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BIOFUELS IN THE ROAD TRANSPORT SECTOR

In 2018, global energy consumption in the road transport sector amounted to just over 2.1 Gtoe, representing an increase of 1.5% compared to 2017. The share of alternative fuels to oil-based gasoline and diesel stagnated at 7.7% of total consumed fuels despite the fact that their quantity increased between 2017 and 2018: from 161.1 Mtoe to 163.4 Mtoe. Among these alternatives (biofuels, LPG(1), NGV(2), electricity), biofuels represented 85.1 Mtoe, i.e., an alternative fuel market share of 52% (Fig.1). Their consumption increased by 7% between 2017 and 2018.

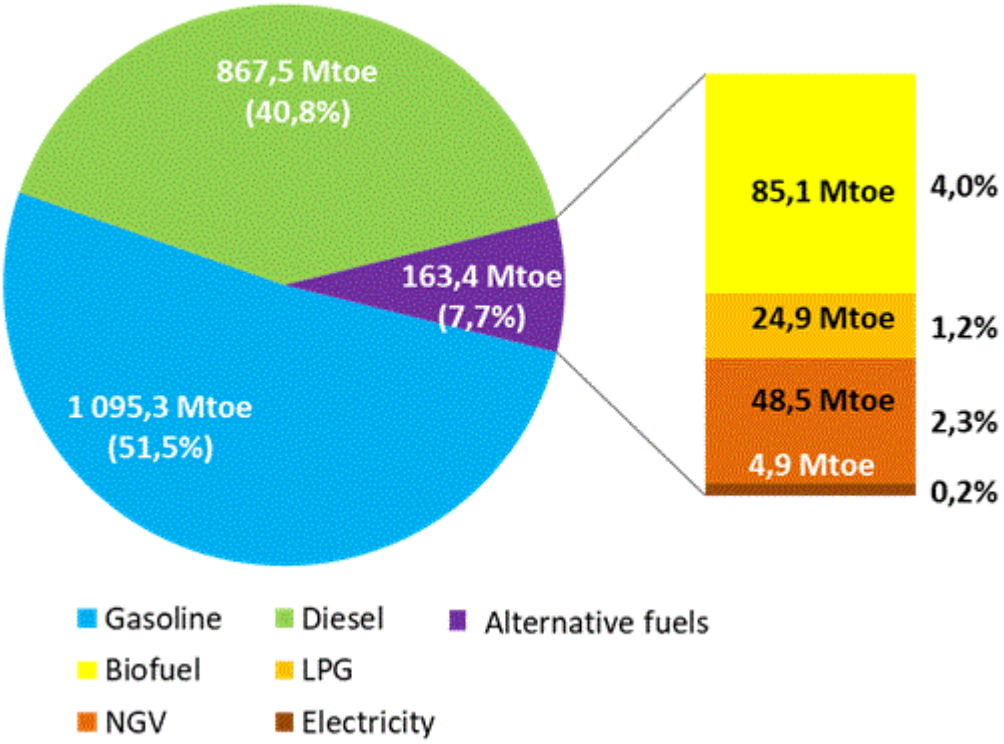

Fig. 1 - Global energy consumption in the road transport sector in 2018

Source: IFPEN, from Enerdata and FO Licht

Throughout the world, the volume of biofuels consumed in the transport sector has been increasing constantly since 2011. While the growth rates of ethanol and FAME (Fatty Acid Methyl Ester) biodiesel slowed in the 2015-2016 period, consumption subsequently began to rise again with the emergence of the HVO (Hydrotreated Vegetable Oil) market in 2017, and then for all products in 2018 (Fig. 2).

