PANORAMA 2014

a look at ...

Overview of biofuel sectors throughout the world

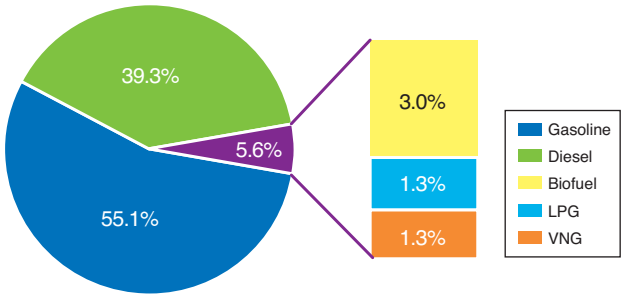
Biomass is all of the organic matter derived from the animal and plant organisms that make up our environment. Nowadays, it is possible to efficiently convert biomass into energy — biofuels in particular, which can be used as an alternative to fossil fuels — thanks to the increased use of new technologies. After a number of years of extremely high growth until 2008, world production of biofuels has continued to increase, but at a slower rate. Investment in them is starting to fall, mainly as a result of a more constrained global economy and the volatility of regulations governing how they can be used. The outlook does, however, look good for biofuels: a number of new promising technologies, still in the R&D stage, are starting to emerge. To a very great extent, their viability will be determined by the development of various state policies on biofuels.

Biofuels throughout the world

In 2010, the road transport sector (gasoline and diesel) accounted for approximately 43% of global oil consumption: around 1.77 billion toe (Gtoe).

The current biofuels industry produces around 57 Gtoe — meeting 3.1% of the road transport sector's energy requirements. This is without counting the percentage of biofuels that are incorporated into fuels for other forms of transport (air and sea) that is not significant today.

Fig. 1 – World energy consumption in the road transport sector in 2010



Source: IFPEN from KBC PEL, OECD, WLPGA, NGV Journal

Bioethanol remains the most common of all biofuels, currently accounting for a 75% share. Fuel ethanol, made by fermenting sugar and used in gasoline engines, is mainly derived from cereals (corn), sugar cane or sugar beet, depending on geographical region.

Biodiesel accounted for approximately 25% of all biofuels used throughout the world in 2010. It is mainly derived from oilseeds (rape, soya, palm) and is incorporated in the form of methyl esters into diesel engines (Fig. 1).

First-generation biofuels consumption throughout the world and their rate of incorporation

Biofuels are used and produced in different ways in different regions throughout the world. The main determining factors are the availability of biomass and the government incentives in place. In all countries, biomass is being developed within specific regulatory frameworks: these include the new and renewable energy directive in Europe and the Renewable Fuel Standard (RFS) in the United States.

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Fuel ethanol

Bioethanol is mainly used in North America and Latin America. The United States and Brazil consumed 24.6 million toe (Mtoe) and 10.5 Mtoe in 2011, respectively (Tab. 1). In Europe, Germany is still by far the biggest consumer of fuel ethanol (0.79 Mtoe), followed by France and the United Kingdom.

As far as the production of fuel ethanol is concerned, the biggest users are also the biggest producers. The United States produced nearly 26.7 Mtoe, while Brazil produced 11.1 Mtoe in 2011.

These high levels of consumption can be attributed to regulations making it obligatory to incorporate them into fuels: the table 2 shows increases and decreases in fuel ethanol incorporation rates[1] over a three-year period for several geographical regions. Latin America — mainly Brazil — still has by far the highest incorporation rates notably due to a large development of high incorporation adapted vehicles (FlexFuel Vehicles).

In 2011, for the first time since at least 2005, Brazil saw its bioethanol incorporation rate fall. The low sugar cane harvest that year was the main reason for this fall. This led to a major drop in bioethanol production at a time when overall fuel demand is rising each year.

2011 also saw slower increases in incorporation rates in Europe (this trend continued into 2012) and in North America compared with previous years.

