Biofuels in Europe

The current leader on the world biodiesel market, Europe is, after the United States and Brazil, one of the regions driving the production and utilization of biofuels. Its ambitious biofuel content targets for motor fuels (5.75% by 2010 and 8% by 2015) encourage Member States to significantly develop those pathways. This raises certain questions, especially about available biomass resources. It is likely that, beyond 2010, technologies other than those in existence today, using lignocellulosic biomass, will have to be implemented.

Biofuels, resulting from programs launched in the late 1970s to reduce oil dependence, have been in industrial development for more than twenty years. Today, there is strong renewed interest in biofuels: in the transport sector, they could lead to a reduction in oil consumption and greenhouse gas emissions. This is especially obvious in Europe, where directives adopted early in the decade set ambitious biofuel content targets for motor fuels (5.75% by 2010 and 8% by 2015) and oblige Member States to develop these technologies.

Background

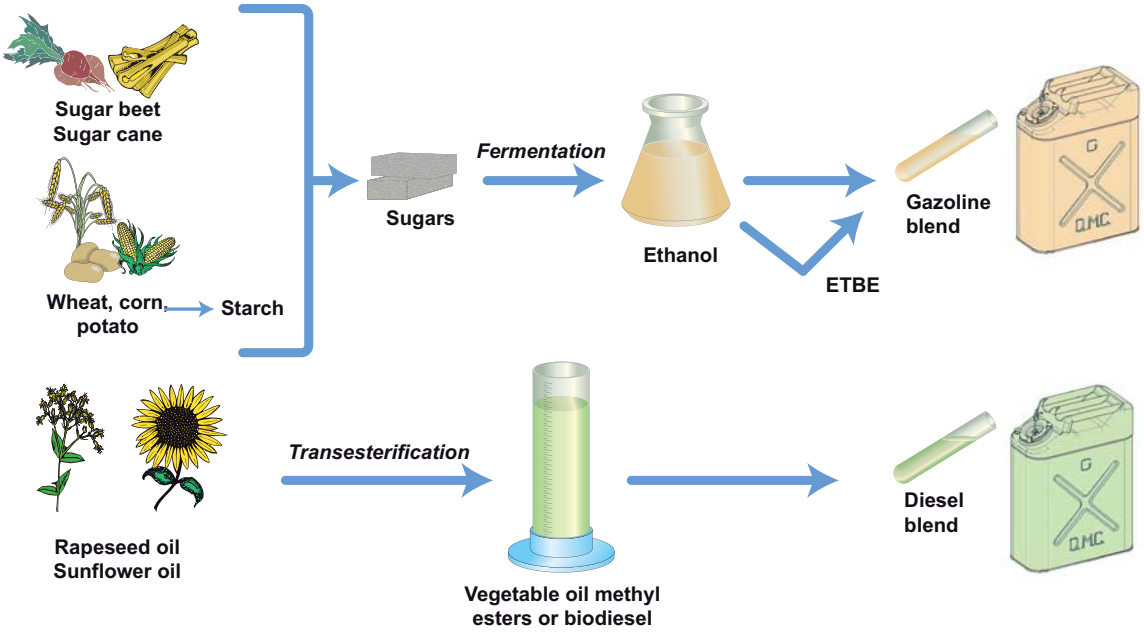
In the wake of the oil shocks of the 1970s, biofuels were perceived in many countries as a realistic albeit partial solution to the problem of dependence on oil resources. Furthermore, when blended with conventional motor fuels, they obtained lower levels of polluting vehicle emissions (particulate matter, NOx, etc.). The oil countershock of 1986 and an excessively high production cost slowed their development. Today, the business environment is more favorable, having changed in three respects:

– Public opinion is in favor of preventing the greenhouse effect from getting worse. This puts pressure on public authorities to find solutions to reduce emissions of CO_2, the principal greenhouse gas (GHG), especially in the transport sector. Biofuels emit fewer GHG emissions than conventional motor fuels: when used pure, they obtain reductions of 30 to 70%, respectively (ethanol compared to gasoline, and vegetable oil methyl esters compared to diesel)[1].