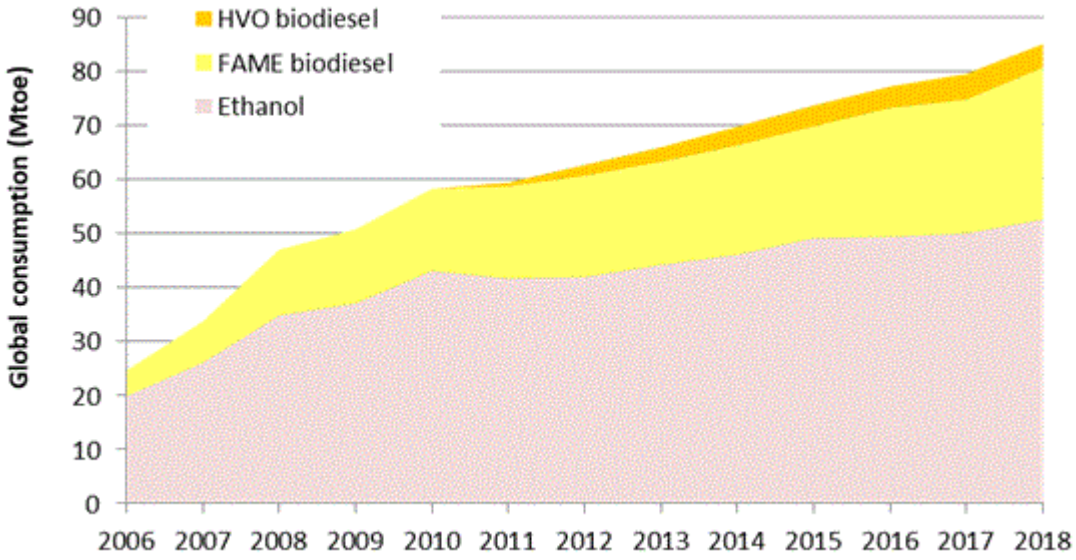

Fig. 2 - Evolution of global biofuel consumption in the road transport sector

Source: IFPEN, from FO Licht

On a continental level, the biofuel incorporation rate in road fuels varies depending on the region, but Latin America continues to boast the highest rate at 10.8% (energy) thanks to its ethanol market: ethanol alone has an incorporation rate in gasoline of close to 14%. North America and Europe follow, with respective rates of 6.3% and 5.1% (energy) respectively. In Asia, the rate only amounts to 1.4%, but it is nevertheless a zone where investments and government policies supporting biofuels have been the most extensive in recent years. In the majority of the world's countries, particularly throughout Asia, despite incorporation rates that have remained relatively stable, the market has been developing rapidly with the growth in the demand for road fuels.

In Europe, total biofuel consumption in the road transport sector has been oscillating between 13 and 14 Mtoe since 2011, marking the slowdown in market growth across the community as well as a number of uncertainties concerning regulatory changes. Since 2017, the European Union (EU) has seen a return to double-digit growth, including growth of 12% between 2017 and 2018, to reach total consumption of around 17 Mtoe. This return to growth is primarily linked to the increase in the consumption of biodiesel, for which some sectors are supported by attractive regulations based on a double counting system for achieving objectives set out in the European Renewable Energies Directive (RED). The latter directive was recast in 2018 to become REDII[(3)], which specifies new incorporation objectives for the period 2021-2030, thereby increasing visibility for industry and, in particular, investors.

In 2018, the renewable energy penetration rate for the European transport sector was 8.3% (energy) [(4)], a rate that has been growing constantly with a view to achieving the regulatory objective of 10% specified for 2020[(5)]. Among European Member States, Sweden and Finland have already exceeded this objective (29.7% and 14.9% respectively). Austria is approaching the threshold with 9.8%, followed by the Netherlands at 9.6%. France and Portugal are ranked 5th with a rate of 9%. It should be noted that Norway has proactive policies, with a renewable energy rates in the transport sector already above 20%.

GASOLINE SUBSTITUTES

Since the emergence of the biofuel market, ethanol has remained the primary substitute to gasoline fuels used around the world. The United States continues to be the biggest producer, followed by Brazil. The two countries alone account for 84% of the global market. With far lower volumes, China, Canada, India and Thailand complete the world's top 6 producers. France is 8th in the global rankings and 1st in Europe. Although still enjoying growth, the ethanol market was less dynamic in 2019 than in the previous two years.

