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# **Policies and measures to promote market development of sustainable biofuels**

**Background document**

**Regional Workshop on “Promoting Sustainable Biofuels Production and  
Use in Central and Eastern Europe”,  
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# 1 INTRODUCTION

## *Policy environment*

The transport sector has experienced steady growth in transport volumes and is expected to continue increasing. Due to the sector's almost complete dependence on oil, concerns about security of supply are becoming more pronounced. Furthermore, greenhouse gas emissions of the transport sector are rising continuously and offset the reductions achieved in other sectors, thus putting the achievement of the Kyoto-Protocol and longer term climate change targets at risk.

Alternative motor fuels are seen as one option to help the transport sector in reducing both its dependence on oil imports and emissions of greenhouse gases. The European Commission has consequently set the objective to substitute 20% of motor fuel consumption by new and alternative fuels (i.e. biofuels, natural gas and hydrogen) by the year 2020 [EC, 2000].

Alternative motor fuels need to fulfil three major prerequisites in order to have the potential of gaining an important market share in the future:

- availability of suitable raw material and other feedstock for fuel production,
- infrastructure to support the storage and distribution of the fuel, and
- engines or other energy conversion devices compatible with the given fuel.

Biofuels are one of the more promising options in short term. A very important advantage is that they can be blended with conventional fuels up to a certain extent. They are thus compatible with most vehicles of today, and can use the existing refuelling infrastructure only with some minor adaptations. Adaptations of cars to high blends (E85) or pure biofuels requires more, yet still limited changes. The main difference of ethanol flexi-fuel vehicles with the neat petrol fuelled vehicles is the material used in the fuel system and modifications to the calibration of the fuel management system.

In addition to its availability and compatibility with today's fuelling system and its potential to reduce GHG emissions and oil imports, biofuels can create alternative outlets for farm produce. Thus, interactions between agricultural, energy and environment policies are key elements.

Biofuels are supported by several individual countries and at EU-level. The EU strategy on biofuels [EC, 2006a] and the Biomass Action Plan [EC, 2005a] build on the existing legal framework and identify need for further action. They formed the basis for the Council conclusions on bioenergy from June 2006. The cornerstone of the EU biofuels policy remains the biofuels directive [DIR, 2003a], which sets 'reference values' of 2% and 5.75% of transport fuels to be met by 2005 and 2010, respectively. In order to achieve these targets, Member States are allowed to exempt biofuels from taxes [DIR, 2003b], and to cultivate non-food crops on set-aside areas up to a certain amount [BHA, 1992]. Besides, premiums for energy crops were introduced to support the cultivation of bioenergy feedstock [REG, 2003], which was extended to cover all Member States [EC, 2006b]. A recent proposal for the revision of the fuel quality directive [EC, 2007a] includes changes to allow higher blends of bioethanol in gasoline (up to 10% from current 5% in volume terms). Similarly, the Commission asked the European Bureau for Standardisation (CEN) to revise the EU

norm for diesel, which currently sets a 5% limit for the biodiesel content in diesel fuel in volume terms.

On a Member State level, the introduction of biofuel tax exemption schemes has been most common. Recently, however, there is an increasing number of Member States that moved towards obligations for fuel suppliers to supply a certain amount of biofuels, including German, Austria and the Netherlands as well as France with a mixed system and the UK and Poland introducing an obligation by 2008. This change is mainly motivated by the important direct revenue losses for the governments, caused by tax exemptions.

Additionally, collaboration with car manufacturers took place in Member States with a successful deployment of biofuels. This was accompanied by the rapid development of national standards ensuring a consistent biofuel quality.

As a result of this support, consumption of biofuels increased substantially in the EU over the past decade. Production volumes of biodiesel and bioethanol grew by a factor of 4.5 and 3.1 between 2000 and 2005, with biodiesel remaining the dominant biofuel in the European with 81.5% of total biofuel volumes. Also on a global scale, the EU is by far leading the biodiesel market, while the European share in bio-ethanol is limited compared with Brazil and the USA.

But even though countries like Germany, France or Sweden played a pioneer role and established a significant and stable market for biofuels in their transport fuels, the average EU biofuel market is lacking behind expectations. On an EU average, biofuels reached a share of about one percent of all transport fuels sold by 2005, and the indicative 2005 target of the biofuels directive was met only by Germany and Sweden. It seems also unlikely that the current policies and measures will stimulate biofuel consumption to the extent needed to meet the 2010 target.

As part of the “renewables roadmap” [EC, 2006d; 2006e] that proposes a 20% share of all renewable energy sources in total energy consumption by 2020, a binding minimum target of 10% was proposed for the share of biofuels in transport. The Spring Summit of the European Council has accepted this proposal in March 2007.

This background document is mainly based on work carried out within the project PREMIA ([www.premia-eu.org](http://www.premia-eu.org)), which was a Specific Support Action, supported under FP6 of the European Commission. The PREMIA project aimed at supporting the European Commission's on-going work on alternative fuels. It provided input into the revision of the biofuels directive and discussed long-term, cost effective policy framework to support the market transition from conventional to alternative fuels for road transport.

## 2 BIOFUELS

Biomass-based fuels are mainly fuels that can substitute fossil-based diesel or petrol in order to minimise needs for additional infrastructure even though a number of other fuels can be produced. A distinction will be made between the so-called "conventional" or "first generation" biofuels and "advanced" or "2<sup>nd</sup> generation" biofuels.

**Conventional biofuels** characterise those fuels that are produced from a limited number of dedicated feedstock through established processes, which in essence are quite mature (such as fermentation and esterification). They mainly include biodiesel based on vegetable oils from e.g. rapeseed, sunflower, soybean or palms; and ethanol based on sugar and starch from e.g. sugarcane, sugar beet, corn, rye, barley, wheat and other cereals.

**Advanced biofuels** are products of processes which are not yet market mature. Compared to conventional biofuels, their key advantage is their suitability to make use of a broader variety of feedstock, in particular cellulosic feedstock and by-products. This is usually combined with a more challenging production technology (leading to higher capital costs). Ligno-cellulosic ethanol and synthetic diesel from biomass are considered to be part of this group.

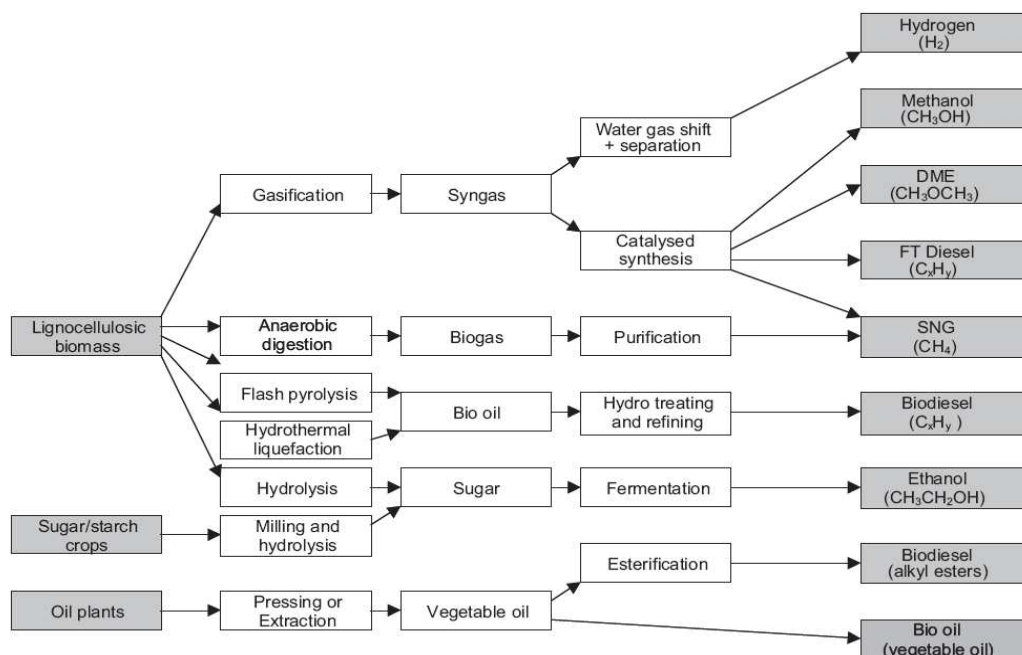


Figure 1: Overview of conversion routes to different biofuels (source: Hamelinck, 2006)

### 2.1 Ethanol

Conventional bioethanol can be produced from any biological feedstock that contains sugar or material that can be converted into sugar such as starch or cellulose. To date, the most widely used raw materials for bioethanol are sugar-cane (Brazil), corn (USA), sugar beet and cereals such as wheat, barley, rye (European Union), which are then processed by traditional fermentation.

Advanced, or ligno-cellulosic ethanol does not depend on a sugar- or starch-based feedstock but can use a much broader variety of feedstock, such as straw, maize stalks and wood straw etc. The ligno-cellulosic biomass is treated with enzymes and hydrolysis in order to extract sugar for ethanol production. While this is still a process in R&D and demonstration phase, it can build on major parts of conventional bioethanol plants. The final product is chemically identical with first generation bioethanol, but generally emits less GHG emissions on a well-to-wheel basis [JEC, 2006].

Ethanol has a lower energy content per volume than gasoline (around two thirds of gasoline). On the other hand, it has a higher octane rating. Due to the tendency to absorb water, transportation of ethanol is difficult as it cannot be shipped via pipeline [F.O. Licht, 2006].

Bioethanol can be used in different ways to replace fossil based fuels: as low blends (up to 10%) in the car fleet or high blends (85% and above) in dedicated flexi-fuel vehicles, or as ETBE to replace MTBE in the fuel production processes. In 2005, around 75% of bioethanol in Europe is used as ETBE [EC, 2007b].

The use of low blends of ethanol to gasoline is limited by its higher oxygen content and the increase of fuel vapour pressure at low blends of ethanol. The EU fuel quality directive [DIR 1998] currently allows a blending of up to 5% in volume terms, corresponding to a 3.4% share in energy terms. This is accepted by all car, engine and fuel injection system manufacturers. However, a recent proposal for its revision [EC, 2007a] suggests elevating the oxygen limit in order to enable the use of higher ethanol blends of up to 10%.

In high concentrations, ethanol is typically used as a blend of 85% ethanol and 15% petrol, known as E85. High blends of ethanol are mainly used in Flexi-Fuel-Vehicles (FFVs) that can operate on any blend of ethanol and petrol, from 100% petrol, up to 85% ethanol and 15% petrol. Ethanol FFVs are similar to petrol vehicles; their main differences are the materials used in the fuel management system to avoid corrosion and modifications to the engine calibration system to account for the lower volumetric energy content of ethanol.

Problems with vapour pressure and transportation of ethanol do not apply to ETBE (ethyl-tertiary-butyl-ether), which is produced by etherification of ethanol and isobutylene or natural gas. ETBE is an additive to enhance the octane rating of petrol as a replacement of the fossil MTBE (replacing lead and benzene in unleaded petrol) and to reduce emissions. ETBE currently presents the most frequent use of ethanol in Europe – about 75% of total bioethanol – and is welcomed by oil suppliers.

The fuel quality directive sets the maximum limit for the ETBE content in gasoline at 15% in volume terms. As the ethanol content of ETBE is 47%, exhausting the maximum level implies that a bioethanol content of some 7% by volume (4.6% by energy) can be achieved in the fuel through ETBE.

Finally, it needs to be mentioned that ethanol can also be blended to diesel. This is however not commercial yet, as it is difficult to stabilize the diesel-ethanol blend.

Ethanol can also replace methanol in the production process of biodiesel (FAME).

## 2.2 Biodiesel

Conventional biodiesel (also: fatty-acid methyl ester, FAME) is based on transesterification of vegetable oils or animal fats, which are derived mainly from rapeseed and sunflower in the EU. Oilseeds are crushed to produce vegetable oil and oil cake, a by-product used for animal feed. Alternatively, other oil types can be used for biodiesel production, such as used frying oil (which has proven successful in Austria). The oil is combined with alcohol (methanol or ethanol) and transformed into biodiesel, with glycerine as a by-product.

