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# Europe's ambition for biofuels in aviation - A strategic review of challenges and opportunities☆

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ABSTRACT

Europe's Biofuel FlightPath Initiative was introduced in 2011 with the aim of producing two million tons of biojet fuel derived from renewable sources for the aviation industry by 2020. This volume, equating to approximately 4% of current EU jet fuel consumption has not yet materialized and Europe's biojet fuel industry is in a nascent state. To date surface transport in the EU has benefited from the push effect of renewable transport targets and this has led to the development of a biodiesel and bioethanol industry in the EU to meet the demand created. Biojet fuel has not benefited from this uplift with only one Member State (Netherlands) acknowledging the option of biojet fuel as a means of contribution to the renewable transport target. Higher costs, investor uncertainty and poor policy awareness at Member State level have contributed to the nascent state of biojet fuel in Europe. A clear and stable policy landscape for biojet fuel can help mitigate some of these issues. However, other non-policy measures are also required to overcome these challenges. This review surveys the challenges and opportunities for a nascent biojet fuel sector in Europe and presents options to stimulate the sector.


## 1. Introduction

All sectors of the global economy must play a role in reducing greenhouse gas emissions to meet the objectives of the Paris Agreement on climate change [1]. Emissions from both domestic and international global aviation accounts for approximately 2% of global $CO_2$ emissions produced by human activity. World air transportation demand is projected to grow at a rate of around 5% per year over the next several decades [2] thus amplifying the challenge of emission reduction for the sector. At a European level, $CO_2$ emissions have increased by almost 80% between 1990 and 2014, and are forecast to grow by a further 45% between 2014 and 2035 [3]. On an average day in Europe, over 26,800 flights pass over European airspace and with just 7% of the world's population, these flights accounts for around 25% of global air traffic. Europe is home to approximately 3800 passenger aircraft and over 700 large commercial airports, which supported the movement of 918 million passengers in 2015.[1] Fig. 1 shows passenger movements between EU Member States for 2014.

Following the economic crisis, a significant recovery in the aviation industry was seen in 2014, with a 4% increase in passenger numbers from the previous year. Final energy consumption in the sector in 2014 was 49 Mtoe, 14% of total transport energy usage or 4% of final energy consumption across all EU 28 sectors. $CO_2$ emissions from aviation in the same year were 137 Mt, representing 15% of total transport emissions or 3.1% of EU 28 emissions [4].

Biofuels can be used in all modes of transport as blend in fuels. In the aviation sector, biofuels known as biojet is particularly critical, with few other obvious alternatives if indeed the sector is going to help contribute meaningfully to carbon reduction targets without severely curtailing growth. There are a wide variety of studies existing in the literature that address the role biofuels in international aviation from different perspectives including technological, environmental and economic perspectives [5–7]. In this paper, we focus on the specific policy challenges and opportunities for the European biojet fuel sector.

## 2. Global aviation policy context

Emissions from domestic aviation, accounting for approximately

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[1] Air transport statistics, Eurostat (Accessed October 2017). http://ec.europa.eu/eurostat/statistics-explained/index.php/Air_transport_statistics.