Table 1

Statistics for the consumption of fuel ethanol in Mtoe per geographical region

	2011	2010	2009
Europe	2.98	2.87	2.35
North America	25.77	25.07	20.74
Latin America	10.83	12.49	11.48
Asia-Pacific	1.94	1.75	1.48
Africa	0.05	0.07	0.05
World	41.57	42.25	36.04

Source: IFPEN from FO Licht, KBC PEL

Table 2

Statistics about the incorporation rates of fuel ethanol per geographical region

	2011	2010	2009
Europe	3.3%	3.0%	2.4%
North America	5.6%	5.4%	4.5%
Latin America	14.9%	17.7%	17.0%
Asia-Pacific	0.8%	0.7%	0.6%
Africa	0.1%	0.2%	0.2%
World	4.2%	4.3%	3.7%

Source: IFPEN from FO Licht, KBC PEL

(1) Energy incorporation rate: share of the consumption of the biofuel under investigation for a given geographical region relative to the total consumption of this biofuel and its counterpart fossil fuel for the same geographical region

Biodiesel

Several product categories have emerged on the biodiesel market since 2011: Fatty Acid Methyl Esters or FAMEs (which have been traditionally incorporated since the early 2000s), and a synthetic biodiesel that is obtained by hydrotreating plant oils: Hydrotreated Vegetable Oils (HVOs). These HVOs have one major advantage over esters: they can potentially be incorporated at far higher rates (at least 50% of total volume), without any modifications needing to be made to vehicles. Like esters, but at a higher production cost, they can also be produced from animal fat and waste oils. This explains the diversification of biodiesel-derived resources on the market. In 2011, world consumption and production of HVOs was still low (under 1 Mtoe consumed and produced). Only a few countries are currently producing HVOs: the Netherlands, Singapore and Finland.

The following tables and analysis will focus uniquely on FAME biodiesel (Tab. 3 and 4).

Table 3

Statistics for the consumption of biodiesel in Mtoe per geographical region

	2011	2010	2009
Europe	10.84	10.72	9.36
North America	2.68	0.75	1.01
Latin America	2.94	2.47	1.23
Asia-Pacific	0.73	0.82	0.68
Africa	0	0	0
World	17.20	14.76	12.28

Source: IFPEN from FO Licht, KBC PEL

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Table 4

Statistics about the incorporation rates of biodiesel per geographical region

	2011	2010	2009
Europe	5.4%	5.4%	4.8%
North America	1.4%	0.4%	0.5%
Latin America	4.9%	4.2%	2.1%
Asia-Pacific	0.2%	0.2%	0.2%
Africa	0	0	0
World	1.4%	1.2%	1.0%

Source: IFPEN from FO Licht, KBC PEL

FAME biodiesel is mainly produced and consumed in Europe (where it is mainly derived from rapeseed). Consumption rose slightly between 2010 and 2011 in Europe, and this trend was even reversed in 2012 compared with previous years. The United Kingdom, Poland (in 2012) and — to a lesser extent — Germany and Italy are the main countries that have been affected by this trend. Consumption has continued to rise in both Spain and — to a lesser extent — France.

FAME biodiesel production in Latin America (mainly derived from soya) is dominated by Argentina and Brazil, which accounted for 89% of production in 2010, and then more than 97% in 2011. This increase can mainly be attributed to significant increases in production in Argentina: an increase of more than 25% between 2010 and 2011 (as opposed to more than 11% in Brazil), with more and more volumes being earmarked for export.

Of these five geographical regions, Europe has the highest incorporation rate of biodiesel into the diesel pool, closely followed by Latin America, where rates have been boosted by a proliferation of regulations that govern mixes in Brazil. In Europe, 2011 was the first year which did not see a rise in the effective incorporation rate of FAME biodiesel. This can be explained by expected or forecast declines in national and European mandates for renewable energies in the transport sector. The European Commission is proposing to cap 1st-generation biofuels (at between 5 and 7%), which is not an incentive for developing the sector in Europe and France.