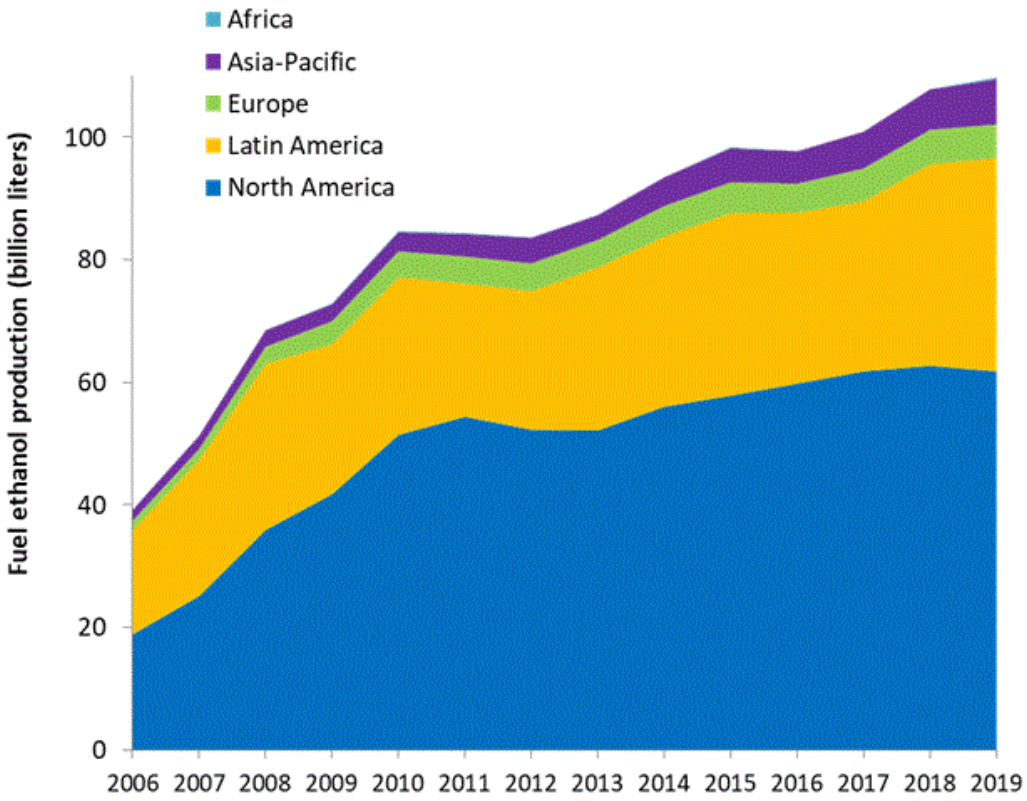

Fig. 3 – Ethanol fuel production movements by zone (in billions of liters)

Source: IFPEN, from FO Licht

The growth in production was primarily been driven by Brazil and the European Union, followed by the three leading Asian producers (India, China and Thailand). Canadian production also saw double-digit growth.

While American consumption remains stable, production in the USA fell for the first time by almost 2%. Despite a highly competitive market price as a result of high stock levels at the beginning of the period (Table 1), American bioethanol exports fell by 12% between 2018 and 2019. This was due to the trade war with China, which reduced its ethanol imports by almost 90%, and the implementation of a tariff quota restricting ethanol imports in Brazil. This trend is set to continue in 2020 as a result of the global fall in demand associated with the Covid-19 pandemic.

US$/ ton	Ethanol Europe (NWE)	Ethanol USA	Ethanol Brazil	Ethanol China
2015	776	527	602	925
2016	704	527	664	804
2017	783	509	677	739
2018	724	482	655	893
2019	864	500	677	803

Table 1 – Annual ethanol price changes by zone (US$/t)

Source: IFPEN, from Argus

Moreover, American corn ethanol has seen a decline in interest in zones where the carbon intensity of biofuel sectors is regulated, such as the European Union, but also nationally with the LCFS(6) in California. In 2019, for example, corn ethanol already only represented 75% of the American domestic market (compared to 94% in 2018).

The situation in Brazil is the reverse, with significant growth in the use of corn for ethanol production instead of sugar cane, the demand for which is also expected to grow, but to supply the sugar industry. From 2020, corn is likely to be the 2nd most important raw material for ethanol production, behind sugar cane and ahead of molasses.

In the European Union, ethanol production is primarily based on cereals (more than 80%), including a growing share of corn too, while the share of sugarbeet has fallen considerably. Due to the increase in European cereal exports and falling stock levels, prices have risen with a direct impact on the price of European ethanol (Table 1). In the short term, a growing share of molasses and other byproducts of the sugar and starch industries is likely to be observed, with a view to achieving the advanced biofuel objectives contained in the RED directive. As a result of the low available volumes of resources of this type, “2nd generation” lignocellulosic processes will need to take over in the short/medium term; a momentum that is beginning to gather following recent announcements concerning industrial projects such as INA in Croatia, PKN in Poland and Clariant in Romania, with production scheduled to be launched during the period 2021–2024.

Behind the USA and the EU, China is the 3rd biggest user of cereals for ethanol production. National raw material stocks will nevertheless be insufficient to enable the government’s target of a 10% incorporation level for ethanol in total Chinese gasoline consumption to be achieved. Other biomass types will thus have to be rapidly mobilized.

DIESEL SUBSTITUTES

Two main biofuels are currently incorporated into the road diesel fuel pool: FAME and HVO. They use biomass resources containing fatty acids, such as oil crops (rapeseed, palm, soybean, etc.) or used cooking oils or animal fats. Unlike FAME, the incorporation of which is limited to a maximum of 10% vol. in diesel distributed at the pump in the European Union, there is no limit to the amount of HVO that can be incorporated in the conventional diesel mix. The youngest industry but one that is enjoying strong growth, HVO now represents 12% of biodiesels consumed globally (Fig. 2).

The world biodiesel market enjoyed growth of 13% between 2018 and 2019. This growth was observed in most regions, excluding some South American countries as a result of local economic crises (in Argentina and Colombia in particular). In 2019, Europe alone accounted for 38% of the biodiesel market, with Germany and France historically ranked 1st and 2nd in terms of European FAME production. The remaining global production is spread almost equally between Asia and North and South America (Fig. 4).