Biodiesel replaces fossil diesel and can be blended in different shares. Low blends can be used in diesel engines without any adjustment to the engine or fuel system [NREL, 2001]. Nevertheless, because of some issues regarding material incompatibility, many European engines and vehicle manufacturers have set limits to the blending that must be regarded, otherwise the warranty of the vehicle or engine is compromised.

As for ethanol, current legislation limits the maximum blend of biodiesel in fossil diesel to 5% in volume terms, equalling 4.6% in energy. This limit is established in the European Standard EN 590 mainly because of concerns over the stability of biodiesel and not in the fuel quality directive, as is the case for ethanol. The Commission has recently asked the European Committee for Standardization CEN to reconsider this limit.

In concentrations above 20%, modifications to the engine are necessary in order to prevent degradation of some rubber compounds [NREL, 2001]. However, with the trend towards lower-sulphur diesel fuel, many vehicle manufacturers have constructed engines with gaskets and seals that are generally biodiesel resistant [IEA, 2004]. Another problem related to high blends of biodiesel can occur at lower temperatures, where the fuel clouds and stops flowing more easily than fossil diesel, so that fuel-heating systems or blends with diesel fuel would be needed in lower temperature climates. All of these problems can be overcome with relatively simple technical adaptations, as can be seen in Germany, where the use of pure biodiesel experienced a boom in past years.

Advanced biodiesel (also known as synthetic biodiesel; Fischer-Tropsch biodiesel; or Biomass-to-liquid BtL) does not rely on vegetable oil as feedstock, but can make use of virtually all kinds of biomass.

The Biomass-to-Liquid combines the gasification of biomass with a Fischer-Tropsch synthesis to derive a liquid fuel from the "syngas" (containing mainly CO and H<sub>2</sub>). Depending on the composition of the syngas and the process control parameters, the final products are kerosene, petrol- and diesel-like products. The focus for automotive applications lies mostly on Fischer-Tropsch diesel. A similar process is also used to produce synthetic diesel on the basis of natural gas and coal. A by-product with the remaining off-gas is the subsequent generation of power used in the production process and also available for the electricity network through a combined cycle.

The BtL process has some major characteristics, which make it a promising technology:

- It can make use of a wide range of biomass feedstock from traditional or short rotation forestry (e.g. miscanthus, poplar, willow) to woody by-products such as forest residues, straw, black liquor from pulp and paper production, etc.
- The final diesel product can be used in all levels of blends in conventional diesel engines without any modifications of the engine and is thus superior to conventional biodiesel;

- The well-to-wheel GHG emissions of BtL-diesel are relatively low both compared to fossil fuels and first generation biofuels.
- Synthetic diesel is sulphur-free and has a very low aromatic content, which in return leads to low exhaust emissions of NO<sub>x</sub> and no emissions of SO<sub>2</sub>. This is of less relevance in cars that are equipped with advanced exhaust gas cleaning technologies, but can be beneficial in older vehicles [EU AFCG, 2003].
- Synthetic diesel has a high cetane number, which indicates better auto-ignition qualities. It may thus form a key element in the development of low-polluting homogeneous combustion petrol-diesel engines in the medium-term [IFP, 2004].

On the other hand, BtL processes are complex engineering projects and require many practical problems to be resolved before they become reliable and commercially viable. Currently, a number of pilot and demonstration projects are at various stages of development. It remains difficult to determine by when, and at what price, BtL will become market-mature.

As described above, production of 2<sup>nd</sup> generation biodiesel differs largely from the processes used for first generation biodiesel. As such, it is not possible to "upgrade" an existing plant to produce advanced biodiesel, unlike for advanced ethanol. Ligno-cellulosic ethanol production builds on the conventional technology production except for the additional part of breaking down the cellulosic part into sugars.

## 2.3 Biomethane, pure vegetable oil and other biofuels

There are a number of conventional or advanced biofuels that have not become mainstream fuels, or mainly have potential in niche markets:

- Biomethane is derived from biogas. A major advantage of biogas is that it can be produced from various types of biomass, including dedicated crops as well as by-products (e.g. manure, green tops of crops) and from landfill gas or sewage treatment. From the latter, the capturing of methane shall be done anyhow in order to prevent emissions of methane, which is a potent climate gas, into the atmosphere. Due to the large range of possible feedstock, biogas has a large potential. It can be used similarly to natural gas after undergoing an enrichment and purification process to tackle the higher sulphur and CO content and achieve higher methane concentration. Whether biogas will be used in stationary plants or purified and used in vehicles will depend on the national circumstances. Biomethane can replace natural gas in gas-powered vehicles either as compressed or liquefied gas. Nevertheless, using natural gas implies major changes to the distribution infrastructure, the on-board storage and the engine. So the introduction of biomethane in the transport market relies heavily on the success of natural gas technology in transport. So far, the use of biomethane as transport fuel has been successful mainly in Sweden, motivated by a surplus biogas production and low electricity prices that stimulated the use of biogas in non-electricity markets. The biomethane use has been diffused from the use in (bus) fleets to private vehicles and reached an overall of about 8000 vehicles by the end of 2005.
- Pure Vegetable Oil from e.g. rapeseed or sunflower can be used in diesel engines. However, these need to be adapted in order to preheat the fuel and avoid fouling of the injector nozzles, cylinder head and piston rings. Thus the use of pure vegetable oil is limited to fleets with converted diesel engines. Currently, pure vegetable oils are often

used for agricultural machines and transport companies. The use of pure vegetable oil as fuel for adapted private cars, trucks or tractors is most advanced in Germany.

- Biomethanol can be produced from biomass and biodegradable fraction of waste and it is equivalent to methanol from non-renewable resources. Similar to Fischer-Tropsch biodiesel, it is based on gasification of biomass in the first step. It is highly corrosive and toxic, being hazardous to both people and environment. Due to these facts it is considered a less promising technology option as a biofuel [Enguídanos, 2002].
- Dimethyl Ether (DME) is an oxygenated hydrocarbon, which is the simplest compound in the class of ethers. It is generally produced from natural gas, but almost any carbon based feedstock can be used, including biomass. DME is a gas with properties close to those of LPG. Volvo is the main manufacturer experimenting with DME engines.
- Hydrogen can be produced through biomass gasification. It is in fact one main component of the syngas, which is often further processed to synthetic diesel or other fuels. However, the use of hydrogen requires a new infrastructure and on-board storage and – if to be used most efficiently – new types of engines.

## 2.4 Greenhouse gas emissions

Combustion of biofuels-based fuel is considered as CO<sub>2</sub>-neutral as it emits only the amount of CO<sub>2</sub> that was captured by the plant during its growing phase. However, cultivation of crops often requires the input of fertilizers and sets free emissions of N<sub>2</sub>O (which is a strong greenhouse gas) as well as the conversion process sometimes is energy-intensive and thus emits greenhouse gases. For that purpose, the net greenhouse gas benefit of a biofuel life cycle is considered more relevant than the zero CO<sub>2</sub> emissions. The following figures for GHG emissions are based on the JRC/EUCAR/CONCAWE study "Well-to-wheel analysis of future automotive fuels and powertrains in the European context", version 2b [JEC, 2006].

For the purpose of illustrating the importance of the production pathways, the minimal and maximal well-to-wheel emissions are used for a typical car engine in 2010. The large discrepancies for one product are largely influenced by the source of energy used in the production process (e.g. lignite based or based on renewables) and the benefits for the use of by-products (e.g. as animal feed, fuel or chemical use).

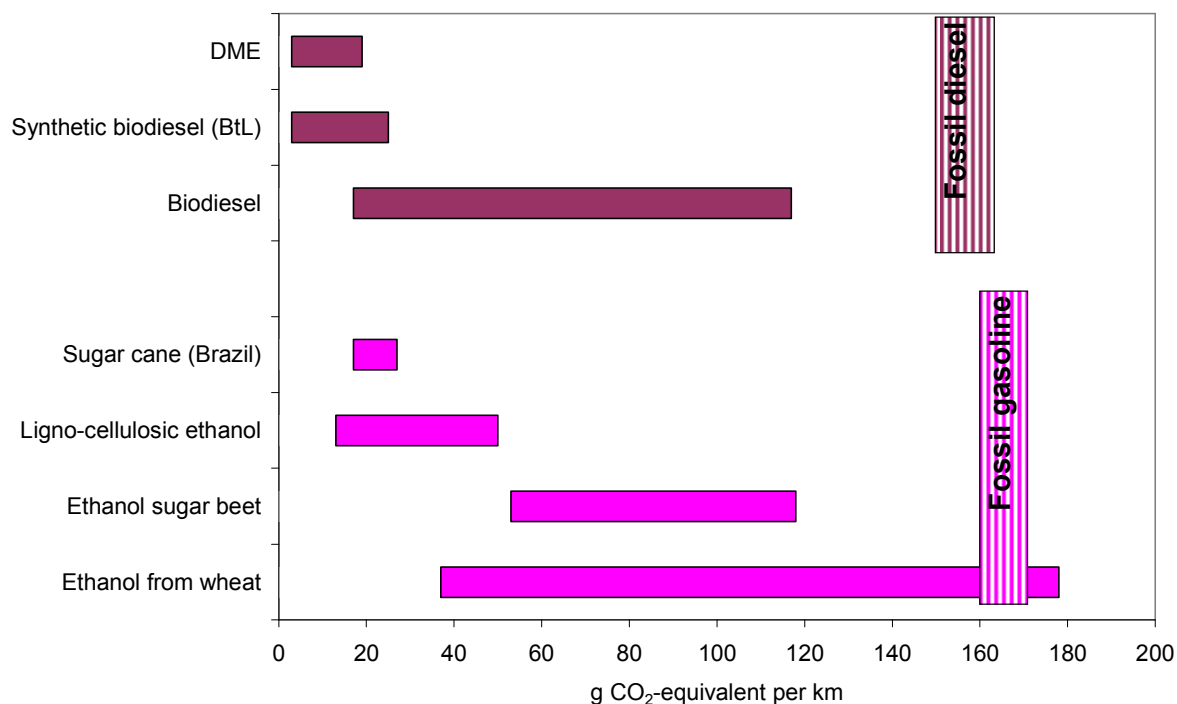


Figure 2: Range of Well-to-Wheel emissions of greenhouse gases for different biofuels and fossil fuels in 2010 (data source: [JEC, 2006])

The broad range shown above is the result of a number of factors influencing the well-to-wheel emissions of biofuels. As the emissions based on [JEC, 2006] account for the use of by-products, the final usage of the by-products (e.g. as chemical, animal feed or energy) has a large influence on the net emissions. Major differences in WTW emissions also occur between different production processes, depending largely on the origin of the energy needed for the conversion (that may come from lignite-based electricity as well as biomass-based one).

Despite the broad theoretical range of emissions particularly for first generation biofuels, it is obvious that

- substituting fossil fuels with biofuels leads to a net reduction of GHG emissions (except for wheat-based ethanol using lignite-based electricity);
- advanced biofuels produce lower GHG emissions than conventional biofuels.

## 2.5 Crop development

Complementary to the development of new biofuel conversion technologies, there is further scope for introducing crops that are optimised for the production of biomass. Historically, crops were optimised for food production rather than for energy content. As the requirements for energy crops are different (energy vs. nutrient value; whole biomass vs. seeds etc.; positive life-cycle energy balance), new crops and crop varieties as well as cultivation methods may be favourable. Instead of focusing on the food outlet, a whole system approach and evaluation of all potential products (energy, biofuels, fertilizers, industrial products, etc.) needs to be applied.