– With conventional crude production concentrated in the Middle East and uncertainty surrounding its evolution in the medium and long term, governments are seeking to implement policies that will promote the emergence of

(1) *"Well to wheels analysis of future automotive fuels and powertrains in the European context", version dated May 2006, EUCAR, JRC, CONCAWE.*

Fig. 1 Current biofuel technologies



Biofuels in Europe

alterative energy resources. In this regard, biofuels appear to be an interesting option, especially since they are the only "renewable" alternative to petroleum-based motor fuels for the transport sector implemented today at the industrial and commercial level. Biofuels are easier to introduce than gaseous replacement fuels like LPG[2] and NGV[3], because they can be added directly to gasoline or diesel fuel (at least, this is possible at contents lower than 10%) with no need to adapt the distribution system or vehicles.

– Finally, oil prices have not stopped rising since the early 2000s. This has generated renewed interest in biofuels, whose production costs were still, until recently, very high compared to oil-based motor fuels.

In Europe and the rest of the world (Figure 1), two biofuels are currently produced at the industrial scale: vegetable oil methyl esters (VOMEs) and ethanol, often used in the form of ethyl tert-butyl ether (ETBE), which is produced from isobutene and ethanol.

In 2005, 2.6 million hectares in Europe were occupied by energy crops used to produce biofuels. This land area breaks down into 2.4 million hectares of crops to produce biodiesel (95% rape, 5% sunflower) and 0.2 million hectares of crops to produce bioethanol (49% wheat, 51% sugar beets).

The European legislative framework

Taxation in Europe

The use of biofuels and their taxation are regulated by several Community texts:

– European directive 98/70/EC authorizes the addition of up to 5% ethanol to gasoline for standard distribution; Directive 85/538/EC permits up to 15% ETBE in gasoline for standard distribution; and 5% VOME in diesel fuel for standard distribution. Higher rates are perfectly compatible with existing engines, but it is mandatory to post information at the pump to notify consumers.

In 2003, the Council of Europe and the European Parliament approved two draft directives to diversify the energy supply and reduce greenhouse gas emissions.

– Directive 2003/30/EC promoted biofuels by setting higher targets for biofuel consumption in the transport sector, which should represent at least 2% of cumulated gasoline and diesel consumption in the transport sector by 2005 and 5.75% by 2010. These percentages are to be computed in energy terms. The targets are indicative, not mandatory, but Member States must inform the Commission of measures taken to reach them.

(2) *Liquefied Petroleum Gas.*
(3) *Natural Gas for Vehicles.*

– Directive 2003/96/EC, which bears on taxation, allows Member States to exempt biofuels partially or fully from excise taxes.

Each country continues to be responsible for the taxation of motor fuels. For instance, the minimum excise tax rates approved in Brussels for unleaded premium, diesel fuel and heating oil have stood at €359/m^3, €302/m^3 and €21/m^3 respectively since January 1, 2004. Effective January 1, 2010, the minimum rate for diesel fuel will be raised to €330/m^3.

It is important to point out that, since motor fuel taxation differs from country to country, the principle of partial or total tax relief for biofuels does not support biofuels in the same way in each country. France taxes gasoline at a rate of €0.59/l and diesel fuel at €0.417/l (not including VAT), whereas Germany applies a tax of €0.654/l to all conventional motor fuels.

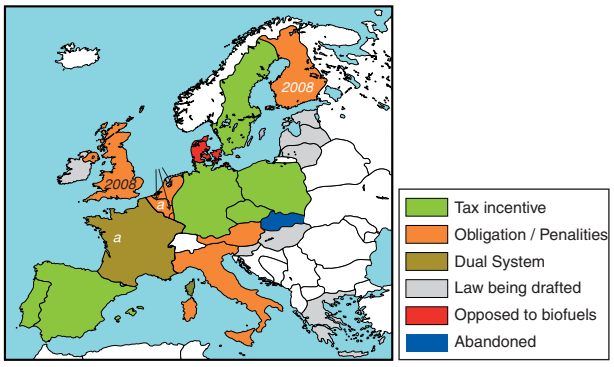
Figure 2 shows the disparate nature of biofuel taxation in Europe. An overall trend seems to give preference to mandatory biofuel contents in motor fuels rather than tax incentives.