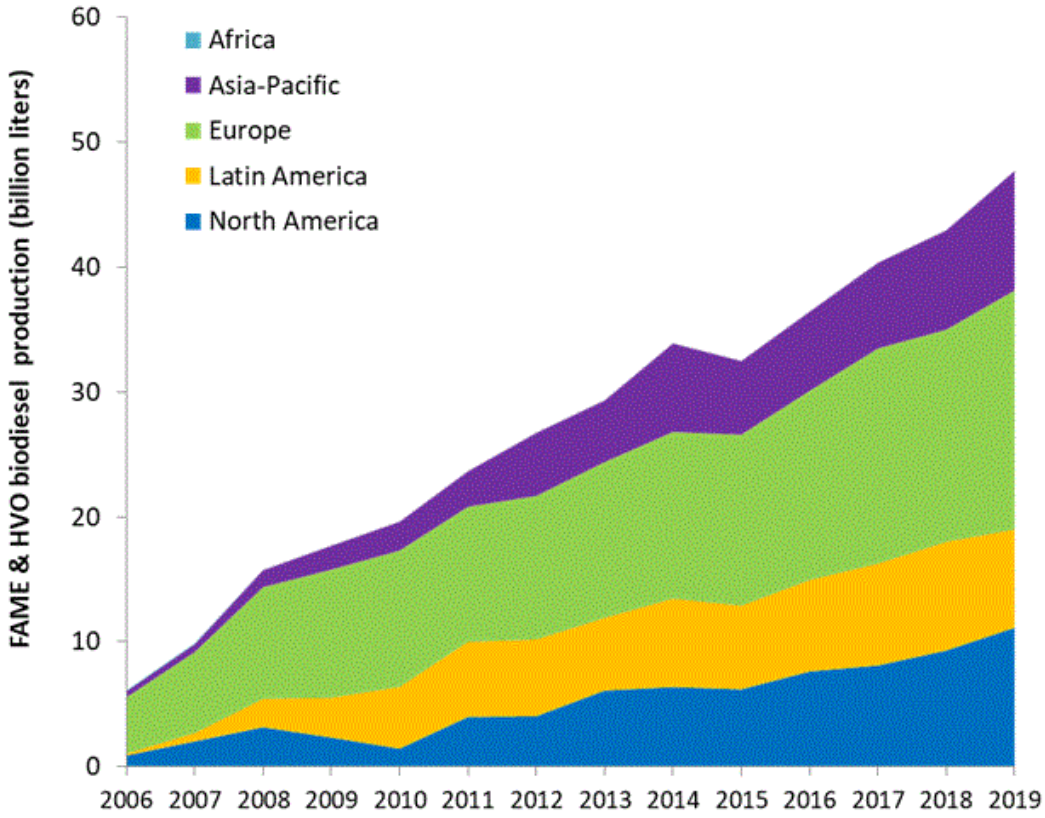

Fig. 4 - Biodiesel (FAME and HVO) production movements by zone (in billions of liters)

Source: IFPEN,from FO Licht's

While European FAME production fell slightly between 2018 and 2019 (12.3 Mt vs 11.8 Mt), the growth in biodiesel was sustained by HVO production, which increased by 13% to reach 3 Mt. A similar trend was observed in the USA where production reached 1.7 Mt. These two zones together account for 83% of global HVO production. Refiners have shown great enthusiasm for this product, the chemical characteristics of which facilitate its use in blend, and for which the production process is similar to that already employed by some refining units.

For example, Total in France and ENI in Italy have converted some of their oil refining sites into HVO production sites. It should be noted that this momentum now means that Finnish refiner Neste is ranked 1st in terms of biodiesel production, all technologies combined, thanks to its 2.7 Mt of production capacities in Europe and Singapore.

Despite a demand for road diesel that has leveled off in recent years and is likely to fall in 2020 as a result of Covid-19, the market share of biodiesels has been increasing thanks to regulatory levers supporting the market and, particularly, biodiesels (FAME and HVO) derived from residual oils (used cooking oils, animal fats in particular). The EU allows double counting of products of this type to achieve 2020 and 2030 objectives, whereas California's LCFS favors sectors associated with significant greenhouse gas emission reductions, as enabled by lignocellulosic processes and waste-based processes.

As was the case in 2018, Indonesia and Brazil recorded the highest growth in FAME production thanks to a significant increase in incorporation requirements (widespread implementation of B20[7]

and B11[8] respectively). These growth rates will continue to rise in 2020, probably enabling them to limit the reduction in demand associated with Covid-19.

While there appears to be significant momentum in the HVO market, the development of the sector in Europe and North America remains hampered by the availability of oil and fat resources meeting sustainability requirements imposed by regulations in the two zones. European vegetable oils are already under pressure due to their significant mobilization by the FAME sector (> 80% of rapeseed oil harvested in 2019), while the local waste oil collection channels are under-developed and costly. Moreover, some oil resources have been identified as having an environmental performance that falls short of expectations (greenhouse gas emission increases and ILUC[9] risks in particular). Accordingly, the European Commission has decided to limit the use of food and feed crops based biofuels to their 2020 level, and to ban the use of palm oil for the production of biofuels contributing to the REDII transport renewable energy objective specified for 2030. It should be noted that a new delegated act under the directive will shortly define certification criteria for biofuels presenting low ILUC risks and a consultation concerning the list of resources enabling the acquisition of biofuels eligible for double counting (annex IX part A and B3) is under way. These revisions expected in the next few months should make it possible to better evaluate the potential of the various biodiesel sectors and to make decisions regarding possible supply sources for HVO units in Europe.

