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Biofuels in Europe

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Biofuels have been under industrial development for over 20 years. Still handicapped by high costs, their future once again looks promising because they might be able to help reduce oil consumption and greenhouse gas emissions in the transport sector. This is especially true in Europe, where recently approved directives contain ambitious production volume targets encouraging member states to develop biofuels.

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Introduction

Biofuels have gained real credibility as fuels to supplement petroleum motor fuels but will never be able to fully replace oil. Public authorities are renewing support for biofuels and setting following transport sector goals, calculated on energy basis: 5.75% by 2010 and 8% by 2020 in Europe; and 4% by 2010 and 20% by 2030 in the US. Judging by the technologies already in place, land use competition between the energy and food industries will have to be intelligently managed. In the effort to attain 2010 or 2020 objectives, large volumes of co-products will also be inevitably generated and will have to find lucrative market. Biofuels represent a new outlet relatively protected from international competition. They are still traded in small volumes and do not really compete with petroleum products because they receive public support. European and American biofuel markets are looking very attractive. Eventually, countries like Brazil (ethanol) and, to a lesser extent, Malaysia or Indonesia (palm oil) will try to export their low-priced production to these new and potentially lucrative outlets. In New York, an ethanol futures market (Nybot) opened in May 2004, which may be a sign that a world ethanol market is emerging.

Two biofuels are already candidates for industrial development: 1) Vegetable oil methyl esters (VOME); and 2) Ethanol, mainly used in Europe in the form of ethyl tertio butyl ether (ETBE).

The Characteristics of Biofuels

The two main types of biofuel are ethanol, used in gasoline engines, and VOME, used in diesel engines. Ethanol is the most prevalent. Brazil and the U S accounted for most of the world production (25 million tons). In the same year, VOME (2.1-2.2 million tons) was produced worldwide, primarily in Europe.

Ethanol is made from sugar-producing crops (sugar cane, sugarbeets) and amylaceous plants (wheat, corn). Production processes require a fermentation stage to convert the sugar to ethanol, as well as a more or less advanced distillation stage to separate alcohol from water. Some processes generate large volumes of co-product, the most virtuous being the production of ethanol from sugarcane; the principal co-product, bagasse (sugarcane fiber), is valorised in energy form, particularly for distillation. When producing ethanol from sugarbeets, from which a large part of ethanol is produced in Europe and particularly in France (70% of the French ethanol is produced with sugarbeet), 0.75 ton of co-product (mostly pulp) is obtained per ton of ethanol. This co-product is currently sold as animal feed.

The production of ethanol from wheat or corn yields residue (1.2 ton/ton of ethanol) that can also be exploited on the animal feed market. Ethanol can be used pure, in a blend or in its ether form (ETBE), obtained in reaction with refinery isobutene. If it is used pure or in a very high concentration (85% or E85), then vehicle modifications are necessary (injection systems, engine adjustment systems, compatibility of plastics and gaskets, special cold-start strategies for pure ethanol). A number of car manufacturers (GM, Ford, Daimler Chrysler, PSA and Renault) have commercialised vehicles that run on

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E85 or gasoline in Brazil or in the United States. On the other hand, no such modifications are required at lower content levels (5-10%) as in the United States.

In Europe, ethanol (5%) is authorised to be used blended to gasoline. But in presence of even traces of water, gasoline and alcohol phases may separate. This phenomenon is known as demixtion. Also, the addition of pure ethanol to gasoline will increase the mix propensity to evaporate (by augmenting vapor pressure). ETBE eliminates these disadvantages. In Europe, ethanol is essentially used in ETBE form. Sweden is the one and only in Europe to use ethanol in its pure form directly blended to gasoline.

VOME are produced from vegetable oils made from rapeseed, sunflower, soybean or palm, among other source plants. When seeds are ground to produce the oil, a solid residue called "cake" is obtained (1-1.5 ton of cake/ton of oil). Generally, it goes to make animal feed. Unsuitable for direct use in modern diesel engines, vegetable oils need to be transformed by transesterification with methanol to obtain VOME and glycerine (0.1 ton /ton of VOME), which plays a significant role in valorising this technology. If VOME are to be produced on a large scale, special attention must be on glycerine market, which is relatively small (0.8 million ton/y of glycerine are produced world-wide, of which 100 000 tons are a by-product of VOME production). VOME is used pure (engine modification required) in Germany or blended in France. VOME are mostly incorporated in blends (up to 30%). VOME is sold at the pump with complete transparency for users. Most French refineries add VOME (2-5%) to motor fuels for sale. It is used in captive fleets (up to 30%) without any particular technical constraints. For Renault V.I. or PSA, however, upper limit (30%) neither will deliver a manufacturer's warranty if this threshold is exceeded.