https://doi.org/10.1016/j.esr.2017.12.008
2211-467X/

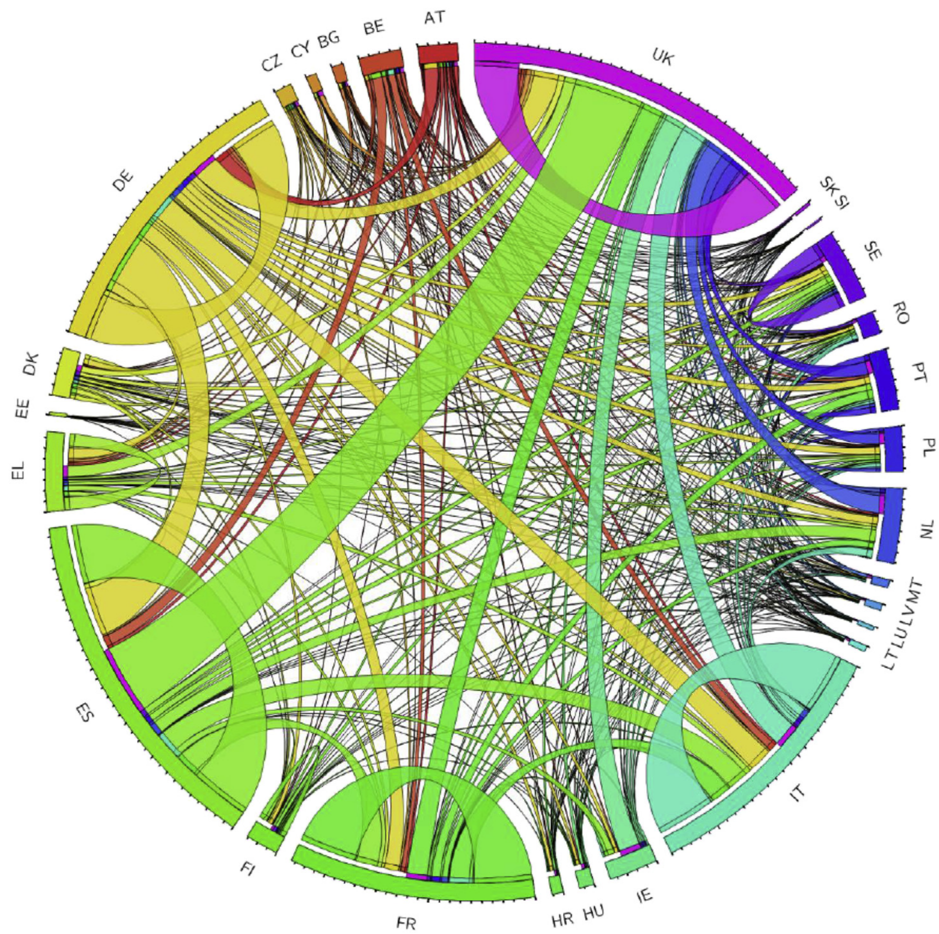


**Fig. 1.** Circle Diagram showing 2014 passenger movements between EU Member States (domestic flights are shows as links within each Member State Segment. Data sourced from EuroStat).

0.7% of global $CO_2$ emissions are reported under the United Nations Framework Convention on Climate Change (UNFCCC) and thus the responsibility for emission reduction rests with countries. International aviation emissions, on the other hand, accounting for approximately 1.3% of global $CO_2$ emissions are the responsibility of the International Civil Agency Organization (ICAO) and therefore these emissions are typically not included in countries' Nationally Determined Contributions (NDCs) under the Paris Agreement. In 2016, ICAO adopted a global carbon-offsetting scheme for international aviation [8]. The Carbon Offset and Reduction Scheme for *I*nternational Aviation (CORSIA) encourages aircraft operators within countries that agree to the scheme to address and offset emissions over and above their average emissions from 2019 to 2020. Offsets may be obtained through existing schemes such as the UNFCCC's Clean Development Mechanism or buying allowances from emissions trading schemes. As of August 2017, 72 States, representing more than 87% of international aviation activity, intend to voluntarily participate in the scheme from its outset. In terms of biojet fuel, ICAO resolution A38-18 [9] on climate change recognizes the role and importance of ‘Alternative Fuels’ and the needs for coordinated policies and sustainability criteria but does not set targets for fuel uptake. It is unlikely that a focus on offsets as the primary means of mitigation will incentivize the uptake of biojet fuel, due to the much lower comparative cost of offsets. ICAO estimate a range of offsetting costs from 6 to 20 \$/ton $CO_2$e for the year 2020. A high carbon price in excess of 200€/t would be required to make biojet fuel commercially favorable with jet kerosene [10].

## 3. European policy context

The emergence of the recent ICAO agreement highlights an important tension arising from differing regulatory jurisdictions, demonstrated in recent European policy moves on aviation emissions. In 2012 the EU led the way in implementing market-based measures (MBMs) for aviation by including aviation in its Emission Trading System (EU ETS). The scheme places the responsibility for emissions reduction on the aircraft operators. Initially the EU ETS was set to cover 100% of EU aviation emissions, which equated to approximately a third of global aviation emissions. However, this was fiercely resisted by the industry and in April 2013, the EU decided to temporarily suspend enforcement (a move called ‘Stop the Clock’) of the EU ETS requirements for flights operated in or to non-EU countries, while continuing to apply the legislation to flights within and between countries in Europe. While the scheme is focused on a ‘cap and trade’ emission principle, aviation companies can gain credits for use of biojet fuels. However their present use by aircraft operators remains extremely small to date mainly due to very high cost differentials [11]. The European Commissions has to give careful consideration on how the EU-ETS for aviation and the recently proposed CORSIA global scheme for emissions reduction from international aviation will work, as both systems together may overlap. Fig. 2 presents an overview of global and EU climate initiatives that impact aviation. In 2017 the European