The EEA/JRC conference [EEA/JRC, 2006] dedicated to 'sustainable bioenergy cropping systems in the Mediterranean' concluded that there is a wide range of crops which might be better suited for bioenergy production compared to current, conventional crops:

- Novel crops for oil production include: *Cynara*, *Carinata*, *Castor bean*, *oil palm*, and *Jatropha*.
- Regarding ethanol production, examples of dedicated novel crops include *jerusalem artichoke*, *sweet sorghum*, *prickly pear* and *wild tobacco*. These usually combine a high yield with little water requirement.
- Ligno-cellulosic feedstock for advanced biofuel production is generally favourable as they can achieve high yields. Furthermore, some varieties have excellent water efficiency and can be used on poor soils. Compared to conventional systems, perennials usually are more environmentally-benign as they reduced soil erosion, require less fertilization and pesticides and increase the carbon sink and organic matter.

In order to make use of promising new varieties that can be grown with limited environmental pressures and at high yields, much RTD is still required on plant breeding, selection of crops, and varieties which may improve the characteristics of crops suitable to arid Mediterranean conditions. The optimal trade-offs between the quantity of water use, the time of irrigation and the yield will still have to be found out. There is much research needed on finding measures to improve efficiency in relation to the input-output ratio of water and nutrients in the cropping phase, and the energy efficiency throughout the full chain, including the conversion step from biomass to energy. Overall there is a need to get an integrated picture of all environmental considerations in relation to the cropping systems, and the whole energy production chain. Eventually, a GIS approach would be useful for incorporating detailed pedo-climatic and socio-economic conditions and determining the most suitable crop mixes for each local situation [EEA/JRC, 2006].

### 3 BIOFUEL MARKETS

There are mainly three large biofuel markets in the world: the USA, Brazil and the EU, with the latter characterised by a dominant share of biodiesel, while the USA and Brazil have a dominant share of ethanol. The following figures show the worldwide evolution of fuel ethanol and biodiesel production.

**World fuel ethanol production**

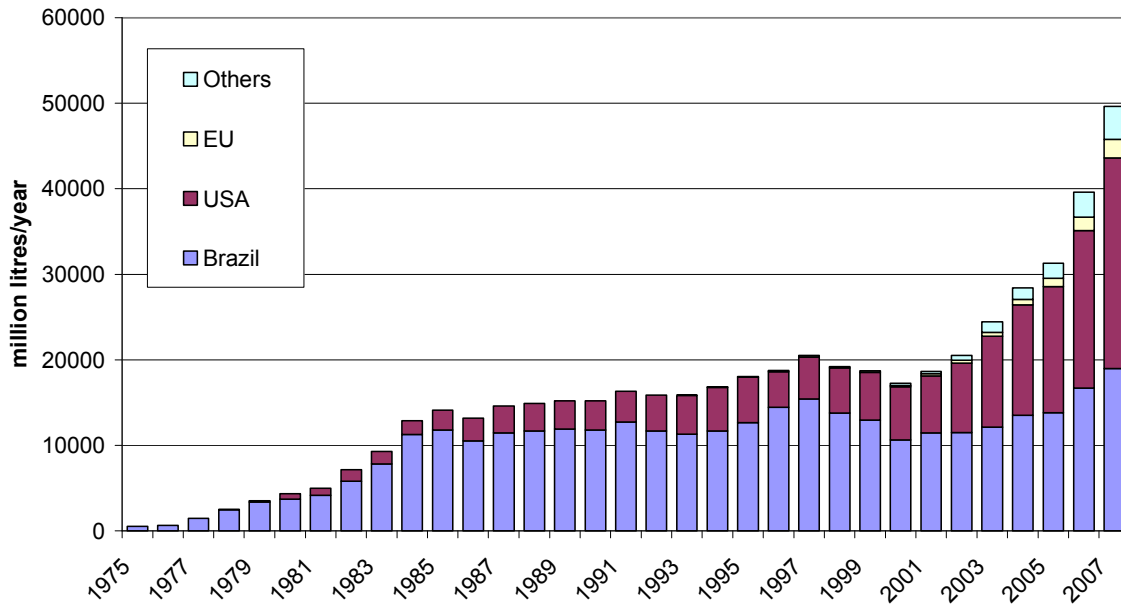


Figure 3: Evolution of worldwide fuel ethanol production (data source: F.O.Licht's 2007)

**World biodiesel production**

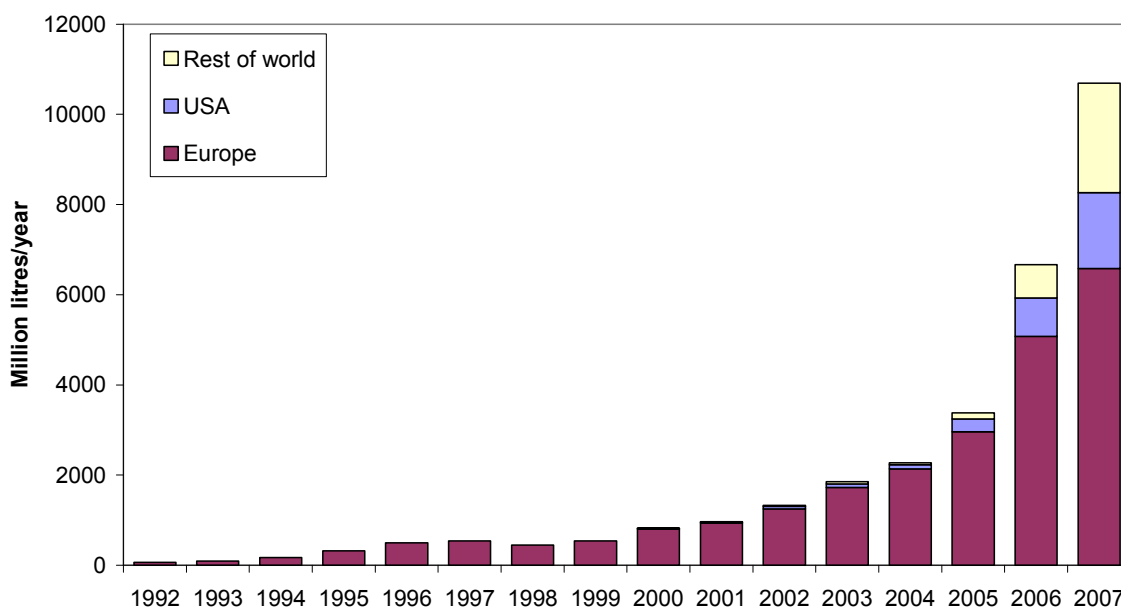


Figure 4: Evolution of worldwide biodiesel production (data source: F.O.Licht's 2007)

On a global scale, biofuel demand is likely to rise, driven e.g. by ambitious biofuel policies and rising crude oil prices. This signal has reached the market that reacted with large (planned) increases in production capacities.

The following figure shows the evolution of biofuel consumption in the EU25, from 1991 up to 2006.

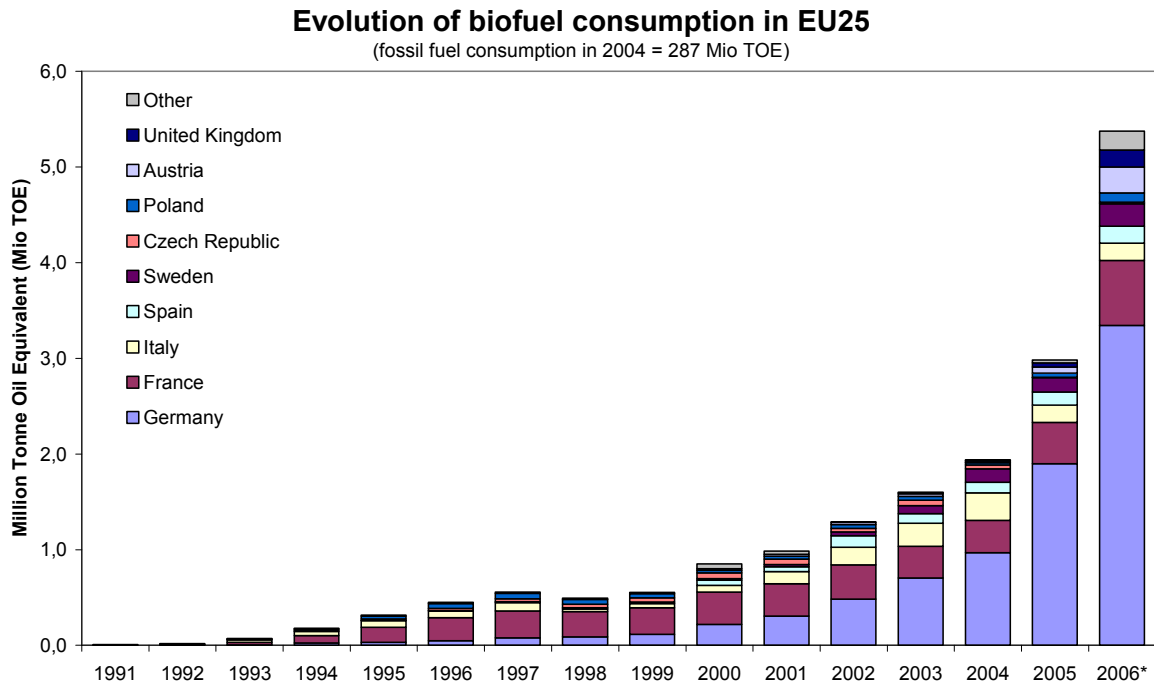


Figure 5: evolution of biofuel consumption in the EU25 (2006 figures based on estimations) (data based on [Pelkmans, 2006] and [EurObserv'ER, 2007])

The introduction of biofuels in Europe started in the beginning of the 1990s. The following phases can be identified:

- until 1992: first initiatives and demonstration actions of biodiesel and bioethanol,
- from 1993 until 1997: first steady increase in market introduction, mainly dominated by France,
- from 1997 until 1999: stagnation, related to low crude oil prices, and lower set-aside area,
- from 2000 until 2006: steady increase in biofuel market introduction, dominated by Germany,
- from 2006-2007 it is expected that other countries will follow, driven by the European biofuels directive.

About 20% of biofuels is ethanol, while about 80% is biodiesel. The fractions of straight vegetable oil (SVO) and biogas are quite small (except for SVO in Germany and biogas in Sweden).

The EU biofuel market consists of many national markets with different trends regarding the type of biofuel used (ethanol or diesel, pure or low blends) and different volumes, reaching

from a biofuel share of 0% to 6 % in 2006, as shown in the following table. In 2006 actually still only Germany, Austria, Sweden reached the 2% (which was the 2005 target), with France and Lithuania reaching a little below 2%.

*Table 1: Reported biofuel shares in the EU25 member states (data source: [Pelkmans, 2006], [EurObserv'ER, 2007], individual country reports)*

	<b>Biofuel share (%)</b>			
	<b>2003</b>	<b>2004</b>	<b>2005</b>	<b>2006</b>
Austria	0.16	0.06	0.93	3.54
Belgium			0.00	0.01
Cyprus			0.00	n.a.
Czech Rep.	1.15	0.75	0.05	0.30
Denmark			0.00	0.10
Estonia			0.00	0.12
Finland	0.02	0.10	0.00	0.02
France	0.78	0.80	0.97	1.75
Germany	1.34	1.86	3.75	6.50
Greece			0.04	n.a.
Hungary			0.07	0.26
Ireland			0.04	0.09
Italy	0.63	0.74	0.51	0.46
Latvia	0.28	0.00	0.33	0.22
Lithuania	0.00	0.15	0.72	1.72
Luxembourg	0.03	0.03	0.02	0.02
Malta			0.52	0.58
Netherlands			0.02	0.29
Poland	0.41	0.23	0.47	0.92
Portugal			0.00	1.02
Slovakia	0.12	0.06	n.a.	n.a.
Slovenia			0.35	0.27
Spain	0.35	0.37	0.44	0.53
Sweden	1.15	2.02	2.23	3.10
UK	0.02	0.04	0.18	0.45

On an EU total, biofuel production more than tripled between 2003 and 2006 and the share of biofuels consumed reached 1.8% of all transport fuels in 2006, up from 0.5% in 2003. Even though this still falls short of the 2% target designated for 2005, further significant growth can be expected with regard to most Member States having adopted national biofuel targets for 2010 in line with the EU biofuels directive and the recently agreed 10% target for 2020.

