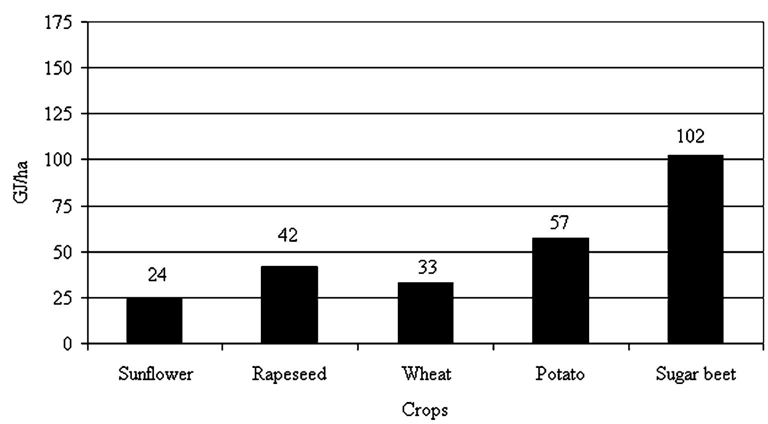

Figure 4. Projected approximate average biofuel yield from different crops in NAC and CC over 2005–2010 under most optimistic estimates (GJ/ha). (*Source*: Kavalov, 2004.)

helps reduce GHG emissions. Full-cycle analysis indicates that, on average, biofuels emit less CO_2 than conventional fuels (IEA, 2001). Due to the low or zero content of pollutants such as sulfur in biofuels, the pollutant (SO_2 etc.) emission of biofuels is much lower than the emission of conventional fuels. The use of biofuels, however, has some environmental drawbacks. The raw materials of biofuels are plants produced by the agriculture having some negative impacts on the environment (Puppan, 2002).

CO_2 savings from biofuels are agreed at 50–70% better than fossil petrol and diesel and some 30% better than road fuel gases (which have a 40 ppl rebate). Hence a blend of only 5% can deliver a 3% CO_2 saving. Low biofuels blends (5–10%) can reach the customer very easily through the existing fuel distribution networks (unlike gas) and without expensive engine conversions. In addition, the efficiency of fossil fuel combustion is increased by biofuel blends (up to about 20% inclusion) as biofuels are oxygenates (BABFO, 2003).

Using biodiesel in a conventional diesel engine substantially reduces emissions of unburned hydrocarbons, CO, sulfates, polycyclic aromatic hydrocarbons, nitrated polycyclic aromatic hydrocarbons, and particulate matter. These reductions increase as the amount of biodiesel blended into diesel fuel increases. The best emissions reductions are seen with B100. Scientists believe CO_2 is one of the main greenhouse gases contributing to global warming. Neat biodiesel (100% biodiesel) reduces CO_2 emissions by more than 75% over petroleum diesel. Using a blend of 20% biodiesel reduces CO_2 emissions by 15%. The use of biodiesel decreases the solid carbon fraction of particulate matter (since the oxygen in biodiesel enables more complete combustion to CO_2) and reduces the sulfate fraction (biodiesel contains less than 24 ppm sulfur), while the soluble, or hydrocarbon, fraction stays the same or increases. Emissions of NOx increase with the concentration of biodiesel in the fuel. Some biodiesel produces more NOx than others, and some additives have shown promise in modifying the increases. Therefore, pure biodiesel or blends of biodiesel with petroleum diesel are safer to store, handle, and use than conventional diesel fuel. In addition, pure biodiesel is essentially sulfur free and results in a total reduction of SO_2 emissions as well sulfate aerosols in particulate