As far as Europe is concerned, France became the leading consumer of biodiesel in 2012 (2.3 Mtoe), just ahead of Germany (2.2 Mtoe), followed by Spain (1.7 Mtoe) and Italy (1.3 Mtoe). Since 2011, Poland has been just ahead of the United Kingdom — the 5th and 6th largest European consuming countries, respectively.

Incorporation rates of fuel ethanol and biodiesel

The table 5 shows how world effective incorporation rates for 1st-generation biofuels in the pool of road fuels have increased or decreased over a three-year period.

Table 5

Statistics for biofuel incorporation rates (ethanol and diesel) per geographical region in the road transport sector

	2011	2010	2009
Europe	4.75%	4.63%	3.99%
North America	4.38%	3.94%	3.37%
Latin America	18.90%	21.22%	10.01%
Asia-Pacific	0.42%	0.41%	0.37%
Africa	0.12%	0.20%	0.09%
World	2.62%	2.55%	2.23%

Source: IFPEN from FO Licht, KBC PEL

Globally, the share of biofuels used to meet our energy requirements continues to grow. But the rate of increase was slower between 2010 and 2011 (3.1%) than in previous years (13.6% between 2009 and 2010). Latin America still has the highest overall incorporation rate (thanks to the sheer numbers of vehicles that run on ethanol in Brazil). Europe and North America are just behind it with rates of just above 5% in their diesel and gasoline pools.

Although there has been a slight increase in consumption of ethanol and biodiesel in Europe, the increase in incorporation rates can mainly be explained by a fall in overall consumption of liquid fuels.

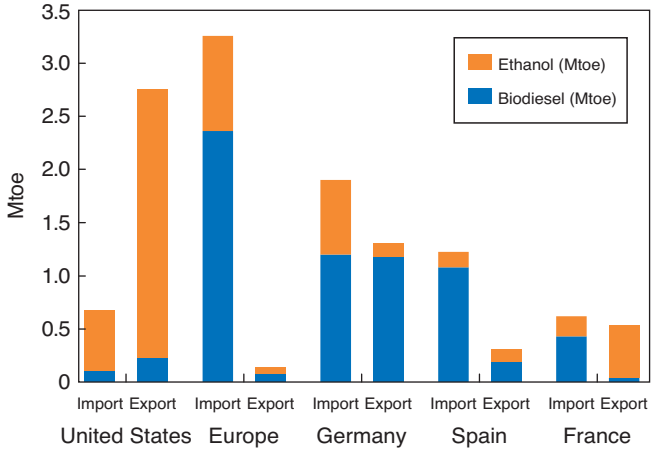
Main biofuel import and export countries

Since 2010, the United States has been a net exporter of bioethanol. In 2011, US ethanol exports reached record levels because of the poor-quality sugar cane harvest in Brazil that year — the main resource used to produce ethanol in Brazil. As a result, Brazil received a third of all American ethanol exports and the United States became the world's leading fuel ethanol export country in 2011. In 2012, Brazil introduced a special tax on ethanol imports from the United States, the aim being to re-establish local ethanol production as a priority. The United States and Brazil exported more or less the

same volumes in 2012, but by 2013, the situation had returned to the way it was prior to 2011, with Brazil once again dominating the fuel ethanol export market.

Significant volumes of biofuels are also being traded in Europe, which mainly imports biodiesel, despite its unused production capacities (Fig. 2).

Fig. 2 – Import/Export of fuel ethanol and biodiesel in various countries and geographical regions in 2011



Source: IFPEN from FO Licht

Most of these imports come from Argentina (more than 50%), Indonesia (39%) and the United States (less than 5%). These imports are mainly due to the knock-down prices that export countries — such as Argentina and Indonesia — are selling biofuels at on the European market (mainly to Spain, Italy and the Netherlands). Argentina and Indonesia introduced a differential tax system on biodiesel exports between 2010 and 2012 that was 10 to 15% lower than the taxes on raw materials used to produce this biodiesel. This resulted in an international dispute and in May 2013, the European Commission introduced a 6-month anti-dumping duty that was renewed in mid-November 2013.