US$/ton	Biodiesel (Rapeseed) Europe	Biodiesel (Soybean) Argentina	Biodiesel (Palm) Indonésie
2015	866	600	662
2016	902	688	712
2017	956	708	754
2018	1 007	659	684
2019	977	743	647

Table 2 – Annual biodiesel price changes by zone (US$/t)

Source: IFPEN, from Argus

On the international market, Europe remains the leading biodiesel exporter, a trend reinforced in 2019 due to the increase in national consumption in other exporting countries, such as Indonesia, as well as the fall in production in Argentina, another leading exporting country.

In terms of agricultural commodity markets, the soybean and palm oil markets are those likely to be impacted by the increase in mandates in Brazil and South-East Asia. For example, in 2019 palm oil was the leading raw material used for biodiesel around the world (i.e., 30% of supplies). The EU primarily uses locally produced rapeseed oil (42% of supplies), but the 2019 harvest was particularly poor and, as a result, imports of oils and esters are likely to increase to meet RED requirements. Waste oils and fats eligible for double counting are particularly in demand. Available in limited quantities, they too are imported, primarily from Asia and, in particular, China. In 2019, Ireland, the United Kingdom and the Netherlands, the main European importers of these waste oils, were investigated for attempted fraud (the importation of palm oil passed off as waste oil) and now Member

States are reinforcing traceability requirements concerning raw materials destined for the biodiesel market.

BIOMETHANE FOR NGV POWERTRAINS

An as yet minority renewable fuel, its consumption is nevertheless increasing in some zones where natural gas has historically figured among road fuels. Currently primarily produced by the anaerobic digestion of organic waste, or via the recovery of landfill gas, biogas is a renewable fuel principally used for heat and electricity production. Only a fraction (less than 10%) is purified to obtain biomethane suitable for injection into the natural gas network or used as a fuel in dedicated vehicle engines.

In 2019, Europe consumed just 0.18 Mtoe of biomethane fuel, i.e., 1% of its overall biofuel consumption. This use was concentrated in nine European countries, primarily Sweden (63%) followed, to a lesser extent, by Germany and the United Kingdom. Today, the fuel use represents 5.7% of all biogas consumed in Europe.

In the USA, NGV fleets made up of heavy trucks, buses and waste collection vehicles, have grown significantly over the past five years. In 2019, NGV consumption was 2.4 Mtoe and 38% of this gas was renewable, i.e., 0.94 Mtoe. In the USA, the source of this renewable gas is primarily landfill gas recovery and biogas from waste water treatment facilities.

BIOFUELS IN THE AVIATION SECTOR

With the growing awareness of the existing environmental impacts of international air travel (which accounts for 13% of CO2 emissions in the transport sector) and given the sector's growth outlook (pre Covid-19), Member States of the International Civil Aviation Organization (ICAO) adopted a greenhouse gas stabilization objective from 2021. In order to achieve this objective, the use of alternative and sustainable fuels (SAF[10]) is seen as the principal lever for reducing emissions along with CORSIA[11]. There are thus a growing number of initiatives aimed at developing biofuel processes for the aviation sector. Given the considerable constraints with respect to the quality of kerosene used around the world, SAFs currently approved for incorporation in kerosene are so-called drop-in fuels, the composition of which is close to, or in some cases identical to, their fossil equivalent. There are currently eight ASTM[12]-approved bio-kerosenes, including some that are produced using process that are already mature or close to industrial maturity, such as HEFA-SPK[13], byproducts of HVO biodiesel units, FT-SPK[14], byproducts of the BtL process for the production of lignocellulosic synthetic biodiesel, and ATJ-SPK[15], derived from the conversion of ethanol or isobutanol into synthetic kerosene. These bio-kerosenes are currently approved for incorporation in traditional kerosene, with a maximum limit of 50% in the blend.

In recent years, numerous demonstration and marketing initiatives have generated the consumption, in limited quantities and over limited periods of time, of different types of bio-kerosene. In 2019, around 100,000 metric tons of bio-kerosene were produced but only a few thousand metric tons are

currently used on a continuous basis, at Los Angeles airport.