## 4 POLICY DRIVERS FOR BIOFUEL SUPPORT

### 4.1 Key drivers

A biofuel policy should not primarily and exclusively aim at fulfilling a certain target for biofuel consumption, but the key drivers underlying a biofuel policy must be kept in mind, namely to increase energy security, secure domestic agricultural income and reduce GHG emissions. Depending on which driver is prevailing, the focus of the policy may change. For example, if support of the agricultural sector is a key-driver, it would make little sense to promote biofuels by tax exemptions at the expense of revenue losses for the government if the biofuel is imported from outside the EU.

The following chart suggests relations between the different key drivers for biofuel support and a biofuel strategy with regard to the share of imports and the share of advanced (2<sup>nd</sup> generation) technologies. The consequences of each of the drivers on the overall biofuel target are not taken into account as they depend on a number of additional assumptions.

*Table 2: relation between policy drivers and share of imports, share of advanced biofuels [Wiesenthal, 2007b]*

	GHG emissions	Supply security	Agricultural income	Innovation	Soil, water, biodiversity
High share of imports	↑ ↓	↓	↓	?	↑ ↓
High share of advanced biofuels	↑	↑	↑ ↓	↑	↑

The impact of high shares of imported biofuels on **greenhouse gas emissions** is ambivalent. Currently, the most common imported biofuel – sugar-cane based ethanol from Brazil – is available at lower costs and often lower GHG emissions than domestically produced biofuels. However, depending on the origin of the imports and the production processes, the favourable trend might change in the future, if, for example, biofuel production leads to deforestation. Similarly, biofuel imports from other world regions can have higher GHG emissions than domestically produced ones. A policy that supports advanced biofuels is likely to contribute well to the key aim of lowering GHG emissions, as these technologies usually have lower per-unit GHG emissions than conventional ones.

In terms of a biofuel policy that primarily aims at enhancing the **security of supply**, increasing the share of imported biofuels seems counterproductive. Nevertheless, it needs to be pointed out that biofuels or feedstock can be imported from a broad range of countries, unlike oil, thus reducing the risks of supply. In the long run, it is also likely that there would be more advanced biofuels, as these can use a broader feedstock and thus have a larger potential.

Reducing import levels are certainly one impact if the focus of biofuels is to **create alternative outlets for agricultural products**. First generation biofuels may benefit from

such a focus, as they depend on agricultural crops, while advanced biofuels would tend to firstly use cheap by-products before using dedicated agricultural crops. On the other hand, advanced technologies can make use of crops that can be grown on poor soils and in arid climates, thus opening up new opportunities for farmers. Furthermore, agricultural by-products can be converted (e.g. straw) which would ensure an additional income for farmers. However, as a co-existence between conventional and advanced technologies can be expected for the medium term, the net effect on agricultural income is likely to be positive.

**Supporting innovation** will certainly focus on advanced technologies. Innovation is, however, not restricted to the processing technologies, but includes research on more efficient oil and starch and ligno-cellulosic crops [EEA/JRC, 2006], which in return may result in a reduction of imported biofuels.

Production of feedstock for biofuels can have an adverse **impact on soil and water resources** as well as biodiversity if grown in sensitive areas and without considering these factors. The impacts can be high for some imports (e.g. if rainforest was transformed into arable land). On the other hand, growing energy crops on tropical lands can result in much higher yields and thus less demand of area. A general net effect of focusing the biofuel support on environmental functions cannot be deducted. A clear impact would occur with regard to the introduction of advanced biofuels. These would be pushed as they can use a broader range of feedstock, in particular multi-annual crops (and by-products), which generally have a lower risk of erosion and nutrient and pesticide leakage than annual crops [EEA, 2006].

## 4.2 Country specific conditions for biofuels production and consumption

Country specific conditions have a major influence in a countries' interest and economic capability in supporting biofuel consumption and in its (agricultural) potential in producing biofuels. It is thus important to set into this context the assessment of past policies and – even more so – potential further strategies and individual targets.

In the following figure, GDP – as a measure of economic capability to support biofuels, but also a main driver for transport energy demand – was plotted over the ratio yield corrected arable area to transport energy demand for the year 2004. The area is corrected to take into account different average yields of typical biofuel feedstock (oilseeds, cereals). The latter ratio provides an indication of a country's suitability to domestically provide an important amount of biofuels compared to total fuel demand of the transport sector. To better illustrate the meaning of this ratio: if 10% of arable land were used to crop biofuel feedstock with an average yield of 1.5 toe biofuels/ha, only countries with a ratio of 0.4 toe/ha or more would be able to fulfil the EU 5.75% target domestically. While 9 out of the 12 new Member States (of 2004 and 2007) would reach or exceed this break-even point, from the pre-2004 EU-15 Member States, only Denmark and France could be self-reliant.

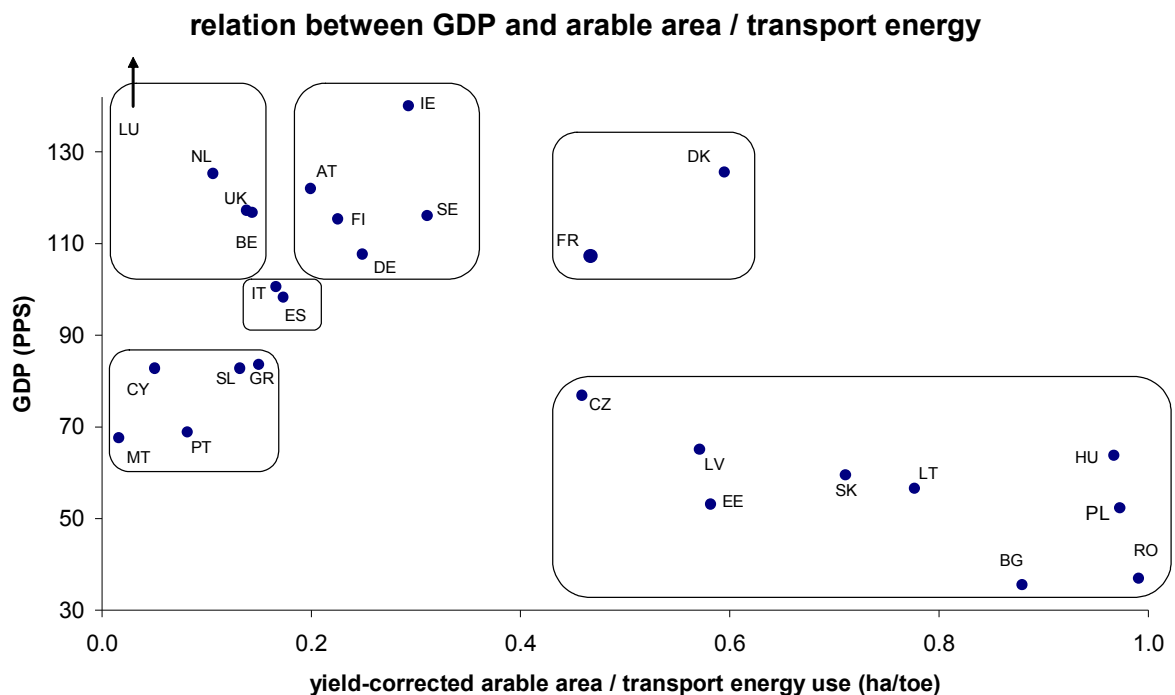


Figure 6: country clustering based on GDP and arable area [Pelkmans, 2006]

Not surprisingly, most of the Central and East European Member States show a large potential of biofuel production, particularly in relation to their transport fuel demand. They would not only be self-sufficient so as to meet the 2010 biofuel target without any imports, but have a considerable export potential. The export potential is further stressed by the fact that they may lack the finance to support the creation of large domestic biofuel consumption. Some countries have started to create a biofuel policy (e.g. Czech Republic, Poland, Lithuania and Slovakia). However, biofuels are often rather exported than used domestically.

From the EU-15 Member States, only France and Denmark show a large potential. Other Member States with a large agricultural area either have less favourable climatic conditions (e.g. the arid climates in Italy and Spain) or high transport energy demand (e.g. Germany). These findings are supported by a number of other studies [Kavalov, 2003] [VIEWLS, 2005] and will basically hold true when also considering ligno-cellulosic material as feedstock for advanced biofuels (even though Sweden and Finland would show a higher potential).

Belgium, Luxembourg, the Netherlands and United Kingdom are countries with a relatively high economic strength but with a limited potential in arable land. These countries have limited means to produce domestic feedstock, but may be interested to import feedstock or biofuels. The option of importing is supported by the factor that these Member States (except for Luxembourg) host important harbours.

There are only few Member States that combine a high production potential with an elevated interest in the consumption of biofuels. These comprise mainly France and Denmark, and to a lesser extent Germany, Spain, Sweden, Austria, Ireland and Finland.

Most of these Member States have implemented an ambitious biofuel policy, with the exception of Finland, Ireland and Denmark that considered the use of biomass for heat and

power production a favourable option compared with biofuels. France has been the leading player on biofuels in Europe in the 1990s, driven by the strong agricultural and industrial sectors. From 2000 biofuel share on the market was controlled by an accreditation (quota) system, which stabilized the market, but also prevented growth. The market was limited to a few big industrial players. French government has now announced ambitious plans for the coming years, aiming for 10% biofuels by 2015. Germany is now leading the European market, driven by strong agricultural and industrial sector backing and a very favourable legislation for biofuels (up to the end of 2006). Spain has become the leading Member State in ethanol production. The Swedish success story is mostly driven by local initiatives, supported by local and national governments [McCormick, 2006]. Even though Sweden imports large amounts of ethanol, there are plans to use the large potential of woody biomass for producing ligno-cellulosic ethanol in the future. Austria was a very active player on biodiesel, but the very favourable legislation in neighbouring Germany has resulted in an almost complete export of produced biodiesel to Germany. With its obligation system from 2005, Austria is getting back on track.

### ***Intra-EU trade***

A comparison of arable area with transport energy demand indicates the possibilities for intra-EU trade. Countries with a high interest in biofuel production but a limited interest in opting for high shares of biofuel consumption may become exporting countries and vice versa. This implies that intra-EU biofuels trade could play a role:

- as exporting countries for Poland, Hungary, Romania and Bulgaria, and to a lesser extent Lithuania, Slovakia, Estonia, Latvia and the Czech Republic, Denmark and France;
- as importing countries for Luxembourg, Belgium, the Netherlands, the UK, Spain, Italy.

These results are more or less in line with the findings of a recent project on sustainable strategies on biomass use in the European context, which was carried out on behalf of the German Ministry of Environment [Thrän, 2006]. A comparison of scenarios on primary biomass production and biomass consumption is made in order to find out biomass flows. Restricting the results to biofuels only, the study indicates that the UK, Italy and the Benelux are likely to be importing countries while most of the new Member States and France would become export countries. If higher biofuel targets and more stringent nature protections rules were assumed, thus restricting the indigenous potential, more countries (e.g. Germany, Spain) would require imports.

With Bulgaria and Romania joining the European Union in 2007, two Member States with an important biofuel production potential now enhance the EU-27 domestic biofuel production potential [Kondili, 2007; van Dam, 2003; VIEWLS, 2005].

The intra-EU trade can be important for enlarging an individual country's potential in biofuel consumption, while the EU potential remains the same, unlike global trade. Furthermore, intra-EU trade can be expected to reduce the costs of biofuel consumption in a specific country only to a limited extent.