Fig. 2 Biofuel taxation in Europe

United Kingdom: Law being revised. New system planned for 2008

Benelux countries: New biofuel regulations, effective 2006-2007

Germany: Incentive system being revised. New system, effective 2007



a = appointed suppliers

Source: Based on data from Total (adapted and updated), Jacques Blondy, presentation made at World Biofuels 2006, Seville, May 2006.

In 2005, the European Commission issued a biomass action plan for 2006, including the following actions relative to biofuels:

– The European Directive of 2003 for the promotion of biofuels will be revised. Biofuel contents in petroleum-based motor fuels may be made mandatory. Per-country targets will be revised. Sustainability certification procedures will be introduced and applied to the entire biofuel production chain.

Biofuels in Europe

– Member States will be encouraged to promote the use of second-generation biofuels based on lignocellulosic biomass (wood, straw).
– Legislation will be proposed to promote the purchase of vehicles running on fuels containing high biofuel contents.
– A study will be conducted to determine the reductions in CO_2 emissions that can be obtained by using biofuels in captive fleets.
– Within the framework of world trade negotiations, the goal will be to reconcile endogenous production and biofuel imports.
– An amendment to existing biodiesel specifications will be proposed to authorize using a range of resources broader than the current one (mainly rapeseed oil) as well as the replacement of methanol with ethanol in the esterification process.
– The factors limiting the biofuel content in petroleum-based motor fuels (vapor pressure for ethanol; biodiesel content for diesel fuel) will be examined.
– The oil industry will have to justify, from the technical standpoint, practices bearing on the use of biofuels in blends that could be considered barriers to biofuel dissemination. Industry practices will be monitored to ensure that no actions discriminating against biofuels are taken.
– Finally, ensuring that developing countries have access to the European biofuels market should be encouraged within the framework of existing international trade agreements.

The Community biofuels trade

Biodiesel imports to the European Union are subject to an *ad valorem* tax of 6.5%. However, there is not much trade on this market between Europe and the rest of the world, because the EU is the largest consumer as well as the largest producer. Furthermore, the European VOME standard imposes a number of technical constraints that limit the possibilities of using soybean or palm oil to produce this biofuel.

Non-EU imports of ethanol for motor fuels total about 200,000 t. Two types of ethanol can be imported: denatured ethanol and non-denatured ethanol, which can be taxed at different rates. For instance, the rates for imports from the ACP zone (Africa, Caribbean, Pacific) are €10.2 and 19.2 per hectoliter. In general, biofuels are produced from non-denatured ethanol.

Output

In 2005, Europe consumed about 4.2 Mt of biofuels (including 80% VOMEs), equivalent to 1.2% of road transport fuel consumption. In other words, the 2% target set in 2003 was not attained.

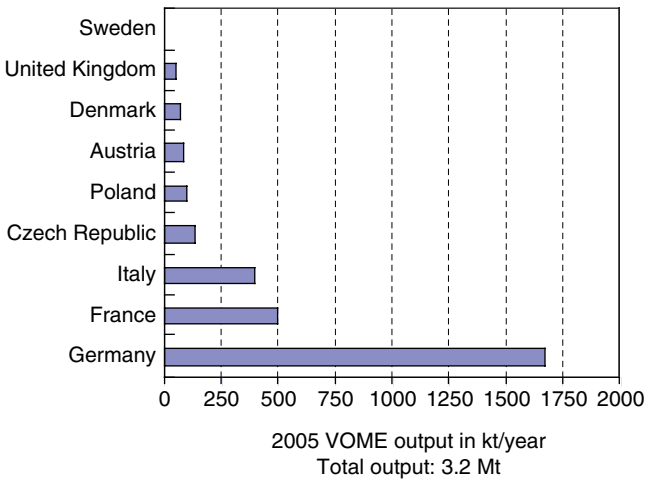
VOME output

In 2005, Europe produced about 3.2 Mt of VOMEs (Figure 3). Output has been steadily rising for ten years: the annual growth rate has averaged 35% for the last five years, more than quadrupling for the period. The pace of growth is accelerating, for it was up 65% in 2005 over 2004.

