BRIEFING

European Parliament

Sustainable aviation fuels

SUMMARY

As part of the European Green Deal adopted in December 2019, which highlights the importance of boosting development of alternative fuels, the European Commission envisages a proposal in early 2021 to support the increased production and use of sustainable aviation fuels, so as to meet Paris Agreement climate change goals.

A number of policy measures are already in place to increase sustainable aviation fuel use, but production and use of these fuels in Europe remains low. Eight different pathways for producing sustainable aviation fuels that can be used without changes to aircraft or refuelling infrastructure have been authorised, but a number of technical, feedstock-related and commercial barriers exist. Development of electro-fuels, which also represent a 'drop-in' type of fuel with potential to help efforts towards carbon neutrality in aviation, is considered technically viable but would require policy action for commercial development.

The Commission is conducting a public consultation and is studying a number of policy measures, including a mandatory minimum share of sustainable aviation fuels to be supplied to airlines and/or to be used by airlines and a financial and technical support mechanism to promote the production and use of these fuels.

In this Briefing

EPRS | European Parliamentary Research Service

Author: Jaan Soone
Members' Research Service

PE 659.361 – November 2020

EN

Background

Aviation is one of the few sectors where emissions have increased since 1990. According to the European Commission, direct emissions from aviation account for 3 % of the EU's total greenhouse gas emissions and more than 2 % of global emissions. Whereas the coronavirus pandemic has caused a drop in the number of flights and associated emissions, the trend for increasing air traffic is expected to return, necessitating the redoubling of efforts to tackle emissions and help achieve the Paris Agreement goals to keep the global warming to below 2 °C above pre-industrial levels and to pursue efforts to limit the increase to 1.5 °C.

The Commission's December 2019 communication on the European Green Deal sets out the need to reduce transport emissions by 90 % by 2050 (compared to 1990), and to increase the production and deployment of sustainable, alternative transport fuels. The 2020 Commission work programme includes an initiative to bolster the production and use of sustainable aviation fuels – 'RefuelEU Aviation' and the Commission has indicated that this will be tabled in February 2021.[1] The initiative is also part of the sustainable and smart mobility strategy to be adopted by the end of 2020.

Encouraging the take-up of sustainable aviation fuels is seen as an important element in efforts to reduce emissions and move towards carbon neutrality in aviation. Other elements include market-based measures, the streamlining of air traffic management. Development of alternative propulsion technologies and aircraft (e.g. electric aircraft) may also begin to contribute to these efforts, as such technologies have not yet matured sufficiently to be ready for commercial use in the coming decades (see text box below on 'Electric flight'), sustainable aviation fuels are considered to have most potential to offer emissions reductions in the short term.[2] These fuels, also known as 'drop-in' alternative fuels, can be used without making changes to the existing infrastructure and aircraft fleets designed for conventional aviation fuel use.

Types of sustainable aviation fuel

Definition and sustainability

Traditional jet fuels are a mix of hydrocarbons, including mostly normal paraffins, iso-paraffins, cycloparaffins and aromatics, produced from the kerosene fraction of crude oil. Drop-in bio-based fuels – synthetic fuels that can be used in conventional engines and fuel logistics – are liquid hydrocarbons that have the same properties as conventional aviation fuels.

The International Civil Aviation Organization (ICAO) differentiates between aviation alternative fuels (AAF), obtained from sources other than petroleum, such as coal, natural gas, biomass, and hydrogenated fats and oils with the potential to be sustainably produced, and sustainable aviation fuels (SAF), which are AAF that meet sustainability criteria. There is no single internationally agreed definition of SAF.

Sustainability criteria for AAF have been defined under the carbon offsetting and reduction scheme for international aviation (CORSIA) – a market-based measure with the aim of limiting greenhouse gas emissions from international aviation to their 2020 levels. In the EU framework, the Renewable Energy Directive (RED) adopted in 2009 set sustainability requirements for biofuels. The revised Renewable Energy Directive (RED II), which reinforced the sustainability criteria, entered into force at the end of 2018 and will need to be transposed into national law by the end of June 2021.