## **4.3 Stakeholder presence**

The presence of stakeholders is an important factor in realizing a successful large-scale introduction of biofuels. This may be an argument for creating a domestic biofuel industry even though a country may be more interested in biofuel consumption than production.

Stakeholders affected by a biofuel policy include oil companies, the chemical industry, car manufacturers and eventually farmers.

Most of the success stories involve the presence of stakeholders (especially industrial stakeholders and farmer associations) in a given country. Germany and France, for example, host a very active automotive industry, eager to support research in the field of alternative motor fuels. This fact is one driver for the interest of the Government to support the strategy of biofuels (and any other AMF) more avidly.

## 5 BIOFUEL SUPPORT POLICIES AND MEASURES

In the previous chapter the motivations for governments to establish a biofuel market were described. In addition to those societal drivers, a successful policy needs to reflect the industry's and consumer's need with regard to the introduction of alternative motor fuels.

From an **industrial** point of view, the key feature is a positive return on investment. As such a long-term, predictable policy framework is important. Indeed, driving forces for involvement by oil companies in biofuel activities highly depend on the stability of the policy framework, which has been improving from 2005 in most countries [Eikeland, 2006]. As such, the on-going change between different biofuel support schemes (i.e. from tax exemptions to obligations) creates some uncertainty. Similarly, it is important that the feedstock (for biofuel producers) or the biofuel (for oil retailers) is constantly available at a certain quality and price. This can be an argument for imports of either biofuels or feedstock in order to minimise the vulnerability related to market changes, short term weather and long-term climate changes, which can drastically reduce the harvested level. Furthermore, in order to reduce additional costs, industry will tend to produce and use those biofuels that can use the existing infrastructure for transport, storage and distribution of the fuel.

The **consumer** will accept biofuels under three main conditions:

- the prices of biofuels at the fuel pump are not above those of the fossil alternative, but preferable below them;
- biofuels can fuel the current engine without any restrictions, unless there are incentives to purchase a car with a modified engine;
- the warranty of the car manufacturers remains.

So far, Member States have applied different policies with varying success:

- Tax exemptions are being or have been applied by almost all Member States and have proven successful if combined with high tax levels; their main drawbacks are the loss of government revenue and the risk of overcompensation.
- Obligations to fuel suppliers do not cause any direct loss of revenue to the government as the costs will be carried by the fuel suppliers and ultimately passed on to the transport users (mind that the added cost is still carried by society, but now at another level). The obligation system is likely to favour lowest cost, low-blend biofuels.
- Supply-side measures such as support to energy crops or investment subsidies are not primarily suited to reduce the final production costs of biofuels. They are best used to

steer the biofuel production process so as to favour certain crops or technologies, which is likely to be needed even further with growing market volumes.

In the following, policies and measures will be assessed based on the experiences made in the EU Member States and with regard to their potential for further stimulating a growing biofuel market.

### 5.1 Policy support schemes

Biofuels are supported on an EU and country level with the instruments being closely interlinked. While support to the agricultural production is carried out on an EU-level (as the Common Agricultural Policy CAP is a common policy under sole EU responsibility), in most other areas, the EU provides the framework (e.g. allowing for tax exemptions of biofuels) and leave the decision on concrete policy measures to the Member States. The EU policy framework is described in section 5.2, followed by an overview of Member States policies in section 5.3.

Biofuels are supported by a large variety of support schemes, ranging from strict regulatory instruments to economic instruments, up to information diffusion. All of these measures can be applied to the different stages of the biofuel chain, i.e. cultivation of feedstock, production and distribution and the consumer market demand.

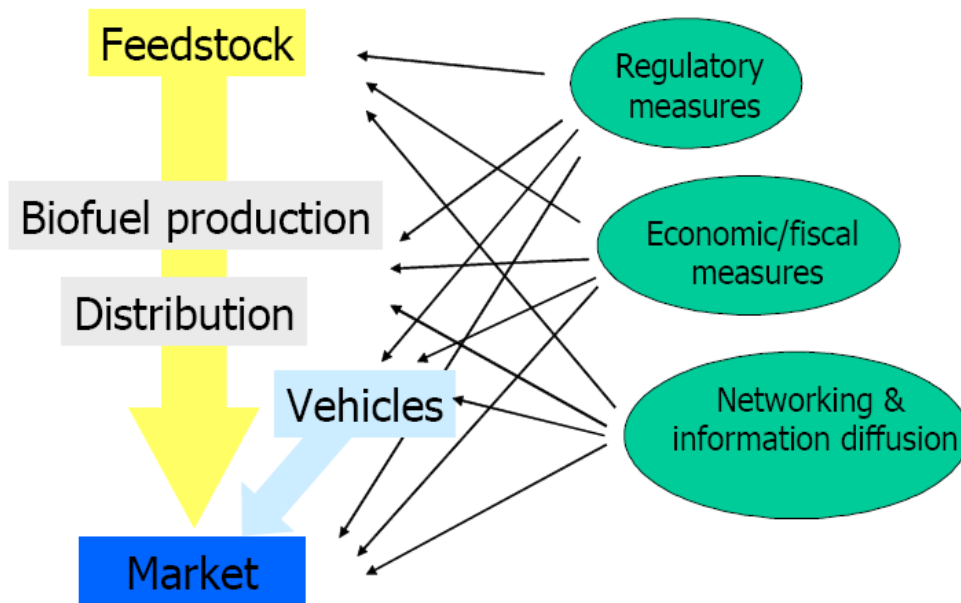


Figure 7 : scheme of impact of support measures on the biofuel chain [Pelkmans, 2006]

Not all possible measures are applied today. The most important measures are shown in the table below, with brackets indicating that a country has only recently introduced this measure. The measures by country were discussed in detail in Work Package 4 of the PREMIA project [Pelkmans, 2006] for Germany, France, Austria, Sweden, Czech Republic, Spain, Poland and the UK.

Table 3: different biofuel supporting measures applied in the EU [Pelkmans, 2006]

Stage	Measure	Application
Feedstock	Support to agriculture (energy crop subsidy / set aside land)	EU15, CZ
Production	RD&D funding	EU + country level
	Loans and subsidies for biofuel production facilities	FR, DE, PL, ES, SE,...
	Producer tax incentives for biofuel production	CZ
	Authorised quota system for biofuel producers, related to tax reduction	FR, IT, (BE)
Distribution	Standards (biofuel & normal fuel)	AT, DE, FR, SE, IT, EU
	Tax differential (tax reduction for biofuels)	DE, FR, AT, ES, SE, ... EU (Energy Taxation Directive)
	Obligations for fuel distributors	AT, DE, NL, SE, (UK),...
	Loans and subsidies for filling stations	DE
Market	Funding of demonstrations	EU + country level
	Procurement methods (green proc., common procurement)	SE, FR, AT
	User incentives (tax incentives biofuel vehicles, free parking, exemption of congestion charge or other road tax, ...)	SE

## 5.2 European policy

EU biofuel support policy is embedded in the wider aim to substitute 20% of motor fuel consumption by new and alternative fuels by the year 2020. This objective was introduced by the green paper on energy supply security [EC, 2000], with the biofuels part building on the white paper on renewable energies [EC, 1997]. It was concretised by the 2001 Communication on alternative fuels for road transport [EC, 2001], which indicated that biofuels might take a share of 8% by 2020.

On that basis, the EU has built a comprehensive strategy aiming at increasing the share of biofuels that covers instruments addressing the supply side as well as those on the demand side. The 2006 EU Biofuels Strategy and the early 2007 Renewables Roadmap and Revision of the Biofuels Directive complement this strategy with an outlook for 2020.

### 5.2.1 Supply side measures

The Common Agricultural Policy determines the support to farmers. Since 1992, bioenergy crops can be cultivated on set-aside areas, which do not allow for the production of food crops, up to a certain amount. The 2003 CAP reform introduced the single farm payment for EU farmers, which decoupled income from production. The reform also introduced a special aid for energy crops of 45 €/ha to support the cultivation of bioenergy feedstock [REG, 2003]. This support is limited to a maximum area of 1.5 million hectares in the EU15. The energy crop premium was recently extended to a maximum area of 2 million hectares and covering all Member States [EC, 2006b].

Biomass production is furthermore supported through the EU's cohesion policy [EC, 2005b].

### **5.2.2 Demand side measures**

The cornerstone of the EU biofuels policy remains the 2003 Biofuels Directive [DIR, 2003a], which sets 'reference values' of 2 % and 5.75 % for the share of biofuels in transport fuels to be met by the end of 2005 and 2010, respectively. The directive obliges Member States to formulate national indicative targets, taking into account the proposed reference values. In order to achieve the targets, the Energy Taxation Directive [DIR, 2003b] allows Member States to exempt biofuels from taxes under the conditions that:

- the tax exemption or reduction must not exceed the amount of taxation payable on the volume of renewables used;
- changes in the feedstock prices are accounted for in order to avoid overcompensation;
- the exemption or reduction authorised may not be applied for a period of more than six consecutive years. This is renewable.

At the moment, the Fuel Quality Directive [DIR, 2003c] sets an upper threshold of 5% for the blending level of bioethanol in petrol. Similarly, diesel must not contain more than 5% biodiesel, according to the European diesel standard EN590. The revision of the fuel quality directive and the diesel standard is likely to allow for higher blends of biofuels in fossil fuels.

### **5.2.3 Recent developments**

In recent years, discussions on the direction of a future EU biofuel policy intensified. The proposed EU Strategy on Biofuels [EC, 2006a] and the Biomass Action Plan [EC, 2005a] build on the existing legal framework and identify the need for further action to achieve the 2010 target and further increase afterwards. They formed the basis for the council conclusions on bioenergy from June 2006, which asked to assess the option of an 8% target of biofuels for 2015. This request and the overall renewable energy roadmap [EC, 2006d] were considered in the progress report on the Biofuels Directive [EC, 2006c] when looking at post-2010 biofuel policies. In the context of the overall proposed target for a 20% share of renewable energies in total energy consumption, a minimum binding target for the share of biofuels to reach 10% of all transport fuels by 2020 was proposed recently (on 10 January 2007 as part of the European Commission's "energy package").

The EU Spring Council from March 2007 adopted the proposed 10% binding minimum targets for biofuels, which shall be achieved by all Member States by 2020. It states, however, that "The binding character of this target is appropriate subject to production being sustainable, second-generation biofuels becoming commercially available and the Fuel Quality Directive being amended accordingly to allow for adequate levels of blending." [Council, 2007].

## **5.3 National policies**

As the production costs of biofuels lie well above those of fossil fuels unless for the case of very high oil and carbon prices, a market demand needs to be created by governments. This can be done through basically two instruments. Either, biofuels are subsidized so as to reduce the price levels to that of fossil fuels (or below), or a fixed quantity of biofuels to be supplied by fuel suppliers becomes obligatory. The first option is realized by a tax

exemption scheme, which has proven successful but incurred important revenue losses for government, unless the revenue losses were compensated with a tax increase on fossil fuel. The second option, an obligation to fuel suppliers to achieve a certain biofuel share in their total sales, becomes attractive as the refineries and ultimately the transport users will carry the additional costs, and there is a greater likelihood for a target to be met. These instruments can be complemented by a number of other incentives, such as support to dedicated vehicles.

Recently, a switch from tax exemption to obligation systems can be observed in the EU, reflecting the need for efficient support systems. Since 2005, 12 Member States have switched or will switch from a tax exemption to an obligation scheme (or mixed system) in the very short term. These countries account for more than 88% of the total EU biofuels consumption as well as production. For example, since 2005 Austria has an obligation system in place, and France introduced a "mixed" system with the TGAP. Slovenia introduced an obligation in 2006. Germany and the Netherlands changed towards an obligation system by 2007; the UK will introduce a Renewable Transport Fuel Obligation as from 2008. Ireland recently announced the introduction of a biofuels obligation. Also in Finland, there is pending legislation proposing a biofuels obligation. Only two major players namely Spain and Sweden have not moved to an obligation or mixed system.

