Analysis of aviation fuel demand on waste fats and oils market

Final Report

(Revised Version)

E4tech (UK) Ltd for the European Waste-to-Advanced Biofuels Association

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E4tech Strategy | Energy | Sustainability

Contents

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List of terms and abbreviations

AF	Animal fats, primarily tallow
CPO	Crude Palm Oil
GHG	Greenhouse gas.
FAME	Fatty Acid Methyl Esters, generally referred to as biodiesel. Used for road transport only.
FOG	Fats, Oil and Grease.
HEFA	Hydroprocessed Esters and Fatty Acids, one of the ASTM-certified pathways for bio-jetfuels, authorised for use in commercial flights.
HEFA+	Also referred to as High-Freezing-Point HEFA or HFP-HEFA, HEFA+ is assumed to be chemically similar to HVO but will require an additional fractionation step to be usable in aircraft. Due a higher freezing point than HEFA, it can only be blended up to 10-15% with kerosene. HEFA+ is currently undergoing the ASTM certification process.
HVO	Hydrotreated Vegetable Oil, also known as renewable diesel. Used as a drop-in substitute for road diesel, HVO is a term mostly used in the European Union. In the United States, renewable diesel used for road transport is often referred to as HEFA.
PFAD	Palm Fatty Acid Distillates
POME	Palm Oil Mill Effluent
RED	Renewable Energy Directive. The current directive (2009/28 EC) is generally referred to as RED whereas the directive to be enforced from 2021 to 2013 (EU 2018/2001) is referred to as RED II.
RTFO/RTFC	Renewable Transport Fuel Obligation/Certification (UK)
TME	Tallow Methyl Ester.
UCO	Used Cooking Oil.
UCOME	Used Cooking Oil Methyl Ester
WTP	Willingness to pay (feedstock)

Executive Summary

This study was commissioned by the European Waste-to-Advanced-Biofuels Association (EWABA) to determine whether current and future European policies in support of aviation biofuels could constitute a risk to the EU FAME industry. The study looked at production costs for FAME, HEFA and HVO/HEFA+ in combination with different policies to understand the conditions under which HEFA or HVO/HEFA+ producers could outcompete FAME producers for waste feedstocks. In particular, it assessed the impact of the 1.2x multiplier for aviation biofuels included in EU RED II. It also considered additional technical, market and policy elements that could have an impact on the FAME industry's use of waste FOGs, such as the ongoing ASTM certification process for HEFA+, current and future HVO and HEFA production capacity within and outside the European Union and the implementation of a cap on biofuels derived from used cooking oil and animal fats under RED II (which Member States may modify, taking into account the availability of feedstock, subject to approval by the Commission).

The main conclusions of the study are:

- HEFA could outcompete FAME producers with higher production costs for waste oil and fat feedstocks in the 2020s if:
  - Biofuel policy incentives are expanded to include aviation biofuels;
  - The 1.2x aviation multiplier is implemented.
- If HEFA+ is certified as a jet fuel by ASTM, and the costs of this route are lower than for HEFA, HEFA+ would result in stronger competition for feedstock than HEFA.
- Producers of FAME could still outcompete HVO, HEFA and HEFA+ for feedstock where they have low or medium FAME production costs.
- Regardless of production costs, HVO (renewable diesel) is already a direct competitor for FAME under current incentives, due to the absence of a blend wall, cold weather performance and high-value co-products.
- Strict implementation of the cap on waste oil feedstock at 1.7% (rather than Member States modifying the limit), and palm oil bans, would further increase competition for alternative feedstocks, squeezing FAME plants out of the market for waste oils and fats.
- National renewable aviation fuel mandates or individual airline commitments could also increase competitive pressure on feedstocks for FAME producers.
- Given the potential for disrupting the FAME industry, policy makers will need to decide whether the benefits of using waste oils and fats in the aviation sector - access to a low cost sustainable biofuel option - outweigh the disadvantages: lower greenhouse gas savings today, disruption of the existing FAME industry, and limited future potential for aviation decarbonisation at scale through waste oils and fats derived biofuels compared with fuels derived from Annex IX Part A feedstocks.

1 Background and Objectives

Several fuels can be produced from fats, oils and grease, including the road transport fuels FAME and HVO and the aviation fuels HEFA and HEFA +. While HEFA is already ASTM-certified, and therefore authorised for use in commercial flights, HEFA+ is currently undergoing the ASTM certification process.