This rise in output was accompanied by a large increase in production capacity, estimated at 6.1 Mt in 2006 (Figure 4).

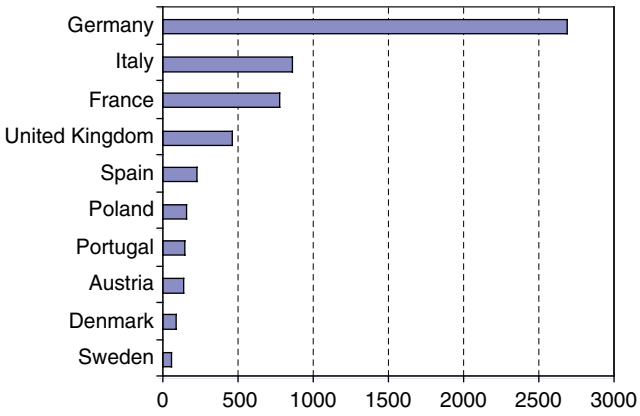
Europe also imported about 150,000 t of palm and soybean oil in 2005, which were used to produce 4.7% of the

Fig. 3 2005 VOME output in Europe (by country)



Source: European Biodiesel Board, 2006.

Fig. 4 2006 VOME production capacity in Europe



Source: European Biodiesel Board, 2006

Biofuels in Europe

biodiesel consumed. Whereas Europe finds itself in a situation of overcapacity for biodiesel production, it lacks oil. Under these circumstances, it can be expected that Europe will continue to rely on imports, especially those of palm oil, whose price is especially attractive (about half that of rapeseed oil), within the limits of the constraints imposed by biodiesel specifications.

In 2003, **Germany** became Europe's foremost VOME producer and consumer; and it still is in the lead today with output standing at 1.7 Mt (cf. Table 1), up from 450,000 t in 2002 (nearly quadrupling). Germany is currently in a situation of overcapacity, since total production capacity in 2006 was close to 2.7 Mt/year. The sharp uptrend in German VOME production can be traced to very favorable tax conditions. VOME is completely exempt from excise taxes, without any quota. (In contrast, France has always granted a partial tax exemption for a given volume subject to a call for tenders). This tax scheme is changing. Effective August 1, 2006, biodiesel has been taxed (€0.1/l when used pure and €0.15/l when used in a blend) and, in parallel, the government is imposing mandatory biofuel contents for motor fuels. This measure is intended to limit the loss of tax revenue for the State: tax relief for biofuels should be virtually nil by 2012. Very recently, new targets have been set to impose biofuel contents in road transport fuels: for example, 6.25% by 2009 and 8% by 2015 (3.6% and 4.4%, respectively, for ethanol and biodiesel). As we can see, Germany is opting to develop the ethanol pathway in the years to come.

The use of motor fuels based on pure vegetable oil (usually rapeseed) is legal in Germany. It would be possible to commercialize an estimated 300,000 to 400,000 t of raw vegetable oil (Source: UFOP), but the quantities actually consumed, mostly by industrial and "off road" vehicles, especially farm tractors, are lower, something like 200,000-300,000 t (about 15% of VOME consumption). The number of passenger cars running on pure vegetable oil, currently estimated to be 5,000 vehicles, has remained relatively stable in recent years.

France, the leader for VOME production until 2001, produced 492,000 t in 2005, exceeding its quota (about 417,500 t authorized). Part of this surplus was exported, especially to Germany, whose tax conditions make its VOME market attractive.