The European Council also introduced a regulation at the start of 2013 imposing an anti-dumping tax (€62.9/t) on ethanol exports from the United States (0.6 Mt in 2012).

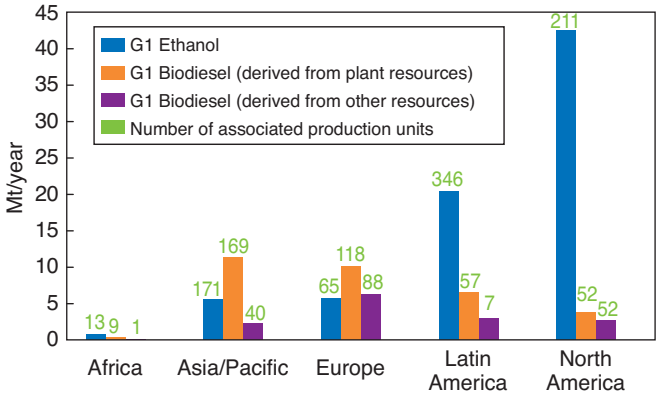
World biofuel production capacity: 1st-generation ethanol and biodiesel

Throughout the world, there are still currently around 350 projects to build 1st-generation biodiesel and ethanol production facilities. These are either under way or in the development phase.

As far as the locations of these new projects are concerned, around two-thirds of them are in the Asia-Pacific region, where there are still a number of active incentive measures in place designed to encourage development of the 1st-generation biofuels sector. The remaining projects are spread over the other continents, but very few are in Europe. Furthermore, around 250 existing production facilities throughout the world have been shut down. Half of these facilities are located in the United States.

The United States has by far the largest 1st-generation ethanol production capacity in the world. It is made up of production facilities the average capacities of which are considerably higher than in Latin America, which has a higher numbers of plants. Similarly, the Asia-Pacific region has the highest number of biodiesel facilities, but their average capacity is lower than in Europe. In the graph below, biodiesel produced from "other" resources considers production units in operation which produce biofuels from resources other than dedicated vegetable resources (waste oils or animal fats, for example).

Fig. 3 – Production capacity of biofuel plants that use food or other resources throughout the world in 2013, and the number of associated facilities



G1: first-generation

Source: IFPEN from GBC 2013

Development of advanced biofuel production units

There are various types of advanced biofuels. So-called 2nd-generation biofuels that are derived from lignocellulosic biomass, and so-called 3rd-generation biofuels that are derived from algal biomass.

Second-generation biofuels — mainly lignocellulosic ethanol (2nd-generation ethanol) and BtL (2nd-generation biodiesel/biojet), are biofuels derived from non-food agricultural biomass or forestry/timber industry biomass. In 2011, the only facilities in existence that used these biofuel technologies were pilot plants and demonstrators.

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To date, none of these plants are actually marketing 2nd-generation biofuels in industrial capacities, although some are scheduled to come into commercial operation in 2013 (this was effectively the case for one plant in the United States and another in Italy).

Advanced 3rd-generation biofuels derived from algal biomass are still in the R&D phase.

For further information about the development of 2nd-generation and 3rd-generation biofuels, see Panorama 2014 article — Overview of second-generation biofuel projects.

Land use and production of biomass resources for biofuels

Generally speaking, areas used for cereal, sugar and oilseed crop production have increased since 2009. As far as biofuel production is concerned, the areas used to grow soya and palm have seen the largest increases — from 9.4% to 13.7%, and from 5.8% to 8%, respectively of total crop surface areas between 2009 and 2011.

The use of cereal crops to produce ethanol is still relatively low at world level. But it is worth pointing out the existence of potentially marked local effects: in particular maize for producing ethanol in the United States, which accounts for 40% of the total surface area used for growing maize in this region.