### **5.3.1 Tax reduction**

Reduction or exemption from fuel taxes for biofuels has been a key instrument in supporting biofuels in all countries analysed. Following the Energy Taxation Directive, the reduction level is limited to the fuel tax. As fuel taxes vary among Member States, this instrument has proven successful in countries with tax levels that compensate the additional production costs of biofuels compared to the fossil alternatives. This relation becomes very clear for Germany, where the introduction of an increasing ecotax on fossil fuels from 1999 onwards led to an important subsidy level for biofuels that eventually lead to biodiesel pump prices being below those of fossil diesel. All EU Member States with a high level of biofuels up to 2005 introduced a tax exemption combined with relatively high taxes on fossil fuels. However, the reverse case does not seem true, which indicates that a tax exemption alone will not be sufficient to reach a high share of biofuels.

Tax exemptions can also steer the type of biofuels introduced. In Germany, for example, only pure biofuels entered the market before 2004, as blends did not profit from tax reductions. After the extension of the support scheme to include biofuel blends, low-blends rapidly gained an important market share.

One of the major drawbacks of tax exemptions are the important losses in revenue for the government. The loss of fuel tax revenue in 2005 alone amounted, for example, to almost 900 Mio € in Germany, some 200 Mio € in France, around 160 Mio € in Sweden and 60-70 Mio € in Spain. This does not take into account any benefits on e.g. rural employment, climate change mitigation or security of supply. With increasing volumes of biofuel consumptions, the revenue losses become important. This was a main incentive for Germany to switch from tax exemptions to an obligation to suppliers from 1 January 2007. Another way of overcoming the revenue losses may be a simultaneous increase in the fossil fuel tax so as to make the policy budget-neutral, as done in Belgium.

Another potential drawback of tax exemptions is the risk of overcompensation. Even though this is prevented for by the Energy Taxation Directive, this may occur with changes in feedstock or fossil fuel prices (although ‘undercompensation’, meaning that the tax reduction is too low, is also possible if fossil fuel prices drop lower, or feedstock prices increase higher than expected). In 2005, the average support to biofuels in different Member States (calculated as the revenue loss due to tax exemptions policies) amounted to in-between 250 and more than 600 €/tonne of oil equivalent, depending on the type of biofuel and the national support system.

Finally, the instrument of a tax exemption can support biofuels only up to a limited share, as the subsidy level is determined by the amount of the fuel tax or the combined fuel and carbon tax.

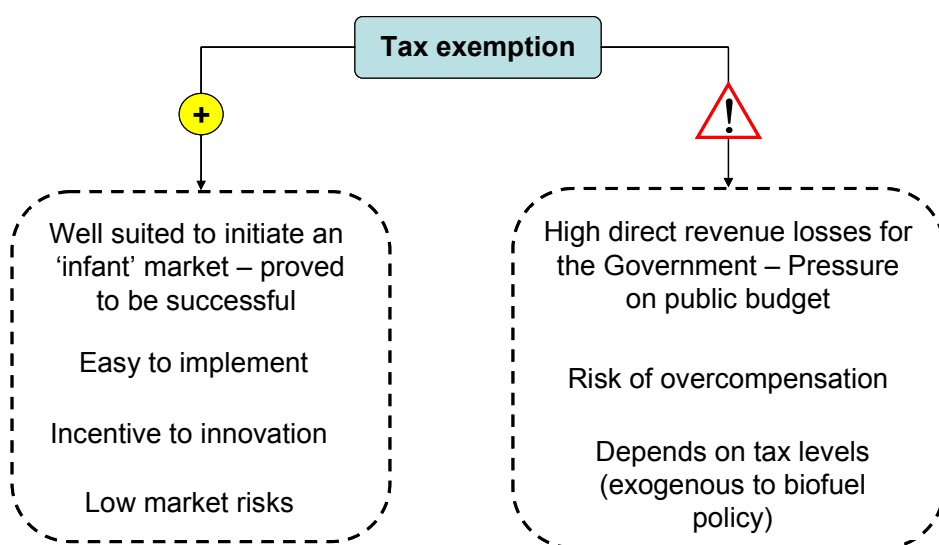


Figure 8: pros and cons of tax exemption systems

In the longer run tax incentives are difficult to maintain as they will become too costly to carry for the governments when market volumes grow. Nevertheless a (limited) tax reduction can also be maintained in a mature market situation to take into account

- the lower energy content of the biofuel (so tax per litre needs to be reduced),
- the lower external cost.

### 5.3.2 Substitution mandate/obligation for oil companies

The most direct way of increasing the share of biofuels is by establishing obligatory substitution levels for the transport fuel sold to consumers in the EU. The obligation would fall onto the oil companies/ fuel distributors to sell a certain share or a fixed amount of biofuels, which may in return imply that this instrument is more difficult to implement. Nevertheless, it is likely to assume that the additional costs would be passed on to the final transport users.

Currently, a number of Member States are in the process of developing obligation systems, especially in order to prevent high revenue losses due to tax exemptions, and also to create

investment security for producers. These include Germany, where an obligation for fuel suppliers replaced the tax exemption system for blended biofuels since January 2007, Austria, the Netherlands and the Renewable Transport Fuel Obligation in the UK starting from 2008 onwards. Also Poland will introduce an obligation system from January 2008. In January 2005, France introduced a general tax on pollutant activities (TGAP) that can be considered as a "quasi-obligation" system in the sense that fuel suppliers who do not incorporate a fixed amount of biofuels have to pay the tax. This instrument acts like a penalty occurring when an incorporation rate is not attained.

One of the major advantages of the obligation to fuel suppliers is the predictability of the market volumes that will be reached in a certain year. As the fuel supplier is obliged to fulfil the quota, it is very likely that this will be met, unless an alternative mechanism seems more attractive. An obligation system thus sets a long-term, predictable framework to the biofuel producers that consequently have a higher investment security than for tax exemptions which can be revised every year, depending on the States' income needs.

Experiences with similar systems to support renewable electricity (e.g. the green power certificate system in Flanders) showed that in the initial phase, the quotas were often not met and penalties needed to be paid, but that over time, the targets were increasingly fulfilled. It is thus important that fines for non-compliance provide a high incentive to meet the targets. In Germany, fuel suppliers will need to pay a relatively high fine of 0.50 €/l biodiesel and 0.80 €/l bioethanol. In the UK, for example, fuel suppliers can pay into a fund when they do not fulfil the obligation.

In theory, the average cost for each litre of conventional fuel displaced would be similar to the one in the tax reduction case, the main difference being that the effects on the government budget would be almost neutral (apart from implementation and monitoring costs, and second-order effects from the other impacts). Costs would be carried by the oil industry and eventually be passed on to the final transport users through higher fuel prices ("polluter pays" principle).

In practice, the costs of achieving a similar target with an obligation may be lower than achieving it by a tax exemption as there will be no overcompensation and the target can be set directly. On the other hand, one of the major risks is related to the incentive to fuel suppliers to opt for the lowest cost biofuels. This in return may lead to the following effects (unless this is influenced by other policies and measures):

- less incentives for innovation (i.e. advanced biofuels);
- likely to favour low-blend fuels and phase out high blend options;
- higher share of imports, thus less support to domestic agriculture.

This also means that a single mandate system is not the appropriate instrument for promoting a special type of biofuels. If pure or high blends or certain technologies shall be promoted, this would be more efficient through other or complementary policy.

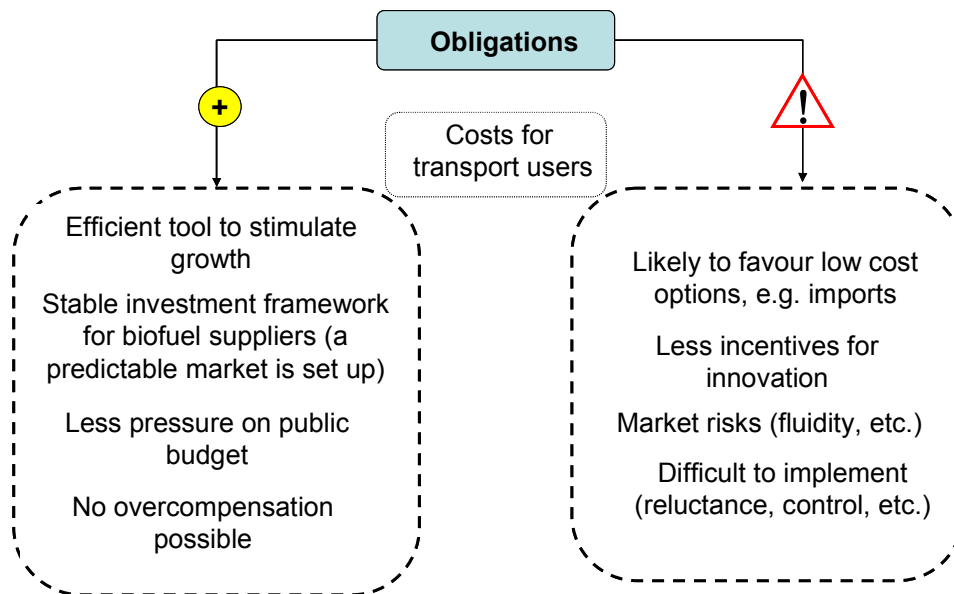


Figure 9: pros and cons of obligation systems

### 5.3.3 Vehicle compatibility / collaboration with car manufacturers

One of the preconditions for the use of alternative motor fuels is the compatibility with vehicles. For the user, it is important that the (adapted) vehicles maintain the manufacturer warranty. Collaboration with car manufacturers is thus crucial for the development of alternative motor fuels. For biofuels, collaboration with car manufacturers is particularly important for the use of high blends or pure biofuels. Both in Germany and Sweden, where pure biodiesel and E85 make an important share of the total biofuels market, respectively, show a successful cooperation with vehicle manufacturers. In Germany, for example, Volkswagen had publicly announced to assure the provisions of warranties for nearly all the diesel models (Audi, Seat, Skoda, Volkswagen) from construction year 1996 up to 2004; in Sweden, flexi-fuel vehicles are increasingly offered and now represent 10-15% of new vehicle sales.

Lately, France has launched an action plan [FAP, 2006] to develop large-scale of Flex Fuel E85 vehicles. This action plan started in January 2007 and includes stepping up energy-crop production, deploying flex fuel pumps and making sure that carmakers offer flex fuel cars at a cheap enough price. PSA has announced it will start selling E85 flexible fuel cars in France from the summer of 2007, Renault announced that by 2009 half of its gasoline models will be flex-fuel.

### 5.3.4 User incentives

User incentives are of interest for promoting those alternative motor fuels that require an adaptation of the vehicle (such as pure or high-blends of biofuels, natural gas, hydrogen). They have proven to be a useful, yet complementary measure to support the initial take-up

of dedicated vehicles. However, once dedicated vehicles become common practice, such user incentives cannot be maintained.

Sweden has introduced a set of user incentives to support eco-friendly vehicles. These comprise a 20% relief of company car taxation and the exemption from the Stockholm congestion charge as well as free parking for eco-friendly vehicles. As a result, FFV vehicles make a share of 10-15% of newly registered vehicle sales.

Incentives to purchase adapted cars do, however, not automatically imply that the users will consume alternative motor fuels. Therefore, user incentives are considered as complementary measures. In Sweden, for example, they accompany the general tax exemption for biofuels.

### **5.3.5 Low versus high blends ?**

Biofuels can be used either in low blends or in high concentrations (up to 100% for biodiesel; E-85 or E-95 for ethanol). In most Member States, there seems to be a tendency towards low-blend fuels as implementation costs are lower than for pure biofuels due to the absence of additional distribution/storage costs. Furthermore, car engines do not need to be adapted.