Currently, producers of FAME, HVO/HEFA+ and HEFA compete for access to low-cost waste FOGs to use as feedstock. There are some differences in the types of feedstocks these plants can use, but broadly they are competing for the same (limited) pool of waste oils and fats, especially used cooking oil (UCO) and animal fats (AF). In the RED II (Recast of the Renewable Energy Directive - (EU) 2018/2001), UCO and AF count twice towards the renewable energy in transport target. In addition, a 1.2x multiplier for the contribution of aviation fuel towards Member State (MS) targets for renewable energy in transport has been introduced. RED II will be transposed into national legislation in each Member State (MS) from 2020. If aviation fuel is included within MS support schemes for low-carbon fuels, on an equal basis with road transport, but with a multiplier of 1.2, producers of aviation fuels from waste fats and oils may out-compete producers of road transport fuels for these feedstocks.

This study aims to understand whether the 1.2 multiplier for aviation biofuels could give a significant commercial advantage to HEFA or HEFA+ over FAME, due to the capacity of the biojet producers to pay a higher price for feedstock (UCO and animal fats). Task 1 consists of an analysis of potential for HEFA/HEFA+ producers to benefit from higher price premiums due to specific policy incentives, which would in turn allow them to buy feedstock at a higher price. Task 2 analyses several additional market and regulatory factors, which may increase or decrease the likelihood of HEFA/HEFA+ producers being able to access these premiums. Such factors include the current and future installed HEFA production capacity in the European Union, the possible ASTM certification of HEFA +, the role played by tariffs on the EU capacity to import FAME or HEFA from third countries, national mandates, and the potential effect of a cap on Annex IX Part B feedstock (UCO and animal fats).

2 Task 1 – Willingness to pay for feedstocks for aviation biofuels

The objective of Task 1 is to evaluate the potential economic value of the 1.2 multiplier and the economic benefit it could confer to HEFA and HEFA+ producers over FAME producers. An important variable to compare for each fuel is the willingness to pay for feedstock, as shown in Figure 1, rather than the value of the policy premium or of the fossil fuel replaced.

Producers’ total willingness-to-pay (WTP) for feedstock has been calculated by subtracting conversion costs from potential revenues. Differentials in WTP between the different fuel producers allow for a comparison of the competitiveness of FAME for feedstock supply. Data has been sourced as follows;

- Conversion costs for FAME have been calculated from data provided by EWABA’s members.
- HVO/HEFA+ and HEFA conversion costs have been calculated from academic literature.
- Revenues for FAME, HVO/HEFA+ and HEFA, are the sum of the respective fossil fuel comparator price and a renewable fuel premium created by country specific policy incentives (e.g. tradeable certificates, tax reductions, etc.) (Figure 1).

- Producer's profits are part of the willingness to pay for feedstocks, but no assumptions have been made in the model regarding each fuel producer's profits.

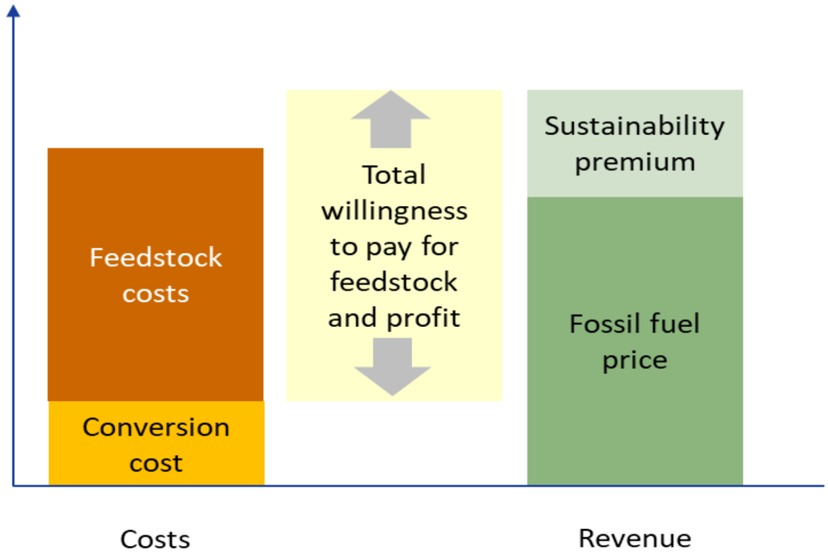

Figure 1: Schematic view of the economics of FAME/HVO/HEFA/HEFA+

2.1 Conversion costs

Conversion costs for FAME production were supplied by EWABA members and are not presented in this report to preserve member confidentiality. Conversion costs for HVO/HEFA+ and HEFA were calculated from academic literature, as conversion costs for companies using these technologies are not publicly available. Multiple sources were used for each production route with an average conversion cost subsequently used in the WTP calculations (Table 1). The conversion costs for HVO/HEFA+ and HEFA were kept constant in all the WTP calculations. The FAME conversion costs were varied during scenario analysis to give medium, low and high cost scenarios corresponding to conversion costs of 135 EUR/tonne, 90 EUR/tonne and 400 EUR/tonne respectively. Note that HEFA+ production is likely to require an additional distillation step, compared with HVO, to remove impurities before being usable in aircraft. Should this be the case, the conversion costs presented in this section would increase, thus reducing the cost competitiveness of HEFA+.