With respect to greenhouse gas emissions (GHG), under CORSIA, SAF should achieve life cycle emission reductions of at least 10 % compared to a fossil fuel baseline of 89 grams of CO_2 equivalent per megajoule (g CO_2e/MJ). According to RED II, in order to qualify biofuels as renewable energy sources, fuels have to achieve a 65 % greater reduction in emissions against a fossil fuel baseline of 94 g CO_2e/MJ.

Production pathways

There are several pathways for bio-based drop-in fuels, at varying levels of maturity and readiness for commercialisation, obtained by converting various feedstocks and residues into fuel. Under the specifications of American Society for Testing and Materials (ASTM) standards, as of June 2020, eight production pathways had been certified for use in civil aviation (see box below). A number other of pathways are in the approval process.

Seven pathways involve blending synthetic fuels with conventional jet fuel and the eighth involves co-processing of bio-based feedstock together with fossil feeds in a refinery. Blending is required as some conventional fuel components allow seals to swell in older engines and prevent fuel leaks. Use of unblended sustainable aviation fuel has been tested in military aircraft.[3]

According to the sources analysed for this briefing, two of the pathways stand out in terms of level of readiness for commercialisation.

Oil-to-fuel pathways, where vegetable oils and/or animal lipid feedstocks (referred to as HEFA – hydroprocessed esters and fatty acids)[4] – are the method most used to produce commercially available SAF.[5]

Another family of conversion technologies referred to as having a high degree of readiness for commercialisation is fuel production via Fischer-Tropsch (FT) synthesis,[6] which uses biomass, such as forestry and agricultural residues.

A 2019 ICAO document on the methodology of life cycle assessment provides a detailed description of pathways, including feedstocks and comparison of life cycle emissions impacts of alternative aviation fuels compared with conventional jet fuel.

Certified production pathways for SAF

HEFA-SPK (hydroprocessed fatty acid esters and free fatty acid). Lipid feedstocks, such as vegetable oils, used cooking oils, tallow, etc. are converted using hydrogen into green diesel, and this can be further separated to obtain bio-based aviation fuel. The maximum blending ratio is 50 %.

FT-SPK (Fischer-Tropsch synthetic paraffinic kerosene). Biomass is converted to synthetic gas and then into bio-based aviation fuel. The maximum blending ratio is 50 %.

FT-SPK/A is a variation of FT-SPK, where alkylation of light aromatics creates a hydrocarbon blend that includes aromatic compounds. The maximum blending ratio is 50 %.

HFS-SIP (hydroprocessing of fermented sugars – synthetic iso-paraffinic kerosene). Using modified yeasts, sugars are converted to hydrocarbons. The maximum blending ratio is 10 %.

ATJ-SPK (alcohol-to-jet synthetic paraffinic kerosene). Dehydration, oligomerisation and hydroprocessing are used to convert alcohols, such as iso-butanol, into hydrocarbon. The maximum blending ratio is 50 %.

CHJ (catalytic hydrothermolysis jet fuel). Triglycerides such as soybean oil, jatropha oil, camelina oil, carinata oil, and tung oil are used as feedstock. The blending ratio 50 %.

HC-HEFA-SPK. Synthesised paraffinic kerosene from hydrocarbon-hydroprocessed esters and fatty acids. Algae as feedstock. The blending ratio is 10 %.

Co-processing. Biocrude up to 5 % by volume of lipidic feedstock in petroleum refinery processes.

Source: ICAO, European Aviation Safety Agency.

Ongoing and future policy measures and initiatives

There are some policy actions already ongoing at EU and global level that aim to create incentives to increase the uptake of SAF. The carbon offsetting and reduction scheme for international aviation (CORSIA) created by the ICAO to target carbon neutral growth in aviation and to be implemented as of 2021 includes the possibility to reduce emissions from international aviation through the use of SAF.[7] ICAO is in the process of finalising the procedures that would allow producers to demonstrate that fuel is CORSIA-eligible and aircraft operators to claim a reduction in their offsetting requirements.[8] The EU has confirmed participation in the CORSIA voluntary phase from 2021.

The EU emissions trading system (EU ETS), which applies to intra-EU/EEA flights, provides an incentive for aircraft operators to use biomass-based SAF certified as compliant with the sustainability criteria of RED or RED II, by attributing them zero emissions under the scheme, cutting operators' reported emissions and the ETS allowances they need to purchase.[9]

According to the revised EU Renewable Energy Directive (RED II), SAF can be counted towards the achievement of the renewable energy targets provided for in the directive in the EU Member States, on the condition that they comply with the sustainability criteria listed in the directive. In addition, a specific multiplier of 1.2 is to be applied to the supplied quantity of non-food- and feed-based SAFs, when calculating the SAF contribution towards the renewable energy targets.