That is because fuel represents a major source of expenditure for airlines and the incorporation of these alternative fuels represents an additional cost compared to a fossil equivalent. While national and regional policies governing transport and the environment increasingly include the aviation sector (REDII(5) and EU-ETS in the EU, RFS(16) and LCFS(6) in the USA, Renovabio in Brazil, etc.), and governments are issuing more and more announcements concerning incorporation objectives (such as the 5% incorporation objective specified for SAF in France by 2030), current regulatory incentive measures are inadequate to encourage regular incorporation (with the exception of national requirements imposed in Sweden and Norway). Although production capacities already exist through potential synergies with the road biodiesel market, concrete incentive policies specifically aimed at the aviation sector, such as ambitious greenhouse gas emission reduction or high CO_2 price objectives, are expected to enable the emergence of a new market for these biofuels.

FOCUS ON FRANCE

In terms of European objectives for renewable energy penetration by 2020, the French transport sector is relatively well positioned today (9% LHV in 2018 compared to 10% expected in 2020 taking into account multiple counts). In 2018, the total consumption of liquid biofuels amounted to 3.2 Mtoe, almost identical to the previous year.

Since 2017, SP95-E10 fuel containing up to 10% ethanol has been the most consumed fuel by French gasoline vehicle owners, with a market share of around 48% in 2019 and 50% in January 2020. France was the first country in Europe to roll out the use of E10 in 2009 but recently more and more Member States have adopted it with a view to meeting the European incorporation requirements specified in RED for 2020.

As for E85 (gasoline containing up to 85% ethanol) superethanol, it enjoyed record growth of + 85% between 2018 and 2019. While it currently still only represents 3% of total gasoline consumption, it is competitively priced and is approved for 14 models of conversion kit(17) enabling its use in a broad range of standard gasoline vehicles. In addition, France also has around 39,000 flexible-fuel vehicles designed to run on both E85 and traditional gasolines. Flexible-fuel vehicle buyers are entitled to a 40% reduction in CO_2 emissions for the calculation of the penalty associated with polluting vehicles, provided the model emits less than 250 g CO_2 eq./km.

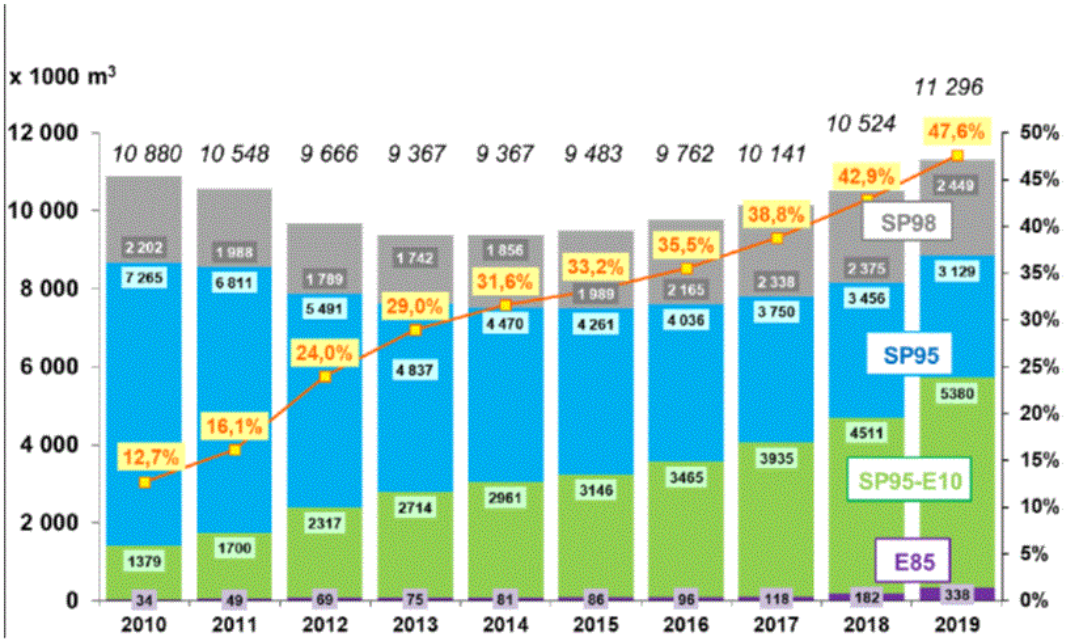

Fig. 5 – Movements in market shares of gasolines consumed in France in thousands of m3 (left) and by % volume
for SP95-E10 (right)

Source: SNPAA 2019 from CPDC (French professional fuel distribution committee), DGDDI (French Directorate General of Customs and Indirect Taxes)

In 2020, a significant decrease in sugar beet production is expected as a result of pest attacks and a reduction in the crop acreage. However, in the 1st half of 2020, with the fall in demand for ethanol fuel associated with lockdown, farmers were able to shift production to the hydroalcoholic gel market, where there was a three-fold increase in demand in March alone.

In terms of outlook, the 2019 French finance law increased objectives for the incorporation of renewable energies in gasolines (to 7.7% in 2019 and 7.8% in 2020) and in diesels (to 7.9% in 2019 and 8% in 2020). Moreover, the French long-term energy program fixes specific incorporation objectives for advanced biofuels in the gasoline and diesel pools for 2023 (1.2% and 0.4% respectively) and 2028 (3.8% and 2.8% respectively). It should be noted that advanced biofuels incorporated in kerosene for the aviation sector will be able to be counted within the diesel pool objective.