Table 1: Conversion costs for HEFA and HVO/HEFA+ as calculated from academic literature.

Fuel type	Conversion cost (excluding feedstock cost) (EUR/tonne)	Reference
HEFA	587	Nikita, 2019
	546	IRENA, 2017
	436	Stamatis, 2018
	409	Jong, 2015
HEFA average	**495**	
HVO/HEFA+	340	Stamatis, 2018
	387	Stamatis, 2018
	195	(S&T) Consultants Inc., 2018
	385	Ramboll, 2017
HVO/HEFA+ average	**327**	

2.2 Renewable fuel premiums

2.2.1 EU biofuel policies

The Renewable Energy Directive (RED – 2009/28/EC) constitutes the corner stone of biofuel policies in the European Union. The first version of the RED was voted in in 2009 and will remain in force until the end of 2020.

As of January 1, 2021, the recently approved (Dec 2018) "recast" of the Renewable Energy Directive (2010/2001, also called "RED II") will come into force. RED II is similar to RED I in many aspects, in particular the mechanisms whereby volumes of biofuels used in Member States are accounted for on an energy basis, and reported against a set target (14%) for renewables in transport. These targets are mandatory for Member States, which are expected to set an obligation on fuel distributors to ensure it is achieved and thus create a market for biofuels. On top of this, the Directive creates specific incentives for using advanced biofuels derived from non-edible feedstocks, waste, residues, etc. rather than conventional biofuels, derived from crops:

- Crop-based biofuels are capped and cannot represent more than 7% of the total biofuels used, or a level 1% higher than a MS's 2020 contribution for these biofuels, whichever is lowest;
- Biofuels considered as having "high iLUC" potential (i.e. triggering land-used change in other regions by diverting food/feed material from other sectors) will be capped at an MS's 2019 contribution level for these feedstocks. This level will be progressively phased out to 2030. This measure follows discussions started in 2018 at EU level suggesting a complete ban on palm biodiesel. A recent Delegated Act from the European Commission (2019a) makes palm oil part of the "high iLUC" feedstock category, which will be phased over the RED II implementation period. Meanwhile, France and Norway have adopted legal amendments excluding palm oil from the list of eligible feedstocks for biodiesel (Assemblée Nationale, 2018; Stortinget, 2018). Such ban, if replicated in several member states, may redirect a significant amount of biodiesel production towards other feedstocks, such as UCO;
- Biofuels from waste and residue feedstocks count double towards the renewable energy in transport target;
- Biofuels derived from waste and residue feedstock other than UCO and AF have a specific and increasing sub-target, which reaches 3.5% of total fuels used in transport by 2030;
- UCO and AF are capped at 1.7% in RED II but "Member States may, where justified, modify that limit, taking into account the availability of feedstock. Any such modification shall be subject to approval by the Commission" (RED II Art 27 para 1.b).

Figure 2 compares the composition of the expected 14% renewable in transport as of 2030, following the implementation of RED II. Land-use criteria in RED II are comparable to those in RED, but the minimum greenhouse gas (GHG) savings are raised to 50-70%, depending on the year biofuel production plants were first in operation.

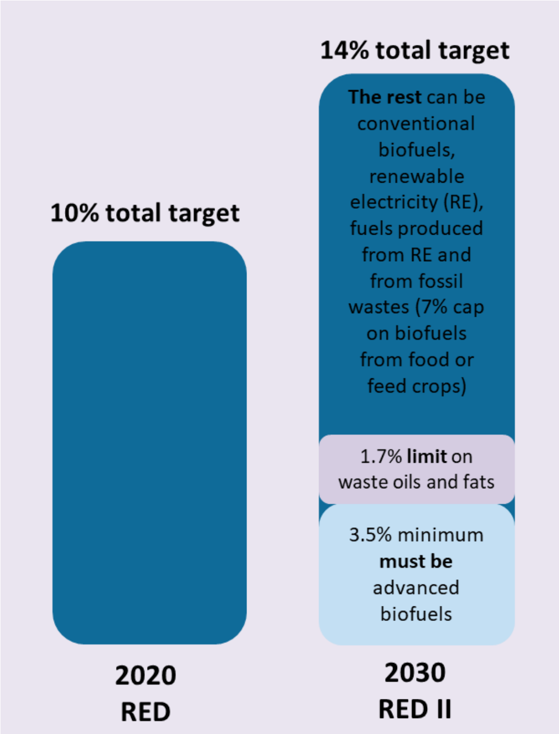

Figure 2: Comparative targets in RED and RED II

2.2.2 Current and future policies in selected countries

This section provides an overview of policy mechanisms currently in place in a selection of EU Member States (UK, The Netherlands, Germany, Spain and Finland) and Norway. These countries were selected in consultation with EWABA based on the relevance of their existing biofuel policies, current and future patterns of biofuel production/consumption and the presence of EWABA members. The current policy mechanisms are used to assess how the aviation multiplier could be implemented and use them to calculate the potential renewable fuel premium presented in Section 2.2.3.