It has been noted, however, that the economic incentive to switch to the use of SAF under the CORSIA mechanism is estimated to be small, incentives under EU ETS have not been strong enough to increase the uptake of SAF in Europe[10] and the multiplier in RED II may not be large enough to provide a sufficient incentive for the fuel producers.[11]

A few EU countries, including the Netherlands, France, Finland, Sweden and Portugal have already put in place or are planning policy support measures, such as SAF supply obligations. There are also a number of initiatives in EU countries to support the development of SAF, such as Bioqueroseno in Spain, AIREG in Germany and the Nordic Initiative for Sustainable Aviation (NISA). Elsewhere in Europe, Norway requires at least 0.5 % of advanced biofuel to be mixed with jet fuel sold from 1 January 2020 with the aim of increasing use of SAF to 30 % of aviation fuel by 2030, and in the UK, the Renewable Transport Fuel Obligation scheme was extended to aviation in 2018 to support and reward the production of SAF.[12]

Various voluntary sustainability certification systems exist for biomass to energy production and supply chains. There are a number of such approved systems in the EU, which are regarded as sufficient to ensure products meet the RED II requirements. The most widely used sustainability certification system for aviation is the Roundtable for Sustainable Biomaterials (RSB). Several certificates are available under RSB, with the 'RSB EU RED Standard' recommended for producers aiming to sell in the EU.

Use and production of sustainable aviation fuels in the EU

A number of airlines have used bio-based fuels for test flights since 2008. According to the International Air Transport Association (IATA), globally by December 2019 more than 215 000 commercial flights had used SAF, 40 airlines had sustainable fuel experience and there were 6 billion litres (4.8 million tonnes)[13] in forward purchase agreements[14]. A number of airports have agreed to supply bio-based fuels through their hydrant systems (e.g. Oslo (since 2015), Los Angeles International Airport (since 2016), Stockholm Arlanda Airport (since 2017), and Bergen Airport (since 2017).[15] The ICAO website provides a map of airports that receive ongoing deliveries or batches of SAF.

Despite these developments and an increasing interest in SAF, current consumption is very low compared to overall aviation fuel consumption. According to the International Energy Agency (IEA), aviation bio-based fuel production of about 15 million litres (approximately 12 thousand tonnes) in 2018 accounted for less than 0.1 % of total aviation fuel consumption.[16] A 2019 study referred to as the SAF 'facilitation initiative', commissioned by the European Aviation Safety Agency (EASA), put the figure for SAF at 0.004 % of total jet fuel used by commercial operators worldwide in 2017. Meanwhile, the European Commission estimates SAF use in the EU at 0.05 % of total aviation fuel consumption in 2017.

Production has grown faster in the US credited largely to the availability of support programmes for producer and incentive programmes for fuel use.[17] In Europe, SAF has not been used on a large scale and most production and use so far has been for demonstration and/or research and innovation purposes.[18] Most SAF used by European operators is tanked or imported from third countries. KLM, the only European airline using SAF on a regular basis, has its fuel supplied from the US. SAS has announced that it used 100 tonnes of alternative jet fuel in the 2016-2018 period. Neste has produced and supplied commissioned batches[19] and Lufthansa has tested and used SAF on their flights.[20] The ICAO website lists recent publicly available offtake agreements for SAF. A number of research and development projects in relation to SAF have been funded by the EU (e.g. Bio4A, Jetscreen, Flexjet, BeCool, BioMates, ABC-Salt and HyFlexFuel). A 2020 report by the EU's Innovation and Networks Agency provides a useful summary of the projects.

In the short term, production is expected to increase in Europe in the next few years, according to company announcements. For example, SkyNRG is developing a production plant in the Netherlands to be opened in 2022 aiming to produce 100 000 tonnes of SAF per year. Neste, with refineries in Finland and the Netherlands will be increasing production capacity up to a total of 100 000 tonnes per year between the US and Europe in 2020-21 and 400 000 tonnes in 2022. Preem, with refineries in Sweden, and SAS signed a letter of intent for an SAF offtake agreement, with a plant to be developed by the end of 2022.[21] Table 1 gives a non-exhaustive list of announcements.