Currently, apart from some thirty thousand metric tons of ethanol produced each year from wine residues in distilleries in a few French wine regions, France does not have a single facility dedicated to the production of advanced biofuels whereas French technologies are available for all fuel pools. Several of these have been developed in partnership with major French and European players by IFPEN(18). However, the first licenses for these processes have not been granted in France: the Croatian oil and gas operator INA opted for Futurol™(19) technology for the construction of its first lignocellulosic ethanol production plant (using agricultural residues and miscanthus), at a site in Sisak, Croatia.

Lastly, it is worth mentioning the launch, at the beginning of 2020, of a French State initiative in support of advanced biofuels, led jointly by the French Ministries for the Ecological and Inclusive Transition, the Economy and Agriculture via a call for expressions of interest concerning the production of sustainable aviation biofuels. This call for expressions of interest follows the publication of a road map setting out objectives for the incorporation of biofuels in the aviation sector in France(20) . The aim is to identify investment projects relating to the construction of 2nd generation aviation biofuel production units in France. Biomass-to-Liquid (BtL) BioTfueL(21) technology capable of producing an FT-SPK(13)-type bio-kerosene from agricultural and forestry residues using Fischer-Tropsch synthesis is one of the technological options for future projects.

COVID-19 EFFECTS AND EXPECTED INVESTMENTS

During the first half of 2020, the current health crisis put the brakes on the global economy generally. But the mobility sector was particularly severely affected, plunging the demand for oil products to levels never seen before, particularly for aviation fuels and gasoline. The demand for biofuels also suffered the biggest fall since they were introduced onto the market. Globally, ethanol was the most severely impacted given its predominant use in the road transport sector, principally passenger transport. Biodiesel benefited from a broader use than that of passenger transport as well as the increase in incorporation requirements in several countries.

While the USA and Brazil have seen a dramatic reduction in their ethanol production in 2020, other regions, while also affected, have fared better given their lower reliance on the market. During the first half of the year, around 40% of American ethanol production units were kept ticking over, a little under a quarter were operating at full capacity and just over one third were at a standstill.

In Brazil, production units increased the production ratio between sugar and ethanol, thereby overcoming the economic difficulties endured by ethanol manufacturers.

In Europe, the reduction in the demand for ethanol for 2020 is estimated to be 13% while the reduction in demand for biodiesel from plant biomass is likely to be around 7%. Moreover, European ethanol manufacturers fear that the market may be flooded by American and Brazilian products given the high stock levels in the two countries at a time when trade borders are starting to open up again. Waste oils have been impacted by the closure of restaurants. Conversely, HVO is likely to see an increase in demand in 2020 associated with extremely high incorporation objectives in the Scandinavian countries.

In terms of investments, while some projects initially scheduled for 2020 have been postponed, several announcements have already become a reality with investment levels potentially close to those observed between 2016 and 2018 (Fig. 6), subject to any further announcements concerning postponements before the end of 2020.

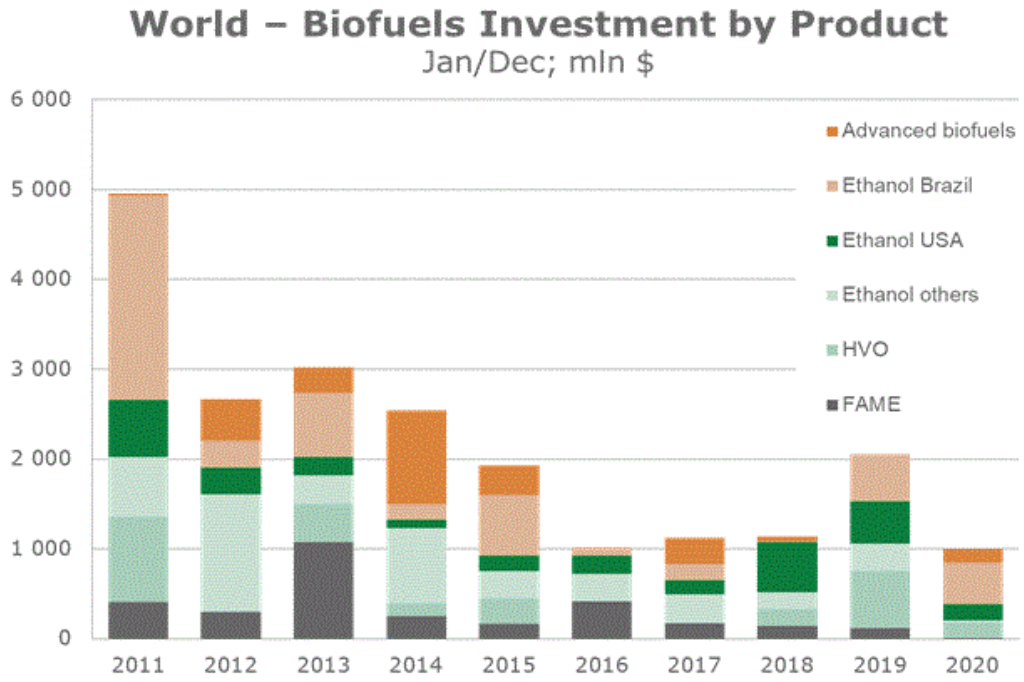

Fig. 6 – Annual global investments in the biofuel sector by product, in millions of dollars