For these reasons, low blends can be implemented rather fast once fuel distributors / petroleum companies are willing to cooperate. In France (biodiesel, ETBE), Germany (biodiesel blends since 2004) and Sweden (ethanol) it only took about 3 years time to create a stable, high volume biofuel market through low blends. Nevertheless the conditions for the fuel distributors need to be clear (mandate, tax reduction, quota) and there should be enough drive for fuel distributors to include biofuels (either by mandate, by tax reduction sufficient to cover extra costs or by a combination of both). The system could fail if tax reduction is not sufficient or too low compared to neighbour countries (UK, Austria, Czech Republic).

On the other hand, both Sweden (E85, biomethane) and Germany (pure biodiesel) demonstrated that also a biofuel policy based on high blends can be successful. Crucial in the developments is the cooperation of vehicle manufacturers to deliver compatible vehicles.

Compared to a general blending system it takes much more time to reach a high volume biofuel market with high blends / pure biofuels. Looking at Germany, it took almost 10 years to reach a 1% share of diesel consumption through pure biodiesel. In Sweden the share of E85 is still very modest, although an increase can be expected with the increased sales of FFVs (13.5% of car sales in 2006; only 5.2% in 2005 [Statoil, 2007]).

High blends can become necessary if ambitious biofuel targets are aimed at. Currently, fuel quality requirements limit the use of biofuels to 5% of volume in regular fossil fuels (and 15% for ETBE). Even though these limits are likely to be loosened with the revision of the fuel quality directive, they can impede high biofuel shares.

Preparedness for the use of high blends might also be a means to enhance responsiveness to an abrupt increase in oil prices. The accelerated introduction of flex fuel vehicles would make it possible to quickly react to supply disruptions or price peaks of fossil fuels. As current new car models are likely to still be on the road by the end of the next decade, such a strategy would imply the active support to increase the market share of cars that can run on

high blends already today. This can be done by different policy instruments such as standards or incentives to the consumers/car industry/fuel distribution sector.

Adapting the engine to high blends of biofuels can also help in reducing exhaust gas emissions. At the moment, engines are optimised for minimising emissions from the combustion of fossil fuels. As ethanol and biodiesel (FAME) have different properties, such as the boiling point, oxygen content or vapour pressure, their combustion in form of low blends in unmodified engines can lead to changes in emission levels. Reducing the emission levels could be optimised in dedicated engines for high blends of biofuels.

Moreover, the use of pure biofuels is also important for increasing public awareness on biofuels.

In any case it needs to be kept in mind that those Member States that achieved a significant share of biofuels supported pure biofuels (or high blends) as well as low blends. Regarding the fulfilment of future targets (and the limits for low-blends) it is important to keep both options open.

### **5.3.6 Feedstock support - application of the energy crop premium**

As described above, the 2003 CAP reform introduced a special aid for energy crop cultivation. This amounts to 45 €/ha, but was limited to a maximum area of 1.5 million hectares in the EU15. In 2006 it was decided to extend the energy crop premium to a maximal area of 2 million hectares and to cover all Member States.

Despite some inconveniences of the energy crop premium for the farmers, such as an administrative burden and the loss of flexibility in deciding upon the use of the crops at the moment of harvest [EC, 2006b], there has been a relatively fast uptake of the scheme. Introduced in 2004, the energy crop premium was applied to 0.6 Mio ha in 2005 and estimated 1.2 Mio ha in 2006, close to the then allowed maximum area. In 2007, the energy crop premium was even requested for 2.8 Mio ha. Because of this enormous increase the European Commission will probably decide to reduce the subsidy amount per hectare.

Nevertheless, the energy crop premium is not the appropriate instrument to increase consumption of biofuels as it lowers the production costs of biodiesel only by 0.03-0.04 €/litre and by 0.01-0.02 €/litre for bioethanol. Also the extra revenue for the farmer remains limited: with an average yield of 3-4 tonnes of rapeseed per hectare, the premium would create extra revenue of 10-15 €/ton, compared with a market price of 200-300 €/ton.

Such a scheme is thus suited as a complementary measure to help steering the choice of crops that are cultivated for energy feedstock. For example, it could be adapted to favour crops that are better environmentally-compatible than others [EEA, 2006] for a classification of the environmental impacts of different energy crops. The recent reform of the energy crop premium allows Member States to grant national aid up to 50% of the costs associated with establishing multi-annual crops for the areas which have been subject to an application for the aid for energy crops. This is a step towards supporting crops with lower environmental pressures. Furthermore, it "could also be an encouragement for an alternative and less intensive use of lower quality arable land or areas with high risk of erosion, giving further environmental benefits to the application of the Scheme" [EC, 2006b].

### 5.3.7 Investment support

So far, capital grants to support investment in non-commercial biofuel production plant facilities played only a limited role in promoting biofuels. This is mainly due to the relatively low investment costs compared to the operation costs of first generation biofuels. If, for example, a typical large biodiesel plant with investment costs of 15-20 Mio € was supported with 10 Mio €, this would affect the biodiesel production costs by mere 0.01 €/litre.

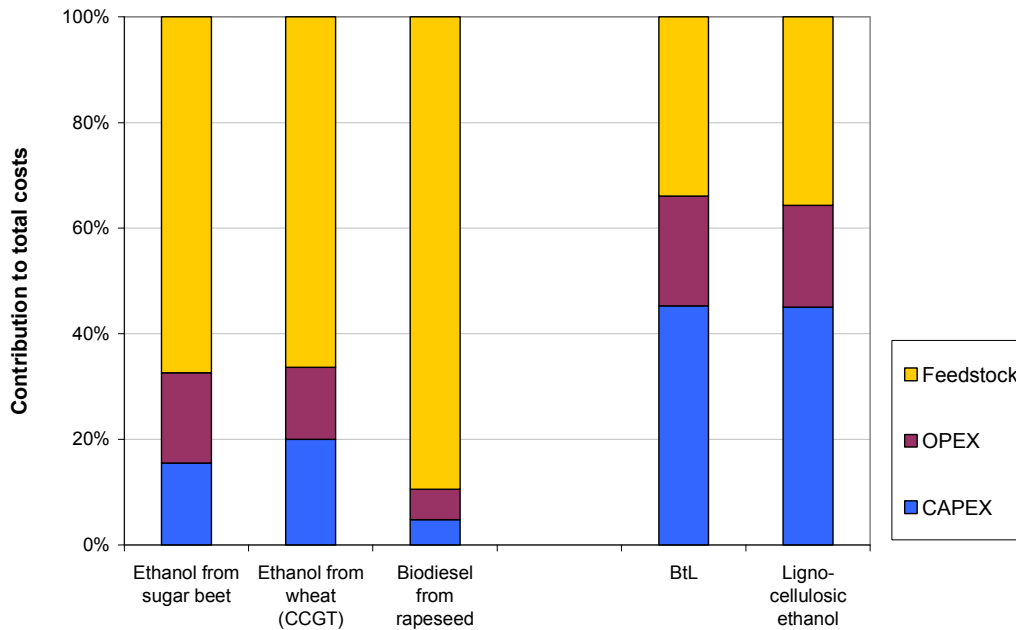


Figure 10: contribution of feedstock, operational and capital cost to overall biofuel production cost (based on data from [JEC, 2006])

This may change drastically with advanced biofuels as the investment of the processing facilities make a higher share of the total production costs of biofuels. While total capital costs account for some 7% (biodiesel) to 30% (ethanol) for conventional biofuels, they are in the order of 60% and above for advanced biofuel production technologies. Here, the investment support can be used to steer the type of biofuels produced in order to e.g. accelerate the market introduction of advanced biofuels.

### 5.3.8 Fuel quality standards

Fuel quality standards are a necessary condition in establishing a market for alternative motor fuels. They create guidelines for producers, distributors and car manufactures and eventually help to create confidence of the consumer in the new product. All Member States with a successful biofuel support policy introduced national standards for biofuels at an early stage (e.g. Austria, Germany, the Czech Republic, France, Italy, Sweden and the USA). On the other hand, Poland lacked clear quality standards in the beginning, which was counterproductive to consumer's confidence in biofuels [van Thuijl, 2006].

More important, an EU-wide standard for biodiesel was introduced in 2004 (EN14214) and has become the reference for all biodiesel producers and car manufacturers. A similar EU-wide standard for bioethanol is still in the discussion phase with a proposal published recently (pr EN 1376). EU-wide standards are essential for facilitating intra-EU biofuels trade.

On the other hand, current quality standards for fossil gasoline and diesel still limit the biofuel content of regular fuel to 5% in volume terms. The relative ethanol content in gasoline is determined by the EU fuel quality directive [DIR, 1998], which allows a blending of up to 5% in volume terms (3.4% share in volume terms). The maximum biodiesel content is limited by the CEN diesel standard EN590.

However, both legislations are in the process of being updated. A proposed revision of the fuel quality directive would allow a 10% bioethanol share [EC, 2007a]. Similarly, the Commission called for a revision of the norm EN590 and Germany's proposal to the European Standardisation Committee (CEN) to increase the community norm for diesel in order to allow a 10% biodiesel share was supported.

## **5.4 Sustainability criteria**

The sustainability of biofuels and biomass for energy is currently a highly disputed aspect. The production of biomass may cause damage to nature and the environment and this needs to be included in its overall environmental rating. The way in which biomass is produced may also have adverse effects socially and with regard to the health of local farmers, employees and their families. These risks can seriously damage the image of biomass as a sustainable energy carrier and thus hamper the large-scale application of biomass in both the present and the future provision of energy and raw materials. But the use of biomass also offers opportunities for the producing countries. Here we may think of, among other things, soil recovery, rural development, improvement of agricultural efficiency and increase of the prosperity and the social well-being of the local population.

To ensure that biomass as a source of renewable sustainable energy will be produced and processed in a responsible manner, various governments are developing sustainability criteria for biomass into the relevant policy instruments. An important example is the work done by the Dutch Commissie Cramer, which prepared a testing framework for sustainable biomass [Cramer, 2007].

They included the following themes:

1. Greenhouse gas emissions
2. Competition with food and local applications of biomass
3. Biodiversity
4. Environment
5. Prosperity
6. Social well-being

The majority of the themes and indicators relevant for the sustainability of biomass (energy) are related to feedstock production and agricultural practices, including their macro-economic effect on the local population.

The European Commission is stressing that it intends to make sure that only biofuels meeting certain sustainability criteria, will be accounted for the 10% target in 2020 and for various obligation systems and financial incentives.

## 5.5 Research priorities

Research can take place at all steps of the biofuel production process, i.e. crop development and optimisation of farming methods; transport logistics; conversion process; distribution; fuel quality and vehicle compatibility.

In the past, much research focused on the compatibility of vehicles with biofuels, the related fuel quality requirements and the conversion process. In both areas, the private sector actively supported research activities, especially car manufacturers and biofuel producers. Examples are the IFP research in France towards B5 general blending and B30 for diesel vehicles; projects with tractor manufacturers in Austria in the 1980s; research at Volkswagen and Daimler to look at compatibility of their vehicles etc.

With biofuels becoming a mature transport fuel with large volumes involved, research priorities are now shifting in order to ensure that biofuel production is done in an efficient, yet sustainable way and to better understand and ultimately limit negative impacts on food supply and the environment:

- **Feedstock:** Current crops are optimised for their nutrient rather than their energy content. Research can support the exploration of agro-environmental characteristics of novel crops that are highly efficient and environmentally-benign. This includes field surveys and the support of plant breeding as well as identifying optimal trade-offs between e.g. yield and fertiliser or irrigation needs.
- **Logistics:** With increasing capacities of production facilities, the logistics can become a problem, especially as production often takes place in rural areas with limited infrastructure. Such problem is expected to increase for 2<sup>nd</sup> generation biodiesel production facilities as economies of scale requires even large plant sizes.
- **Production processes:** Advanced ('2<sup>nd</sup> generation') biofuel production processes combine a number of advantages such as low emissions of greenhouse gases and their suitability to use ligno-cellulosic feedstock. They will thus be able to use perennial crops as well as by-products and some waste streams. More research is needed for these processes, as well as for other processes that can tackle additional resources, e.g. from waste.
- **System approach – modelling:** The discussion on future biofuel resources implies a complex analysis of the local natural and agro-environmental conditions, the development of food and feed demand, development of energy and transport demand and the development of international trade, the latter again being influenced by a number of factors. For the time being, there is no single model that is able to address these issues simultaneously. A coupled agricultural-energy model that can operate on a local as well as global scale, including trade among different world regions, would thus be a valuable tool. Such a model would need to be able to reflect the effect of policy decisions (e.g. possible development of the CAP; WTO regime; biofuel support policies).