Advantages and Disadvantages

Biofuels provide an alternative to petroleum fuels in the transport sector and reduce greenhouse gas (GHG) emissions. Biofuels can deliver gains (60-90%) for the most efficient technologies (sugarcane) and the best estimate when they are used pure. Similar gains are obtained with respect to fossil fuel consumption, compared to petroleum-based motor fuels (the energy balance accounts for all stages in the life cycle of biofuel). But, gains can vary notably depending on the nature of the vegetal matter, the conversion process, the methodology used for the co-product allocation, etc. For ethanol ex-wheat, GHG emissions reduction can vary (0-60%) compared to fossil fuels.

Biggest disadvantages of biofuels relate to the availability of resources and the costs of the technologies involved. Biofuel technologies post fairly low energy efficiencies per ha: 1 ton oil equivalent (toe)/ha for VOME produced from rapeseed or sunflowers, 1-2 toe/ha for ethanol produced from wheat or corn, and 3-4 toe/ha for ethanol ex-sugarbeet or ex-sugarcane. Owing to a number of agricultural constraints, it is impossible to grow all species in all soil types under identical conditions. Therefore, large-scale biofuel development will be competition between the energy and food sectors over land occupancy. It will be necessary to find the best trade-offs. This is particularly true for Europe, which has to face a high bio-diesel fuel demand due to the commercial success of diesel cars (45% of sold cars and 22% of vehicles in use). If 5.75% fossil fuel substitution objective set by the commission is to be reached in 2010, Europe will have to consume about 22 million tons of biofuel, of which 12 million tons will be bio-diesel. Unfortunately, bio-diesel has the lowest productivity, making thus 5-6 million ha of fallow available insufficient to meet the desired production target. At this point, at least two solutions could be imagined: 1) To import ethanol and/or VOME or more probably vegetal oil that can be converted into VOME that can meet the European specifications; 2) To produce bio-diesel from new sources as for example lignocellulosic matters using Fischer-Tropsch process associated with a high temperature gasification stage. But those options are not easy to implement. All the vegetal oil cannot be converted into VOME to be used in Europe: The Iodine Index, which measures the esters degree of unsaturation, must remain below 120. This makes the use of pure soybean oil to make esters difficult: the Iodine Index of soybean oil esters is around 135. On the contrary palm oil can offer a good Iodine Index but a less interesting cold properties (it becomes "solid" above 0°C.

Finally, the cost of producing biofuel is higher than the price of fossil fuels (exclusive of tax), even if the high barrel price is narrowing the gap (Table 1). This makes appropriate support from public authorities still needed for the development of biofuels, particularly in Europe.

Table 1—Price comparison for motor fuels

Ethanol Europe	Ethanol Brazil	Ethanol US	VOME Europe	Petroleum fuels 25 $/bl	Petroleum fuels 50 $/bl
0,4 -0,6 €/l	0,23 €/l	0,3 $/l	0,35-0,65 €/l	0,2 $/l	0,4 $/l
19 - 29 €/GJ	11 €/GJ	14 $/GJ	10,5 - 20 €/GJ	6 $/GJ	12 $/GJ

Source: IEA/IFP

Table 2— VOME production in 2004

Country	Production 000 tons
Germany	1 035
France	348
Italy	320
Denmark	70
Czech Republic	60
Austria	57
Slovakia	15
Spain	13
United Kingdom	9
Lithuania	5
Sweden	1
Total	1 933

Source: EBB

Table 3—European ethanol production

Country	Production 000 tons
Spain	194
France	102
Sweden	52
Poland	36
Germany	20
European wine surplus	87
Total	491