Source: from F.O. Licht, June 2019

In 2020, as in 2019, the majority of investments relate to the commissioning of new HVO and corn-based ethanol units in Brazil. In addition, an upturn in investments in advanced sectors has been observed, particularly for lignocellulosic ethanol production units.

In Europe, there have been four new HVO unit projects since 2019, in Poland (Orlen/300 kt), Sweden (Preem/630 kt; St1/200 kt) and Finland (UPM/500 kt), as well as a capacity extension project in Italy (ENI/600 kt). These projects will increase European HVO production capacities by more than 2.2 Mt over the next five years. Projects are also underway in the USA, China and Paraguay.

In recent months the majority of biofuel development projects have stemmed from partnerships between aviation sector players. In addition to HVO projects that could potentially support the SAF market, there are two dedicated greenfield unit projects in Europe: SkyNRG with Amsterdam Airport for a HEFA-SPK production unit with a capacity of 100 kt and Altalto in the UK with a first FT-SPK unit exploiting SRF[(22)]-type waste. In the USA, in addition to HVO units able to produce HEFA-SPK, in the relatively short term there will be three BtL units capable of producing FT-SPK14 (Red Rock Biofuels and two Fulcrum Bioenergy units) and in the longer term, on the basis of demonstrator projects underway, two ATJ-SPK15 -type units (Gevo and LanzaTech).

In addition, in terms of advanced technologies, investments in lignocellulosic ethanol production units appear to have been materializing once again since last year, with a total of six projects in the European Union (Romania, Poland, Finland, Slovakia, Bulgaria and Croatia), one project in China and a dozen or so projects in India. This is a trend that may continue in zones where demand for products derived from advanced processes is specifically supported (as is the case in California and some European countries) and where the demand for fuel and the supply of lignocellulosic biomass are high

(as is the case in some Asian countries). Generally speaking, in the current economic context whereby crude oil and fossil fuel prices are low, the maintenance, and indeed the development, of policies to support biofuels is crucial in order to support growth in the sector.

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[1] LPG: Liquefied petroleum gas

[2] NGV: Natural gas for vehicles
[3] EU Directive 2018/ 2001 (recast) - *in French*
[4] Incorporation rate taking into account multiple counts
[5] Directive 2009/28/EC relating to the promotion of the use of energy produced from renewable sources - *in French*
[6] LCFS: Low Carbon Fuel Standard, a regulation in the State of California aimed at reducing greenhouse gas emissions in the transport sector
[7] B20: Diesel containing up to 20% FAME biodiesel by volume
[8] B11: Diesel containing up to 11% FAME biodiesel by volume
[9] ILUC (Indirect Land Use Change) risk: greenhouse gas emission risk associated with indirect land use changes
[10] SAF: Sustainable Aviation Fuels
[11] CORSIA (Carbon Offsetting and Reduction Scheme for International Aviation): https://www.icao.int/environmental-protection/pages/climate-change.aspx
[12] ASTM: American Society for Testing and Materials International
[13] HEFA-SPK: Hydroprocessed Esters and Fatty Acids – Synthetic Paraffinic Kerosene
[14] FT-SPK: Fischer-Tropsch – Synthetic Paraffinic Kerosene
[15] ATJ-SPK: Alcohol-to-jet - Synthetic Paraffinic Kerosene
[16] RFS: Renewable Fuel Standard
[17] https://www.bioethanolcarburant.com/boitiers-bioethanol-rouler-facilement-au-superethanol-e85 - *in French*
[18] https://www.ifpenergiesnouvelles.com/innovation-and-industry/our-expertise/renewable-energies/biofuels/our-solutions
[19] https://www.ifpenergiesnouvelles.com/article/advanced-bioethanol-futuroltm-technology-set-market-launch
[20] Further information on the road map: https://www.ecologique-solidaire.gouv.fr/lancement-feuille-route-des-biocarburants-aeronautiques-durables-dans-transport-aerien-francais - *in French*
[21] Further information on BioTfueL technology at: https://www.ifpenergiesnouvelles.com/innovation-and-industry/our-expertise/renewable-energies/biofuels/our-solutions
[22] CSR: Solid recovered fuels

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