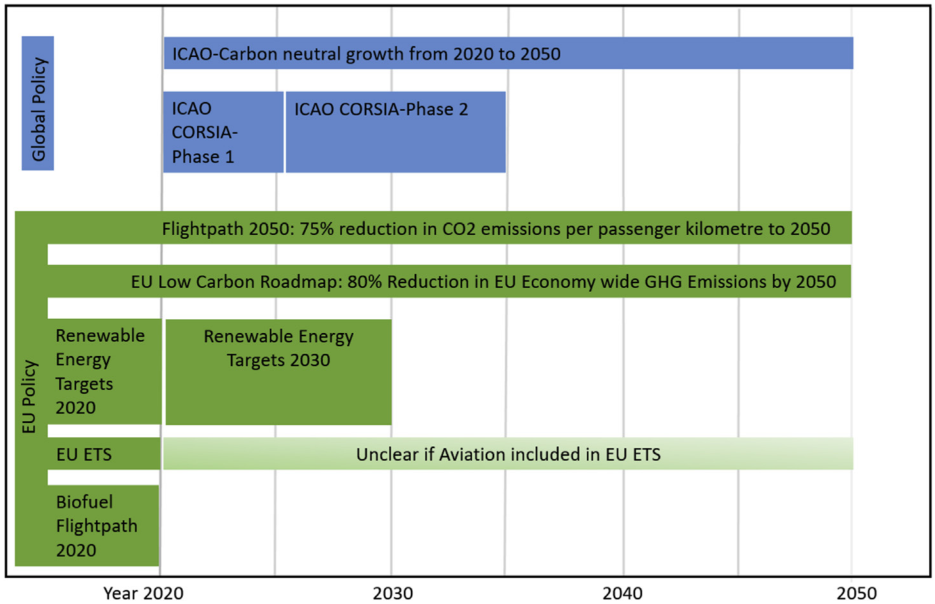


**Fig. 2.** EU (in green) and Global (in blue) Policy Landscape to 2050.

Commission acknowledged that amendments are needed and proposed to continue the current form of the EU ETS to 2020.[2]

With poor prospects for biojet fuel under the existing EU ETS and CORSIA agreement, the Commission has recognised more needs to be done, to strengthening existing legislation on renewables and at the same time develop specific initiatives to support biojet fuel production capacity and uptake.

The revision of the Renewable Energy Directive (RED) aims to accelerate a transition to biofuels with low Indirect Land Use Change (ILUC) [12]. The process of ILUC can occur if biofuel production takes place on cropland which was previously used for other agriculture such as growing food or feed. Since this agricultural production is still necessary, it may be partly displaced to previously non-cropland such as grasslands and forests.

The current Renewable Energy Directive (2009/28/EC) sets a binding target of 20% gross energy consumption from renewable sources by 2020 (20% RES). Each Member State is also required to have at least 10% of their (land-based) transport fuels from renewable sources (10% RES-T) by 2020. While biojet fuel can contribute toward these targets, current levels of consumption are very low and it is anticipated that liquid biofuels in road transport will make the majority of the contribution to the 10% RES-T target. Proposed revisions of the Renewable Energy Directive include the contribution of fuels supplied in the aviation and maritime sector being weighted by 20% more than other conventional fuels. While Member States are free to decide which biofuels they want to incentivise through national schemes, to date only the Netherlands has acknowledged the option of biojet fuel as a mean of contribution to the renewable transport target. This lack of visibility, and ongoing uncertainty as to the support for biofuels in the post-2020 regime, has contributed to limited biojet fuel activity and capacity development in recent years.

To support biofuel use in aviation specifically, the Biofuel FlightPath Initiative was introduced in June 2011 [13]. The European Commission in partnership with the aviation industry, including airline and biofuel producers,[3] targeted 2 Mt annual production of fuel derived from renewable sources by 2020. It is important to note that no formal mechanism exists to ensure delivery of this target, although a range of options have been discussed [10]. This equates to approximately 1% of the total global jet fuel consumption in 2020 or 4% of EU jet fuel consumption. To put this in context, in 2015 approximately 14.3 Mt of biofuels were consumed in all forms of transport in Europe. There are no specific figures for Europe in terms of volumes of biojet fuel consumed. Lufthansa carried out a series of over 1000 flights between Hamburg and Frankfort with an A321 aircraft, with one engine powered by a 50% biojet fuel blend and the other one with conventional jet fuel, allowing a direct comparison between both fuels and showed no negative impact of biofuels over the 6 months trial period [14].