Table 1 – List of companies with plans for SAF production in Europe

Company	Country	Production start year	Production volume (tonnes/year)
Repsol	Spain	Mid 2020s	250 000*
Swedish Biofuels	Sweden	Not available	5 000
LanzaTech	UK	Not available	Not available
Quantafuel	Norway	Not available	5 600-7 200
Total	France	2019	5 000**
Preem	Finland	2022	1 000 000*
Altalto	UK	Mid 2020s	60 000*
SkyNRG	Netherlands	2022	100 000
Neste	Finland	2022	400 000***

* total renewable fuel capacity; SAF fraction unknown
** one-off target as part of Bio4A project
*** production spread between Europe and US

Source: EASA report SAF 'Facilitation Initiative' (2019).

Potential capacity and future demand of SAF in the EU

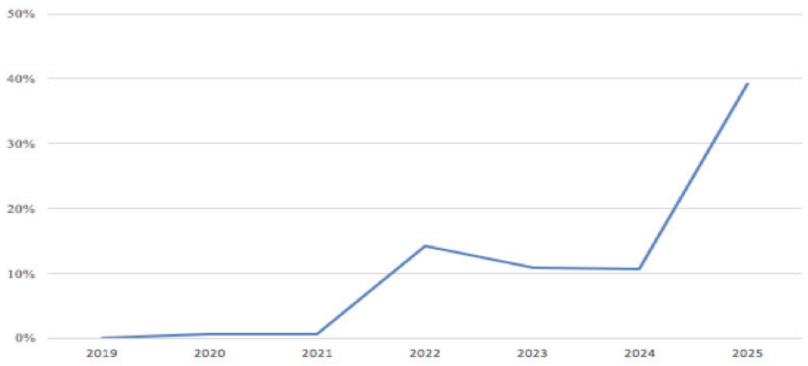
In addition to the capacity listed above, there are a number of refineries in Europe that are planning to produce or are producing biofuels and that could change their output to produce SAF, provided incentives from the market or policymakers emerge. Most of these focus on products from the HEFA process, using used oils, animal fats or tall oil (refineries in operation or nearing completion in Finland, Sweden and Italy) and co-processing (refineries in Spain, Portugal, Sweden and Ireland). A 2019 study commissioned by the EASA on the SAF 'monitoring system' provides estimates of production capacity. Potential annual renewable fuels production in the EU, part of which could be used for SAF production, is estimated at 4 million tonnes in 2020 rising to more than 7 million tonnes in 2025.[22] It is estimated that in the short term approximately 80 % of potential capacity for SAF will come from HEFA refineries.

Considering the yield rates of different pathways (e.g. SAF yield from HEFA refineries is estimated at 50 %) the potential annual SAF production in the EU was calculated as 1.95 million tonnes in 2020 and 3.66 million tonnes in 2025 and 2030. This represents approximately 6 % of total jet fuel consumption. Globally, the ICAO estimates put production capacity in 2030 at more than 14 billion litres (approximately 11 million tonnes), but highlights that there is uncertainty over how much of production will be directed towards SAF compared with other fuels.

On the demand side, the current SAF promotion plans in European countries could lead to a SAF demand to increase to 2.23 % in 2025 and 6.4 % of jet-fuel use in 2030 (1.35 million tonnes and 4.07 million tonnes respectively).[23] This is expected to increase if further incentives and measures are introduced. Meanwhile, the IEA's sustainable development scenario anticipates biofuels reaching around 10 % of aviation fuel demand and SAF consumption of 37 billion litres (approximately 30 million tonnes) by 2030 worldwide.

Comparing the estimates of production and demand in the EU, it is estimated that short-term demand based on current policy measures could be covered by existing potential capacity to produce SAF (see also Figure 1), but it would require incentives to shift from road fuel production to SAF production in refineries capable of producing SAF and additional production capacity would be needed if policy driven demand increased.[24] These estimates were compiled before the coronavirus pandemic, which has caused a drop in airline activity; however, the aviation industry has repeated its commitment to eliminating carbon emissions going forward, while calling for investments in decarbonisation, such as sustainable fuels, in the pandemic recovery plans. The EASA's SAF monitoring study points out that according to a Commission analysis, to reach the carbon neutrality targets by 2050, 23 to 45 % for biofuels and 10 to 34 % for electro-fuels (see below on electro-fuels) would be needed in the aviation fuel mix.