Source: Observ'er
Note: 1 ton ethanol = 26.8 GJ or 0,64 toe

Europe: Present Status

Europe appears to be lagging in comparison with the programs, including some on a large scale, underway in Brazil and the United States. In the last 20 years, only France has remained relatively consistent in implementing this type of policy. Since 2001, however, Germany has taken the lead for VOME while Spain and Poland have moved into the forefront for ethanol. Contrary to the situation in Brazil or the United States, the European motor fuels consumption has been increasingly dominated by diesel fuel (in Europe, 60% of the total). In Europe, VOME production has been growing fast in the last 10 years, reaching 2 million tons in 2004 (Table 2). Annual growth during 1992-2004 averaged 35 percent. In 2004, Germany became Europe's top producer of VOME (1 million ton) as well as the top consumer. France, European leader until 2001, produced 348, 000 tons in 2004. The production quota, set at 317, 500 ton/y, was revised upwards in 2004 (+70, 000 tons). It also has been announced that a new 160, 000 ton/y unit will be built in Sète to feed refineries located in the south of France implementing the IFP's new process: *esterfip H*. Biofuels was one of the strong points of the climate plan introduced by the French government, which approved construction of four new units and the multiplication by a factor of three of the global 2004 biofuels production volume in 2007 (1.2 million tons). This means the addition of 800, 000 tons of biofuels to the actual level of production (480, 000 tons of VOME and 320, 000 tons of ethanol). It can be added that in 2005, a new 130, 000 tons quota of biofuels has been granted (100, 000 tons of ethanol and 30, 000 tons of VOME). A new legislative framework has also been inaugurated in 2005 in France: Fuels sellers has to incorporate a mandatory level of biofuels set by the government on a annual basis to their sold product; if they do not meet the target they will have to pay a tax. Italy produced nearly 320, 000 tons of VOME in 2004 (growth up 17 % over 2003).

In 2004, European ethanol production remained concentrated in France and Spain and to a latter extent, Sweden and Poland. Practices in Europe (except Sweden) differ from that in the United States and Brazil, where ethanol is not generally used directly, but transformed into ETBE then blended with gasoline. This European particularity is partly due to compliance requirements relative to motor fuel properties such as volatility (pure ethanol makes ethanol/gasoline blend more volatile). It also helps avoid demixtion in the presence of traces of water (separation of alcohol phase and "gasoline" phase). A long-time European leader in ethanol production, France has been overtaken by Spain (Table 3).

Spain is Europe's most dynamic producer, with one company, Abengoa, as the driving force behind this trend. Spanish capacity has been estimated at about 500 million l/y (400 k ton/y). The ethanol is mainly produced from wheat and barley. Sweden now consumes more ethanol than it produces. This has been true since the E5 biofuel was virtually generalized in early 2003 and the E85 was developed at some 50 service stations. National consumption is now around 200, 000 m^3 (or 160 k ton). The difference between production and consumption is essentially covered by imports from Brazil or Spain. Germany is finally shifting to ethanol. Three distilleries are either under construction or have already been brought on stream, which should bring domestic capacity to nearly 500, 000 ton/y and make it the number one European producer. Finally, The European Commission just published new rules for the use of wine alcohol for fuel. Up to now, just four companies have been registered: Ecocarburantes and Bioetanol Galicia (both from Spain), SEKAB (Sweden) and Altia (Finland). The price for ethanol ex-wine in the last sale organised by the European Commission which occurred on 2nd March 2005 were 23.5 €/hl.

The European Legislative Framework

European Directive 98/70/EC on motor fuel quality officially authorises, for regular sale at the pump, gasoline (5% ethanol) or 15% ETBE (Directive 85/538/EC) as well as diesel fuels (5% VOME). Higher content levels are perfectly compatible with today's engines, but in that case customer notification at the pump would be necessary.

In 2003, the Council of Europe and the European Parliament approved two draft directives concerning energy supply diversification and the reduction of GHG emissions:

- Directive 2003/30/EC promotes biofuels by setting progressive targets for their consumption in transport sector. By 2005, biofuels should represent at least 2 percent of all gasoline and diesel motor fuels consumed in this sector. The objective for 2010 is 5.75 percent. These percentages will be computed using an energy base. Although these targets, provided as indications, are not mandatory, member states must keep the European Commission informed about measures taken to reach them.
- Directive 2003/96/EC concerns taxation. It allows member states to grant partial or total exemption from excise tax on biofuels. Motor fuel taxation remains the prerogative of each member state. By way of an indication, Brussels recently approved the minimum excise rates for unleaded premium, diesel fuel and heating oil, effective January 1, 2004 as €359/m3, €302/m3 and €21/m3, respectively. For diesel, the minimum rate will be raised to €330/m3 by January 1, 2010.