As far as sugar cane is concerned, Brazil is the main country that uses it to produce fuel ethanol, but the overall proportion of total surface area used to grow it has been falling since 2011: the 17% fall can be attributed to the low yields that year, shifting production towards sugar for use in the food industry.

As far as oilseed crops are concerned, although the share of surface area given to rapeseed production for use in biodiesel has seen the highest increase, this share has, however, remained relatively stable over the last few years. The shares of soya and palm — which are lower — have been growing steadily, with a marked phenomenon in Argentina where more than a quarter of all local soya production has been used for biodiesel.

At European level, although smaller plots of land are used for fuel ethanol production, the areas used for growing rapeseed for use in the production of biodiesel account for nearly two-thirds of the overall land used for growing rapeseed, and are nearly three times higher (62.4% — some 5.5 million hectares) in proportion to the total area used to grow energy rapeseed throughout the world (24.3% — a little under 8.2 million hectares).

Similarly, in France, the proportion of the total area used for growing rapeseed and sunflower for use as energy is also quite considerable: 65% (nearly 1.5 million hectares). It is probably nearing its maximum. The saturation of rapeseed production area in Europe and the double counting schemes in the Renewable Energy Directive serve as an incentive to rapidly develop and use waste oils and animal fats for biodiesel production, as described above.

Conclusions and outlook

As the only alternative to fossil fuels in the transport sector, world biofuel production capacity continued to grow in 2011 and 2012, and a number of major projects are in preparation for 2013. However, there has been a significant slowdown in investment and in the increase in consumption. As far as 1st-generation biofuels are concerned, although production and consumption have continued to grow, the rate of growth has been slowed down by a number of debates which question their sustainability. Their production generates competition between agricultural resources used for food and those used for energy, there are questions over the extent to which using them reduces greenhouse gases compared with comparable fossil fuels, indirect changes in land use are factored in and the incorporation rate for ethanol is limited to 10% in conventional vehicle fleets. Furthermore, production levels that are dependent on uncertain weather conditions (resulting in highly volatile prices), a lack of visibility as far as incorporation targets and other public incentives are concerned (the RED[2] is in the process of being revised, and the emphasis of the RFS[3] is being shifted, etc.) are all affecting their development.

As far as new-generation technologies are concerned, a number of projects have been slowed down or even abandoned altogether following the major investment programmes in these sectors between 2009 and 2011. But some industrial plants started operations in 2013 (IOGEN, Chemetx) and others are set to start in 2014 (Dupont, Abengoa, Poet). The production levels associated with these advanced biofuels are, however, considerably lower than the predictions that were made in 2007. The EPA has therefore revised — as it has done in previous years — its renewable fuel standards for advanced biofuels, adjusting them on the basis of annual production forecasts. Major breakthroughs have nevertheless recently been made in terms of reducing

(2) The Renewable Energy Directive is Europe's biofuel regulation
(3) The Renewable Fuel Standard (RFS) is the United States' biofuel regulation

the costs and selectivity of different types of biomass, see Panorama 2014 article — Overview of second-generation biofuel projects.

The microalgae sector is up against a number of both technical and economic obstacles which require co-production of high added-value products, and so the development of more complex sectors that are more geared towards producing high added-value molecules.

Generally, there will still be development opportunities on the international markets in the years ahead, such as, for example, growing energy needs in a number of South American and Asian countries, the need for energy independence in most OECD countries and the use of fuels that are more environmentally sustainable than benchmark fossil fuels. This last point is particularly important in the aeronautics sector which is supporting the development of biofuels that can be used as an alternative to kerosene.

However, because these advanced technologies are still very young and because the raw materials market does not yet encourage competition among these sectors, they will not be able to develop in the short term without a special mid- to long-term regulatory framework that will ensure that previous investments are paid off, as well as encourage future investment.

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