Figure 1 – EU SAF demand, percentage of potential capacity



Source: EASA report SAF 'Monitoring System' (2019).

Barriers to production and use of SAF

The low production and use of SAF has been attributed to a number of barriers. One major barrier to demand for sustainable aviation fuels is cost, with the price ranging from approximately two to eight times that of conventional aviation fuel, according to an analysis by the International Council on Clean Transport. For example, EASA estimates that the price of AAF produced from used cooking oil is about €950 to €1 015 per tonne, while the price of conventional aviation fuel is €600 per tonne.[25] Production processes can be complex, depending on the pathway, and the cost of feedstock may be high, while existing policy measures, such as the EU ETS, do not appear to be sufficient incentives to drive up demand.

HEFA pathways are seen to have lower investment costs (estimated capital costs range from €0.40 to €1.50 per litre of annual capacity)[26] than other pathways with relatively simple production processes. However, they have been associated with concerns over availability and cost of feedstock, including current and future restrictions on use of food-based feedstock. Furthermore, the feedstocks used in the HEFA process (such as used cooking oil and tallow) are also used for road-sector biodiesel production, which has a simpler and less costly production process, and may therefore be a more attractive option for producers.[27] Competition for feedstock between the road and aviation sector is expected to increase as more ambitious policy measures to decarbonise the transport sector are adopted. Meanwhile, Fischer-Tropsch (FT) synthesis pathways, using generic biomass, benefit from a low cost and abundant feedstock, but a complicated production process entailing higher capital costs (€4 to €6 per litre of annual capacity).[28]

It has also been pointed out that the authorisation process for SAF may also present significant barriers. The industry reportedly faced costs of US$2 million for the first products to be marketed and the process could last three years. Meanwhile, industry stakeholders, such as aircraft operators and ground equipment owners require industrial scale demonstration of product performance as evidence of technical maturity.[29]

Electro-fuels

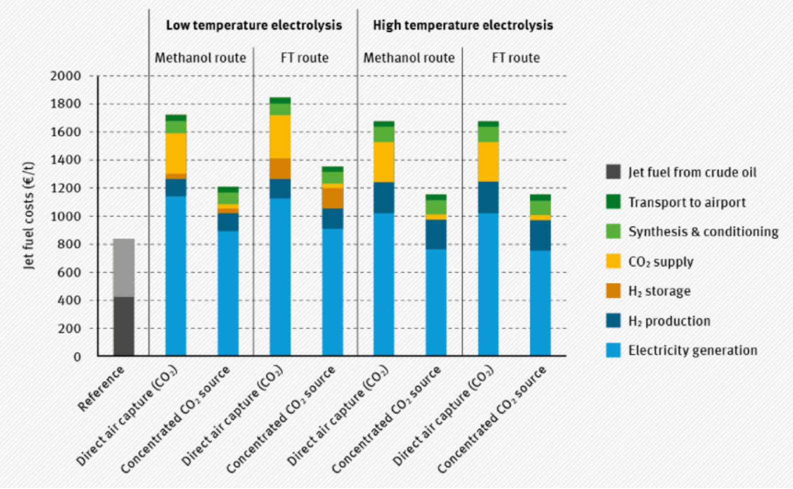
There has been increased interest in electro-fuels as potential sustainable aviation drop-in fuels. Also known as power-to-jet fuels, power-to-liquid (PtL) fuels or electro-fuels, these fuels are obtained by using electricity to produce hydrogen through electrolysis, which is then combined with carbon to yield a liquid hydrocarbon that can be consumed in an internal combustion engine. PtL fuels are considered renewable fuels of non-biological origin (RFNBO), if electricity from renewable sources is used in the process.

According to a 2016 study conducted by Ludwig-Bölkow-Systemtechnik GmbH (LBST) on behalf of the German Environment Agency, there is a high level of technological readiness for electro-fuels, with Fischer-Tropsch (FT) synthesis and upgrading and Methanol (MeOH) synthesis and conversion identified as the main pathways.