## 4. Why targets have not delivered

While the technological feasibility for alternative jet fuels is proven, lowering cost, increasing availability, and sustainability of feedstocks remain important prerequisites to successful market uptake. There are many pathways for aviation fuels [15,16] and as such, it is likely that multiple feedstocks will be used globally and in Europe to produce future aviation biojet fuel. Technical standards for biojet fuels have successfully been in place for a number of years. However, barriers to large-scale deployment remain, including high cost, policy uncertainty and poor policy awareness.

### 4.1. High cost

Biojet fuel is expensive and is projected to remain so relative to jet kerosene, as illustrated by Fig. 3. At production costs of over $1/litre [2,17,18], this is much higher than for road fuels. This is largely because of aviation's requirement for “drop-in” fuels which needs more advanced processes than those deployed for the first generation of road transportation biofuels (e.g. ethanol and biodiesel), and for further upgrading of the fuel in order to meet jet fuel specifications. In addition, biojet fuels are currently produced in

[2] European Commission Press Release. The EU tackles growing aviation emissions. http://europa.eu/rapid/press-release_IP-17-189_en.htm.

[3] Airbus, Air-France-KLM, British Airways, Lufthansa and biofuel producers Chemtex Italia, Neste Oil, Biomass Technology Group, UOP and UPM.

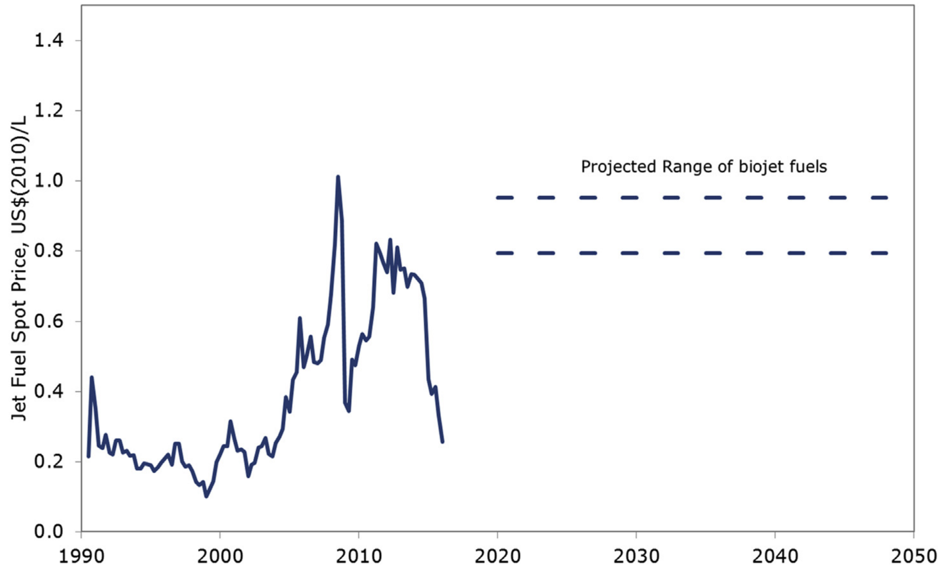


**Fig. 3.** Kerosene jet fuel spot price and an estimation of projected range in costs for biojet fuels [2].

small quantities compared to jet kerosene, without the economies of scale, and therefore remain an unattractive option for large-scale uptake by the industry. However, it is also important to note that biojet costs are strongly influenced by a range of factors so under different circumstances can be produced at much lower cost [19]. While the unit cost of biojet fuels are expensive, it is helpful to put this cost in context of what the extra cost of including biojet fuel on a typical flight might be to a passenger, for illustrative purposes. At low blend levels and if additional costs are incorporated into intra-EU passenger fares, the costs become relatively low. Compared to jet kerosene, the additional costs for biojet fuels are estimated between 0.42 €/L and 1.20 €/L. If spread across all domestic and intra-EU-28 flights in 2020, this would add between €1.20 and €4.30 to the cost per passenger of a typical 1000 km flight. This is based on achieving the current EU ambition of 2 Mt of biojet fuel production in 2020 [20].