An overall systematic assessment of biofuel costs, logistics and supply chains will eventually also need to explore the impact of climate change on the biomass resources. Some physical impacts of climate change on the potential future distribution of crops were analysed by [Tuck, 2006] in the framework of the ATEAM project. Such assessment can be important also for industrial investors for which a continuous feedstock supply is essential.

## 5.6 Synthesis of support schemes

Looking at the experiences in Member States with high shares of biofuel consumption in 2005 – Germany, Sweden, France and Austria – shows that a **mix of policies is necessary** in order to successfully stimulate the biofuel market:

1. On the one hand, all of these countries managed to introduce a **reliable "technical" framework** at an early stage, which is the precondition for an increasing biofuel market: they reached **agreements with car manufacturers** that guaranteed the availability and warranty for cars adapted for the use of biofuels. At an early stage, they also adapted **biofuel quality standards** (FAME standard already in 1991 in Austria, followed 1992 and 1994 by France and Germany, respectively, and in 1996 Sweden, followed soon by standards on ethanol and biogas in Sweden). These countries also succeeded in establishing a distribution network by supporting filling stations that offered biofuels.

The establishment of a stable technical framework in all of these Member States is to some extent also the result of an **early involvement in biofuels R&D**.

2. On the other hand, they all arranged for a **favourable and stable financial framework** to cover the additional costs of biofuels. In those Member States, **tax exemptions** were in place since the early 1990s and the tax levels on fossil fuels is among the highest of all EU Member States. Finally, all of those countries supported **low blends as well as high blends or pure biofuels**.
3. However, with rapidly rising biofuel volumes resulting in high tax losses for the governments, there is a **shift towards more efficient financial support** mechanism in three out of the four Member States. From 1 January 2007, Germany introduced an obligation system; reduced tax rates are applied only to pure biofuels in order to keep that market. France had introduced a 'mixed system' in 2005 and also previously limited the maximum tax losses. Since October 2005 an obligation is in place in Austria.

It also needs to be noted that in all those Member States **interest groups** actively supported the introduction of biofuels. In Germany and France, the agricultural sector pushed biofuels as a means to establish an alternative market for agricultural products. Furthermore, oil companies and/or car manufacturers were open to biofuels. The **political awareness** of biofuels as one option to support agriculture or **reduce environmental pressures** of the transport sector formed another important factor in creating a market for biofuels.

The following table shows an overview of the various measures, their application field, timing (function of market maturity), possible success, cost and who carries the cost. The costs are a rough estimate and are subject to a number of factors, including feedstock and oil prices as well as technology learning. Regarding the costs and who carries them, only first order effects are included.

**Necessary policies and measures** are put in bold, others are seen as complementary.

The application phase is divided into the following phases:

1. research stage
2. first prototypes of vehicles and/or production installations
3. first market introduction (< 1% market share)
4. limited market share (< 5% or 10%)
5. high market share

While the table summarizes the assessment based on Member States experiences so far, the column "prospects" provides an idea about how the instrument may be used in a more mature market.

*Table 4: overview of measures and their characteristics [Wiesenthal, 2007]*

Process chain	Measure	Application phase	Impact	Cost	Direct cost carried by	Prospects
Supply: Feedstock	Subsidies of energy crop growth	Up to limited market share (3-4)	Use of set-aside had very clear impact; energy crop premium has no clear impact on increase	Limited to 45€/ha => effect up to 0.5€/GJ (compared to total production cost of 17€/GJ)	Government	May be used to direct feedstock to crops with high yields and lower environmental pressures
Supply: Conversion	Investment support for production facilities	Up to first market introduction (1-3)	Useful to overcome high investment costs in the first stage of technology.	Limited; equivalent to 0.5€/GJ (can be higher for prototypes, small-scale and first commercial systems)	Government	May gain importance for advanced biofuel production plants with higher capital costs than conventional plants
Supply: Conversion	Producer incentives	Up to limited market share (2-4)	Makes alternative fuel cost-competitive. Should give long-term prospects.	High (10€/GJ in Czech Republic)	Government	
Supply and Demand	<b>Fuel standards</b>	From first prototypes (2-5)	Necessary for market introduction	Limited to research funding	Government / industry	Crucial for ensuring market penetration
Demand: end users	<b>Tax reduction</b>	Up to limited market share (2-4); for high market share differentiation is possible according to external impact and calorific value	Makes alternative fuel cost-competitive. Success if production sector follows.	High (11 – 17€/GJ)	Government	Proven to be successful to initiate markets if combined with high fuel taxes. For more mature markets, revenue losses become very high.
Demand: fuel suppliers	<b>Mandates for fuel suppliers</b>	Limited market share (4)	Stabilize market share, long term prospects. Fast market response if supply of feedstock/biofuel is assured. Could restrict the market if quota set too low	High (~10€/GJ)	Fuel consumers & distributors → eventually transport users	No revenue losses for governments and may thus be applied for more mature markets, too. Favours low blends, thus may require more complementary measures.
Demand	Subsidies for filling stations	Up to first market introduction (2-3)	Main effect for first market introduction of high blends (so AMF users can find	Depends on type of fuel; limited	Government	Is of importance especially for the introduction of high blends

			filling stations)			
Demand	Mandates for filling stations	Limited market share (4)	Fast market response if supply of fuel is assured.	Depends on type of fuel	Fuel distributors and consumers	
Demand: end user	<b>Vehicle compatibility</b>	Prototypes and first demonstrations (1-2)	Very important for later market introduction	Limited to research projects	Vehicle manufacturers, government research	Crucial step, both for low blends (general warranty) and high blends (dedicated vehicles)
Demand: public sector	Procurement systems	Up to limited market share (2-4)	Important to create visibility and experience on the market.	Depends on type of fuel (very limited for liquid biofuels, higher for gaseous)	Vehicle owners / users	Is of importance especially for the introduction of high blends
Demand: end user	Direct user incentives	Up to limited market share (2-4)	Direct advantages can create high public response	Limited	Governments	Is of importance especially for high blends that require adapted vehicles

## 6 CONCLUSIONS

### 6.1 Policy framework

A successful policy mix needs to simultaneously:

- create stable "technical" preconditions, such as fuel standards, fuel availability and compatibility with engines;
- create a financial or regulatory framework that reduces the final consumer prices of biofuels to that of fossil fuels;
- create long-term investment security for investors: this requires a stable predictable framework and binding targets, a political commitment and support from stakeholders.

Due to efforts from some pioneering countries and the EU, key preconditions for a wider market introduction are now fulfilled on an EU level with the existence of fuel standards, the compatibility of engines to low blends and the availability of vehicles that can use high blends or pure biofuels. Furthermore, with the creation of substantial production capacities, a market momentum has been created.

A wide range of mature technologies is available and more promising advanced technologies are likely to enter the market in the coming decade.

A future biofuel support policy will need to be adapted to the situation of larger volumes being involved. It will therefore have to focus on:

1. the most efficient policies and measures to promote biofuels,
2. measures to steer the composition of biofuels and underlying production pathways in order to better meet the dominant objectives of a biofuel policy,
3. combining national and EU biofuel policies to create long-term investment security.

#### *Cost-efficient measures to stimulate biofuel demand*

So far, subsidies through (partial or total) tax exemptions (complemented by other measures) have proven to be the most successful instrument in creating a market niche for biofuels. This has been the case particularly in countries with high taxes on fossil fuels, wherein the tax exemption could compensate the higher production costs of biofuels.

While tax exemptions seem to be one key instrument in creating a niche market for biofuels, they may be too expensive for achieving high shares of biofuels. When biofuels gain a considerable share in total transport volumes, obligations for fuel producers to sell a certain amount of biofuels relative to the total volume of transport fuels sold can to some extent overcome this problem.

#### *Steering the biofuels market*

Within a large biofuel market, it is possible – and desirable – to differentiate between different biofuels and production pathways. Factors such as the share of imports, the choice

of feedstock, or the dominance of conventional (1<sup>st</sup> generation) or advanced (2<sup>nd</sup> generation) technologies strongly influence the impact of a biofuel policy on avoided greenhouse gas emissions, security of supply or agricultural income. From an environmental point of view, it might be useful to ensure a traceability of biofuels. Furthermore, a ranking of different biofuel production pathways based on the efficient use of biomass, the carbon content and GHG savings potential, and production costs would be helpful to identify those pathways that should primarily be supported to best fulfil a Member States' objectives in supporting biofuels.

### *Aligning national and EU biofuel policies to create long-term investment security.*

Creating a long-term stable framework for farmers, biofuel producers, oil companies and car manufacturers is an important factor for a successful biofuel policy. This can best be met by setting long-term targets and a predictable policy. From an industry point of view, this would argue in favour of a unique EU biofuel policy.

On the other hand, biofuel markets differ widely among Member States and it is likely to assume that differences will continue as Member States have a different level of interest and potential in supporting biofuels (indicated by the country clustering).

Moreover, the specific objectives that are aimed at by supporting biofuels is likely to vary among Member States; some may be more suited and interested in producing biofuels and thus creating alternative incomes for the agricultural sectors, while greenhouse gas reduction or concerns about security of supply are major objectives to increase the consumption of biofuels for others. The right policy mix can only be found when determining first the key objectives of the policy.

Standards for biofuels are best taken on an EU-level. This will be beneficial for transport users and car manufactures as well as the biofuel industry. Also a certification scheme to ensure sustainability of domestic and imported biomass is most efficient on an EU and even worldwide scale. Furthermore, current European legislation (i.e. fuel quality directive) will need to be adapted so as to allow for higher shares of biofuels, the process of which has already started.

Additionally, RTD is necessary in a coordinated way between the national and EU-levels. In particular, advanced biofuels are a promising technology that requires further R&D. Additionally, there should be an emphasis on R&D for dedicated energy feedstock. Today's production techniques use traditional food/fodder crops. These crops can be further optimised for energy/biofuel production. Also new crops can become interesting for advanced biofuels.

## **6.2 CEE countries**

The Central and East European Member States show a large potential of biofuel production, particularly in relation to their transport fuel demand. They would not only be self-sufficient so as to meet the EU 2010 biofuel target without any imports, but have a considerable export potential. A comparison of arable area with transport energy demand indicates the possibilities for intra-EU trade. Countries with a high interest in biofuel production but a limited interest in opting for high shares of biofuel consumption may become exporting countries and vice versa. This implies that intra-EU biofuels trade could play a role:

- as exporting countries for Poland, Hungary, Romania and Bulgaria, and to a lesser extent Lithuania, Slovakia, Estonia, Latvia and the Czech Republic, Denmark and France;
- as importing countries for Luxembourg, Belgium, the Netherlands, the UK, Spain, Italy.

Some countries in Central and East Europe have already started to create an active biofuel policy (e.g. Czech Republic, Poland, Lithuania and Slovakia), some even started in the 1990s. However, in the past years biofuels were often rather exported than used domestically, as financial conditions in neighbour countries like Germany were much more favourable.

Interest for biofuel consumption in CEE countries may however rise, as most countries have adopted national biofuel targets for 2010 in line with the EU biofuels directive and the recently agreed 10% target for 2020. Opportunities for local agriculture and local employment, but also growing fuel demand will be the main drivers.

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