As of 2016 no demonstration plants for the production of power-to-kerosene were in operation, but demonstration projects for power-to-diesel and power-to-methanol were ongoing, which would require further refining to jet fuel according to existing processes.[30] A number of PtL demonstration plants are being developed or are planned in Finland, Germany and Norway and Canada. The EU has funded several research projects (e.g. Sun-to-Liquid, Kerogreen and ECOCOO).[31]

The production process is currently very expensive, with EASA estimating that PtL fuels are three to six times more expensive than kerosene due to high conversion losses and high transportation and distribution costs. According to one calculation, the price of PtL fuels is up to €7 per litre, although the price is expected to fall to €1 to €3 per litre by 2050, if economies of scale can be achieved and the price of renewable electricity decreases. The LBST study provides a comparison of projected costs of PtL fuels, with a conventional jet fuel reference price of €422 per tonne in 2016 and a projected future price of €837 per tonne, and the price of electricity at €40/MWh (Figure 2).

Figure 2 – Jet fuel costs projected for future PtL plants in 2050



Source: LBST on behalf of the German Environmental Agency (2016).

Possible future policy action: Refuel EU

In the run-up to presenting the RefuelEU aviation initiative to promote take-up and production of SAF scheduled for the end of 2020, the Commission launched a public consultation preceded by an inception impact assessment outlining areas of concern in the demand and supply of sustainable aviation fuels, and possible policy actions.

The inception impact assessment lists areas of concern such as a lack of a policy framework that would encourage investments to scale up production and achieve cost reductions through economies of scale, scarcity of waste-based feedstock, suboptimal energy efficiency of the conversion process for electro-fuels, and high costs associated with the approval process of new production pathways.

A number of policy options are listed, including a minimum share of SAF to be supplied to airlines and/or a minimum share of SAF to be used by airlines, revision of the 1.2 multiplier for aviation fuel under the Renewable Energy Directive, a central auctioning mechanism for SAF producers to bid to supply a certain volume of SAF to the aviation market, a funding mechanism to encourage the deployment of SAF production facilities and uptake of SAF, prioritisation of feedstock for SAF production, development of a platform to facilitate purchase agreements between SAF producers and airlines, and an initiative to provide technical support to producers in the approval process.

Electric flight: Reality by the 2030s?

Although commercial flights with electric aircraft may not be possible before the 2030s, the aviation sector is nevertheless going through a pioneering era with regard to electro-mobility. The number of projects developing electrically propelled aircraft have grown increasingly rapidly and it is estimated the number of new developments grew by 30 % in 2019. In June 2020, EASA announced the certification of a two-seater electric airplane, the Pipistrel Velis Electro, the world's first type certification of a fully electric aircraft. The ICAO maintains a platform (E-HAPI) to keep track of developments, providing a non-extensive list of projects.

However, so far, existing projects mainly concern single or twin-seater categories with the fastest growth in the urban taxi concept. Some projects exist for aircraft with up to 10 seats. The end of May 2020 saw a 30-minute test flight of a nine-seat modified Cessna Caravan 208B, regarded as largest electric plane to fly so far. The company Eviation has developed a new design for a small nine-seat electric aircraft with a range of 1 000 km to put into service in 2022.

When it comes to converting conventional large passenger aircraft to electric propulsion, the main concern is the energy density of batteries. According to one calculation, jet fuel contains around 30 times more energy per kilogram than lithium-ion batteries, meaning that an Airbus A380, which can travel 15 000 kilometres in a single flight, could only fly a little over 1 000 kilometres with batteries. Meanwhile, battery technology, such as lithium-air batteries, that could reach the same energy density as jet fuel is at early stage of development.

Hybrid-electric solutions have been explored as a solution. Until May 2020, Airbus, with Siemens and Rolls Royce, was developing a 100-seat aircraft as part of a project called E-Fan X with one of the four engines as an electric motor. The project was discontinued citing coronavirus realities. The EU is also funding projects in the area of hybrid-electric aircraft and alternative aircraft designs to improve aerodynamic performance. These include IMOTHEP, FutPrint50, Parsifal, SMS and Novair.

MAIN REFERENCES

Sustainable Aviation Fuel Facilitation Initiative, study conducted by Envisa and others, for the European Aviation Safety Agency, 2019.