The Number Three, **Italy** produces almost 400,000 t/year of VOMEs, part of which is used for heating. Italy is the only country to use biodiesel for heating on a large scale, although the quantities used for this purpose are steadily falling. For years, the excise taxes on diesel fuel for heating were equivalent to those on diesel fuel for motor fuels, while biodiesel for heating was completely exempt from excise tax. The latter market absorbed over 20% of Italian output a few years ago, but is in a slump today. This is due to a sharp upturn in demand for biodiesel for transport as well as the implementation of many reductions in excise taxes on heating oil to lessen the impact of rising oil prices on household budgets. The heating oil segment represents no more than 3 to 5% of the Italian market (probably 15,000 to 20,000 t/year at most) and is still shrinking. A new law making it mandatory to add biofuels to conventional motor fuels is expected to give the market a boost.

The Czech Republic and **Poland** also produce VOMEs but in lower volumes. We should note an interesting development in **Austria,** where several market players have opted to produce VOME from used vegetable oil (frying oil, etc.).

Ethanol output

In 2005, Europe produced about 750,000 t of ethanol for motor fuels and imported 200,000 t to cover consumption (950,000 t). The bulk of production took place in Spain, Sweden, Germany and France. In these countries (except Sweden), ethanol is not used directly but converted to ETBE, which is then blended with gasoline. This practice, specific to Europe, is due to the obligation to comply with a standard bearing on motor fuel properties, including volatility, and to the fact that the use of ETBE avoid demixtion risks when ethanol and gasoline are blend and are in the presence of traces of water in the storage tanks.

After leading the European ethanol market for years, **France**, which produces as much ethanol as it consumes, has been overtaken by Spain, Sweden and Germany, as shown in Figure 5. The quotas giving entitlement to partial tax relief granted by the French State for ethanol in 2005 amounted to 134,587 t of ethanol in the form of ETBE for gasoline blends and 72,416 t of ethanol pure to be added directly to low-volatility gasolines. In 2005, ethanol was mostly consumed as ETBE, for which the production quotas were almost reached (114,000 t).

On the other hand, the volumes of partially tax-exempt ethanol for use in blends with low-volatility gasolines were not put on the market. Public authorities are seeking to promote the use of ethanol via different actions including the following, implemented in 2006:

- An experiment on the use of ethanol in blends with low-volatility gasolines is being conducted in the city of Rouen, France.
- The use of E85 (85% ethanol, 15% gasoline) received a boost: for 12 months, the Conseil Général de la Marne will be operating an experimental fleet of flexfuel vehicles. The

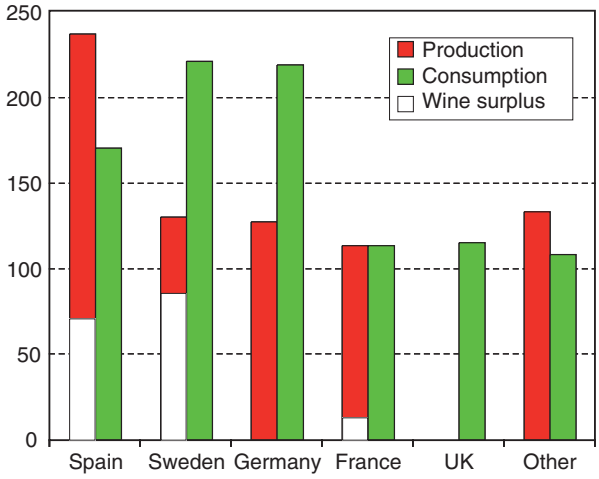
Biofuels in Europe

scientific expertise will be supplied by ADEME (France's Agency for the Environment and Energy Management) and IFP; E85 will be for sale in 2007 with a special fiscal scheme, several hundred of dedicated E85 sales outlets are scheduled to be built.

The most dynamic market player in Europe is **Spain**. The **United Kingdom** consumes about as much ethanol as France, but uses imports only. **Sweden** consumes more ethanol than it produces, due to the near-generalization of E5 since early 2003 and the development of E85 at about fifty service stations.