In the European Community, each country continues to exercise responsibility in the area of motor fuel taxation which is high: In France or Germany, excise is respectively for gasoline of 589 and 654 €/m^3 and 417 and 470 €/m^3 for diesel (to which VAT should be added). To date, a number of member states have obtained biofuel tax exemption waivers (30-100% of excise taxes levied) on petroleum motor fuels.

Impact of the Common Agricultural Policy (CAP)

In addition to the relevant European directives and the tax policies implemented by each Member State, the CAP has always had and will continue to have a major impact on biofuel economics. Two mechanisms were introduced to help control production: 1) The reduction of guaranteed intervention prices; and 2) The introduction of direct subsidies based on land area (average reference yields). In the sector of high-yield crops (mainly cereals and oilseeds), eligibility for these direct aids was contingent on a "land freeze" (hence the notion of a fallow land premium). Raising sugarbeets for ethanol was not covered by this framework (a system of guaranteed prices, about €42/ton per quota). Introducing the concept of "industrial freeze" paved the way for the allocation of aid when the land is cultivated for non-food purposes. Starting in the 2000-2001 season (the Berlin Agreement), the amount of cultivated land to be left fallow was fixed (10%) and the amount of compensatory aid at €63/t (about €350/ha for an average region) for cereals and oilseeds. The purpose of this aid was to guarantee compensation to the farmer for loss of income. In Europe in 1999, about 5.7 million ha were left fallow, of which 17 percent was used for non-food purposes (mostly to produce biofuels).

In France, nearly 1.5 million ha were left fallow in 1999 and 20 percent were used to produce biofuels. For all intents and purposes, a portion of the land is "set aside" for the production of biofuels, whose future therefore depends directly on the CAP. Any change in the fallow land area or the amount of compensatory aid will directly affect the farmer's judgment as to whether it is worthwhile to raise crops for non-food purposes. In spring 2004, a new CAP reform was approved for possible implementation in early 2005, through 2013. Its avowed purpose is to "decouple" aid and production by aiming for more quality and less quantity. Farmers would receive a single premium per farm, and payment would be contingent on compliance with environmental and public health specifications. The allocation of aid would be computed on a historical basis.

As for biofuels, use of fallow land for "non food" purposes is still allowed. Furthermore, a new aid of €45/ha has been granted for energy-related crops raised on non-fallow land up to 1.5 million ha. Such crops should have a beneficial effect in the reduction of GHG emissions.

Conclusions

R&D work is underway to develop new solutions to the problems represented by production costs, restricted land volume (competition with food crops) and the management of coproduct volumes. These solutions will focus on lignocellulosic substances (wood, straw). Two alternatives are being considered: 1) To produce ethanol, which has been under development in recent years especially in North America; and 2) Using the Fischer Tropsch (FT) method to make synthetic diesel fuel, figures prominently in European plans. These two technologies could be combined at a single industrial facility, a sort of biorefinery at which ethanol process wastes could serve to supply gasification-FT synthesis process. Like present-day refineries, this unit would generate two motor fuels, a "gasoline type" and a "diesel type". This option allows also the production of a "bio-jetfuel" that can feed air transport sector, giving thus an opportunity to reduce GNG emission in a sector where there are very few alternatives to petroleum fuels.

References

1 Marleix A, *Rapport n°1622 de l'Assemblée Nationale sur les biocarburants*, 26th May 2004, http://www.assemblee-nationale.fr/12/rap-info/i1622.asp.

2 Pasty J C, Les débouchés non alimentaires des produits agricoles: Un enjeu pour la France et l'Union Européenne, *Rapport du Conseil Economique et Social*, 12th may 2004, http://www.ces.fr/rapport/doclon/04051912.PDF.

3 *Bilans énergétique et gaz à effet de serre des biocarburants en France*, ADEME/DIREM, November 2002. http:///www.ademe.fr/partenaires/agrice/publications/documents_francais/synthese_bilans_energetiques_fr.pdf.

4 Well to wheels analysis of future automotive fuels and power train in the European Context, *JRC/EUCAR/CONCAWE*, January 2004. http://ies.jrc.cec.eu.int/Download/eh.

5 Biofuels for transport - An international perspective, *International Energy Agency*, 2004, ISBN 92-64-01512-4.