Sustainable Aviation Fuel Monitoring System, study undertaken by César Velarde and Envisa, for the European Aviation Safety Agency, 2019.

ENDNOTES

[1] Transport Commissioner Adina-Ioana Vălean announced during a meeting of the Parliament's Transport and Tourism Committee on 12 October 2020 that the proposal will be presented in February 2021.

[2] The International Air Transport Association (IATA) estimates that sustainable aviation fuels have the potential to cut aviation emissions by up to 80 %. An Airline Handbook on CORSIA, IATA, 2019, p. 4.

[3] Producing sustainable aviation fuel, Aviation Benefits Beyond Borders website, An initiative of the Air Transport Action Group (ATAG).

[4] The HEFA pathway consists of the hydroprocessing of lipid feedstocks) such as vegetable oils recovered from food related activities and tallow, which is produced through rendering of the animal by-products from cattle slaughtering) through various catalytic reactions mechanisms, in the presence of hydrogen to upgrade them to aviation fuels. Source: CORSIA Supporting Document, 2019, p. 19.

[5] Sustainable Aviation Fuels. The Best solution to large sustainable aircraft?, Roland Berger, 2020, p.7.

[6] The Fischer-Tropsch (FT) pathway is a conversion technology that comprises gasification of biomass (such as agricultural residue, e.g. wheat straw, forestry residues and municipal solid waste), cleaning and conditioning of the produced synthesis gas, and subsequent synthesis to obtain liquid biofuels. Source: CORSIA Supporting Document, 2019, p. 14.

[7] Sustainable Aviation Fuel Monitoring System, study undertaken for the European Aviation Safety Agency, 2019, p.8.

[8] Ibid., p.32.

[9] Sustainable Aviation Fuel Monitoring System, 2019, p.54.

[10] Sustainable Aviation Fuel Monitoring System, 2019, pp. 91-92.

[11] Legislating for aviation alternative fuels, Transport & Environment, July 2019, p.10.

[12] Sustainable Aviation Fuel Monitoring System, 2019, pp. 92-95.

[13] Conversion based on conversion factor for jet fuel in the U.N. Statistics Division Energy Statistics Yearbook.

[14] Sustainable Aviation Fuels factsheet, International Air Transport Association (IATA), 2019, pp. 1-2.

[15] Sustainable aviation fuels guide, ICAO, 2017, p.39.

[16] Are aviation biofuels ready for take off?, International Energy Agency (IEA), 2019.

[17] Sustainable Aviation Fuel Facilitation Initiative, 2019, p.12.

[18] European Commission staff working document, Towards clean, competitive and connected mobility, SWD(2017) 223, European Commission, May 2017, p.52.

[19] Sustainable Aviation Fuel Monitoring System, 2019, p.101.

[20] Report. Sustainable Aviation Fuels. The Best solution to large sustainable aircraft?, Roland Berger, 2020, p.7.

[21] Sustainable Aviation Fuel Monitoring System, 2019, pp. 103-105.

[22] Ibid, pp. 106-110 and 118.

[23] Ibid., p.117.

[24] Ibid., p.121.

[25] Sustainable Aviation Fuels, European Aviation Safety Agency website.

[26] The cost of supporting alternative jet fuels in the EU, 2019, p.4.

[27] Sustainable Aviation Fuel Facilitation Initiative, 2019, p.9.

[28] The cost of supporting alternative jet fuels in the EU, 2019, p.4.

[29] Ibid., pp. 33-34.

[30] Power-to-Liquids: Potentials and Perspectives for the Future Supply of Renewable Aviation Fuel, A study by Ludwig-Bölkow-Systemtechnik GmbH (LBST) on behalf of the German Environment Agency, 2016 p.16.

[31] The Innovation and Networks Executive Agency (INEA) report 'Towards Climate Neutral Aviation provides useful summaries of Horizon 2020-funded SAF implemented by INEA, 2020, pp.15-25.

DISCLAIMER AND COPYRIGHT

Photo credits: © malp / Adobe Stock.

eprs@ep.europa.eu (contact)

www.eprs.ep.parl.union.eu (intranet)

www.europarl.europa.eu/thinktank (internet)

http://epthinktank.eu (blog)