Europe saw its output of ethanol for motor fuels climb from 500,000 t in 2004 to 750,000 t in 2005, as a result of a large increase in the use of wine surpluses (+170,000 t).

Fig. 5 2005 ethanol production and consumption in Europe (in kt)



Source: eBIO for ethanol and wine surpluses, the French Ministry of Agriculture, Ballerini 2006 for the conversion factors.

Production costs

Production costs in France

Cost is key to the long-term future of the biofuels sector.

The energy content is lower (by about one-third) for ethanol than gasoline. This is penalizing when the ratio formed by the cost over the quantity of energy available (€/GJ) is compared to the cost per liter. For this energy application, the comparison should be made between energy efficiencies.

Biofuels still require public-sector funding. This is especially true now, given the high level of demand and the particularly elevated prices of ethanol in the United States and Brazil, and of VOMEs in Europe. In the United States, the ethanol price climbed to $3/gal ($0.8/l, or nearly $1,000/t in July 2006, four times the announced production cost). In Brazil, the ethanol price is in the vicinity of $0.4/l (nearly double the announced production cost). In Europe, the VOME price reached €0.720/t, due mostly to an upsurge in the price of rapeseed oil, the principal raw material, quoted at nearly $800/t (May 2006) in Rotterdam[4].

See Table 1 for an example of VOME and ethanol production costs for Europe.

Table 1
Comparison of production costs for biofuels and petroleum-based motor fuels

	EtOH Europe	EtOH Brazil	EtOH USA	EMHV Europe	Gasoline $60/bbl	Diesel $60 /bbl
€/l	0.4-0.6	0.2	0.3	0.35-0.65	0.32	0.36
€/GJ	19-29	10	14	10.5-20	9	10

Source: IEA/IFP.

Impact of the Common Agricultural Policy (CAP)

In addition to the European directives mentioned earlier and the tax practices of individual Member States, the Common Agricultural Policy has and will continue to have a major impact on biofuel economics.

In 1992, it was decided to reform the CAP. Two mechanisms were set up to keep production under control by lowering guaranteed intervention prices and introducing direct subsidies based on land area (average reference yields).

In the sector of high-yield crops (mostly cereals and oilseeds), access to these direct subsidies was made contingent on a land freeze (hence the idea of a fallow land premium). The production of ethanol from sugar beets does not fall in this category (a system of quota-guaranteed prices at around €42/t).

The concept of "industrial» freeze concept makes it possible to receive this aid when land is used to cultivate non-food crops. The purpose of these subsidies is to compensate farmers for lost income. From the growing season 2000-2001 onwards, under the reform agreement made in Berlin, this freeze was set at 10% of cultivated land areas, which represents about 8.2 million hectares in the Europe of Twenty-Five and 1.5 million hectares in France.

In this way, some land is virtually "reserved" for the production of biofuels. The future of these technologies is directly related to that of the CAP: any change in the area of fallow land or in the compensatory aid will directly influence whether a farmer finds it profitable to develop non-food crops or not.

(4) In comparison, oil priced at $70/bbl is equivalent to about $500/t.

Biofuels in Europe

It was agreed to give the CAP a new orientation from early 2005 to 2013. The avowed purpose of this reform was "decoupling", *i.e.* to sever the linkage between subsidies and output by gearing products more towards quality than quantity. Today, farmers receive a single payment per farm that is contingent on compliance with specified environmental and public health standards. The amount is allocated on a historical basis.

As for biofuels, the system whereby fallow land may be cultivated for non-food purposes has been maintained. In addition, a new aid of €45/ha has been granted for energy crops grown on non-fallow land. This aid is justified by the fact that these crops ultimately have a beneficial impact on the greenhouse effect.