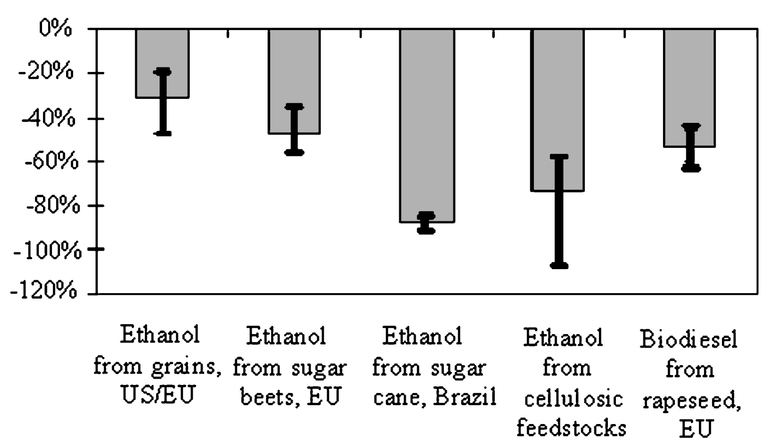

Figure 5. Range of estimated greenhouse gas reductions from biofuels. Note: Relative well-to-wheels CO_2-equivalent GHG emissions per kilometer from vehicles with various biofuel/feedstock combinations, compared to similar conventional-fuelled vehicles. (*Source*: Fulton, 2004.)

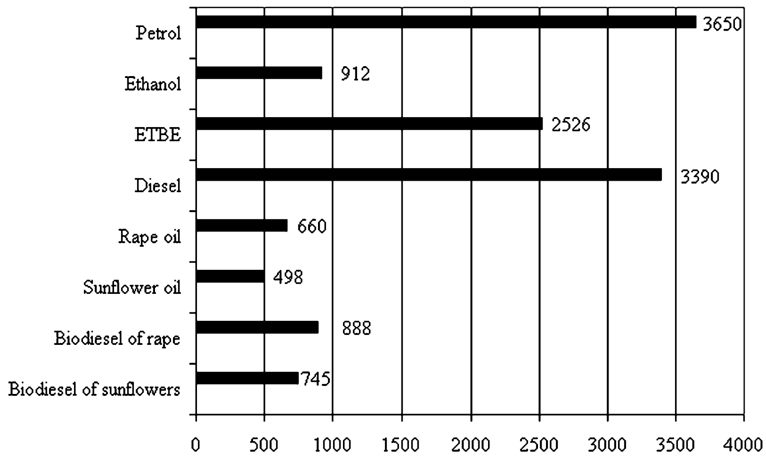

Figure 6. Biofuel greenhouse gas indicator (in CO_2 equivalents per kilogram). (*Source*: Brand, 2004.)

matter. These reductions should help increase both vehicle and catalyst life over time (Demirbas, 2003).

Ethanol and biodiesel provide significant reductions in GHG emissions compared to gasoline and diesel fuel, on a "well-towheels" basis. While a range of estimates exists, Figure 5 shows that most studies reviewed find significant net reductions in CO_2-equivalent emissions for both types of biofuels. More recent studies tend to make estimates toward the higher-reduction end of the range, reflecting efficiency improvements over time in both crop production and ethanol conversion. Few studies exist for sugarcane-to-ethanol, and the variation reported in these studies is small (Fulton, 2004). Figure 6 shows that, for example, ethanol emits 75% less CO_2 equivalents than petrol. This means that one hectare of sugar beet for ethanol would save four tons of carbon. ETBE which is made of more than 50% fossil fuel gives also comparatively positive results but to a much lesser degree: only 31% of CO_2 equivalents would be saved (Brand, 2004).

In Europe road fuels must meet 50 ppm sulfur limit from 2005. By 2002 these fuels had already attained a share of 47% for petrol and 43% for diesel, even though current limits are 150 ppm for petrol and 350 ppm for diesel. "Sulphur-free fuels" (<10 ppm) represented 2% of the market. This share is likely to expand due to a directive that will require all road fuels to be sulphur-free from 2009. Germany already offers tax incentives for the near zero sulphur fuel. In Finland, fuels below 10 ppm sulfur content get a tax incentive of 2.65 cnt/liter from 1 September 2004 (AMFI, 2004).

Conclusion

The EU is on the third rank of biofuel production world wide, behind Brazil and the United States. In Europe, Germany is the largest, and France the second largest producer of biofuels. In Europe the most important biofuel is biodiesel. In the EU biodiesel is the by far biggest biofuel and represents 82% of the biofuel production.

The European Commission has set as a goal that by the end of 2005, 2% of the energy used in transportation shall be biofuels. The use of biofuels is then to grow by 0.75% annually. The ambition is to have 5.75% biofuels in transportation by 2010.

The actual share of biofuels in European consumption today is estimated to be 1%. These goals are part of the main energy policy target of the EU which is to double the share of Renewable Energy Sources (RES) in gross inland consumption from 5.4% in 1997 to 12.0% by 2010.

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