### 4.2. Policy uncertainty

Europe's Renewable Energy Directive came into existence in 2009 and biojet fuels were at a less advanced stage, considered a more niche technology at the time, and potentially not given appropriate attention. However, from an industry perspective, biofuels and biojet fuel development has been hindered by the policy and political uncertainty surrounding first generation biofuels and associated indirect land use issues. While the production of biofuels was originally strongly encouraged by the Commission, current debates at European and national level rather focus on their limitations, particularly in relation to sustainability [21]. Investors who experienced negative consequences from the unstable support policy for first generation biofuels may be more reluctant to invest in second generation biofuels, including biojet fuels, particularly where they compete with current investments. Equally, Europe has a patchwork of fragmented renewable transport policies and sustainability criteria that differ across Member States. Given the international dimension of the aviation sector, a coherent international biojet fuel policy would strongly benefit the sector [22].

Poor policy awareness: There is a low level of policy awareness of biojet fuels across Europe with only one Member State recognizing the contribution of biojet fuel to national renewable energy targets. Since 2013 the Dutch government has allowed biojet fuel to voluntarily opt-in under the European RED mandate for road transport fuel. Biojet fuel suppliers can generate biofuel certificate, which can be sold to the road transport sector. There do not seem to be any fundamental barriers that would prevent biojet fuel support schemes being extended as the Renewable Energy Directive allows for this, with the RED numerator including all forms of renewable energy in all forms of transport [23].

## 5. Discussion-what can policy and other measures do

In the long term, the creation of a biojet fuel industry either in Europe or at a global level is a key pathway to meaningful long-term decarbonisation for the aviation industry. The question on how to stimulate increased biojet production and use is one of utmost importance. Incentives to grow and kick-start the industry need to be explored today, given that any new scheme may require regulatory changes and will take time for operationalization. A review undertaken by Insight—E [23] pointed to a number of ways to develop the European policy framework to increase biojet fuel uptake across Europe.

### 5.1. Increase awareness of biojet and the use of existing policy mechanisms

Existing renewable legislation, and the targets therein, could be used to increase demand for renewable technologies, and establishing production scale. Across Europe renewable transport policies do not lend themselves to the harmonisation that the international aviation industry would benefit from. As a starting point, the European Commission should encourage Member States to fully utilize existing policy legislation under the Renewable Energy Directive that allows for consideration of biojet fuels' contribution to renewable transport targets.

### 5.2. Integrate biojet objectives into the key European strategies

Like many areas of European energy and climate policy, biojet fuel policy has multiple stakeholders and linkages across a wide range of existing and proposed EU strategies. For greater policy cohesion, it is recommended that biojet fuel be considered and integrated into the following EU strategies - Bioeconomy strategy, Circular economy strategy and Aviation Strategy.

### 5.3. Develop a stable and clear policy landscape for the long term

As part of the consultation in preparation for a new Renewable Energy Directive for the period after 2020, many respondents noted that the main barrier to increasing renewable energy in transport is the lack of a stable policy framework for after 2020. Therefore, renewable energy policy out to 2030 should be decided on before 2020 to provide clarity on market outlook and continuation of the current RED provisions beyond 2020. Issues such as Brexit and internal Member State political changes will of course make any policy landscape more challenging and uncertain.

The possibility of introducing a levy on aviation kerosene within Europe or the cost recovery of biojet fuel through the modulation of en-route charges have been evaluated [10]. It was found that these methods are generally unsuitable due to the challenges with the operationalization and implementation of the scheme within a suitable timeframe; uncertainty of how such a schemes would integrate with the existing EU ETS and forthcoming ICAO market based proposal, and the potential for reputational risk to the existing route charging scheme should the issue be politicized.

### 5.4. Diseminate learning from proactive Member States, particularly the Netherlands and Nordic countries

While strong policy mechanisms are fundamentally important to the stimulation of a biojet fuel industry, they should be seen as complimentary measures and not as substitution for other measures. In the Netherlands, actors within the biojet fuel landscape are diverse, from entrepreneurs and established firms to research organizations, governments and end-users. Innovation is seen as a collective activity, supported by many institutions including government with strategies that look to the future. A system based approach is embraced with buy-in from a broad industrial base. Importantly, the Netherland has a number of collations and champions of the cause that can provide momentum in times of political inertia.

### 5.5. Lead by example

Similar to the Dutch Government, the Commission should explore taking a top-down leadership approach by mandating that all flights required for Commission business and research make a contribution to a biojet fuel fund.

In summary, lessons can be drawn from existing literature on technology transitions and innovation system. Three core elements of best practice can be distilled from the literature which are relevant for the nascent biojet fuel industry; namely, a broad system wide perspective should be considered; there should be strong mix of complimentary policies; polices themselves should be clear and stable; and advocacy coalitions may be required to counteract inertia from incumbent systems.

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