Outlook

In 2005, the European Union did not attain its target biofuel content of 2%—which represents 5.8 Mtoe of biofuels, *i.e.* 3.3 Mtoe of biodiesel and 2.5 Mtoe of bioethanol—but posted a content of about 1.2%. The medium-term biofuel objective for Europe is 5.75% by 2010, which implies biofuel consumption of 16.6 Mtoe by 2010 (5.6 Mtoe of bioethanol and 11 Mtoe of biodiesel, assuming that the target rate is to be applied separately to gasoline and diesel fuel). Attaining this biofuel output would require about 82 Mt of farm biomass and a land area of about 13.8 Mha. To meet demand for biodiesel, it would be necessary to allocate a land area for rape alone larger than the cumulated area of all fallow land in Europe (8.2 Mha), knowing that not all of these land areas are cultivable. That being the case, it will apparently be necessary to mobilize land other than fallow land to reach the biofuel content objectives for 2010. Possible medium-term solutions include:

– Using "surplus" land, *i.e.* land used to grow crops for export outside the European Union and non-fallow land now used to grow non-food crops. The maximum potential comes to about 8.2 Mha. This surplus land could yield up to 10 Mtoe of biofuels, provided that crop rotation is adapted to biodiesel/bioethanol demand. By itself, this surplus land is not sufficient to attain the 2010 target.

– Resorting to imports, particularly of vegetable oil, seems inevitable. On what scale will depend partly on what other land surfaces (fallow and surplus land) can be mobilized and partly on the technical constraints (biodiesel specifications) that put a 10% ceiling on soybean or palm oil added to rapeseed oil.

– There remains a last possible scenario, in which the replacement target of 5.75% is not attained for gasoline and diesel fuel individually, but cumulatively, as authorized by the European directive. For instance, this scenario could be realized exclusively with European crops by producing a maximum quantity of biodiesel ex-rapeseed, which could represent up to 3 to 4% of diesel fuel consumption and by replacing up to 10% of European gasoline consumption with ethanol. This high rate of replacement would have repercussions for the motor vehicle manufacturers and oil companies, for it implies the use of E10 and/or large-scale development of FFVs.

For Europe, the most advantageous solution would maximize biomass quantity while minimizing land occupancy. Using "surplus" farmland is a solution that is fairly easy to implement but its contribution will remain limited, because of heavy competition from the extra-European food market for the farm products grown there. Relying on imports is a flexible option offering a range of raw materials that can be easily adapted to requirements (and at lower cost). For the agricultural powers of the European Union, such as France or Germany, imports can only represent make-up or alternate capability in order to keep biofuel production profitable. For countries that possess little farmland, this solution will inevitably be used on a relatively large scale.

Beyond 2010, it will become necessary to rely on lignocellulosic biomass resources and implement second-generation processes to obtain ethanol or synfuels (biodiesel and biokerosene). Lignocellulosic biomass consists of cereal and oilseed straws that are not currently exploited, wood industry waste (harvest slash, sawdust, scraps, chips, etc.) and any dedicated energy crops planted. Starting in 2015, not including dedicated crops and accounting for logistical constraints, the potential surplus of lignocellulosic biomass could represent up to something like 100 Mt of dry raw materials (16 Mtoe of biofuels). In the final analysis, taking all production technologies into consideration, biofuels have the **potential** to replace between 12 and 18% of European motor fuel consumption (33 Mtoe) by 2015. However, this is only feasible if half of the total output consists of second-generation biofuels produced using pathways that are still in the research stage and for which future investments are still very uncertain. One should also keep in mind that the new biofuel content targets for the transport sector, currently the object of negotiation in Brussels, are expected to be lower than this estimate for potential output by 2015. The unofficial figures in circulation at the time of writing were on the order of 9% by 2015 and 14% by 2020.

Anne PRIEUR-VERNAT, Stéphane HIS
anne.prieur@ifp.fr - stephane.his@ifp.fr

Final draft submitted on December 20, 2006

IFP
1 et 4, avenue de Bois-Préau - 92852 Rueil-Malmaison Cedex - France
Tel.: +33 1 47 52 60 00 - Fax: +33 1 47 52 70 00

IFP-Lyon
BP 3 - 69390 Vernaison - France
Tel.: +33 4 78 02 20 20 - Fax: +33 4 78 02 20 13

www.ifp.fr