United Kingdom

The Renewable Transport Fuel Obligation (RTFO)[1] is one of the UK government's main policies for reducing GHG emissions from transport. The RTFO obliges fuel suppliers to supply a minimum percentage of renewable fuel to the market. It is a traded mandate system, with the option to buy-out. The obligation on each supplier is a percentage of their total volume of fuel supplied for road transport (Department for Transport, 2018). The obligation is currently set at 8.5% for 2019, rising annually to 12.4% for 2032.

The obligation covers suppliers of road and non-road mobile machinery (NRMM) fuel supplying petrol, diesel, gas oil or renewable fuel totalling 450,000 litres or more in a year. The UK is one of the few countries where renewable fuel used in aviation is already eligible for reward (introduced in 2018), although fossil aviation fuel is not obligated.

[1] RTFO https://www.gov.uk/guidance/renewable-transport-fuels-obligation

Qualifying biofuels must meet sustainability criteria, including minimum GHG savings, which are based on EU RED sustainability criteria. One Renewable Transport Fuel Certificate (RTFC) may be claimed for every litre of sustainable renewable fuel supplied (or per kg for gaseous fuels). There is differentiation between different types of fuels:

- Crop-based biofuels are limited to 4% by volume in 2018 decreasing to 2% in 2032.
- Fuel from wastes or residues and Renewable Fuels of Non-Biological Origin (RFNBOs) are incentivised by awarding two RTFCs per litre or per kilogram supplied (double counting). This includes fuels from UCO and AF.
- In January 2019, a sub-target for 'development fuels' was introduced, to encourage fuels which can be used in 'hard to decarbonise' applications, such as aviation. These fuels generate dRTFCs. The technologies to produce these fuels are at an earlier stage of commercial development and are more expensive than other fuels. This target starts at 0.05% by volume in 2019 and rises to 1.4% in 2032. However, Annex IX Part B feedstocks are specifically excluded from being classed as development fuels.

The renewable fuel buy-out prices are currently set as £0.3 per RTFC and GBP 0.8 per development fuel RTFC (which are currently not traded). RTFCs are currently traded at GBP 0.13 and this value has been used in the WTP calculations (Census Energy, 2019). If the aviation multiplier was introduced in the UK then distributors of bio-jet fuels would receive 1.2 RTFCs for single-counted HEFA and 2.4 RTFCs for double-counted HEFA (i.e. derived from Annex IX Part B feedstocks).

Germany

The first biofuel mandate in Germany was introduced in 2009. This mandate applied to the rail and road transport sectors setting a 6.25% target energy consumption from biofuels and allowing for double-counting. The mandate lasted until 2015 when the obligation on biofuels was changed from energy to GHG emissions basis. In 2015, a new 2025 target was set to reduce the GHG emissions from the transport sector by 6% compared to a 100% fossil-fuel level[2]. Whilst double counting is still used for National reporting to the European Commission the new regulation eliminated the use of double counting as a pricing mechanism.

As a result of recent European policy developments, in 2017 Germany introduced an advanced biofuel mandate for fuel suppliers producing more than 20 PJ per annum. This mandate transposes the EU ILUC Directive and categorizes biofuels into two groups:

- Conventional biofuels: made from cereal and high-starch crops, sugar crops, oil crops and energy crops on agricultural land, plus fuels from UCO (fuels derived from animal fats are excluded from counting towards an obligated supplier's quota);
- Advanced fuels: made from a specific list of raw materials, similar to the feedstocks listed in Annex IX Part A of the RED. This includes Renewable Fuels of Non-Biological Origin (RFNBO), fuels produced using captured CO_2 and renewable energy sources and fuels produced using bacteria.

The 2017 regulation establishes a 6.5% cap on energy from conventional biofuels and set a growing trajectory for advanced biofuels. These are required to cover 0.05% of road and rail energy use in 2020

[2] BImSchG https://www.gesetze-im-internet.de/bimschg/BJNR007210974.html (article 37)

and 0.5% in 2025. Biofuels produced from used cooking oil are considered as conventional biofuels under current German legislation.

Since 2015, penalties for non-compliance are EUR 470 per tonne of CO_2 equivalent above the limit. However, biofuels producers generate GHG saving certificates that can be traded, allowing obligated suppliers flexibility in how they meet their quota targets. As of August 2018, the traded price for CO_2 savings under the policy was EUR 160 per tonne of CO_2 equivalent[3].

To calculate a renewable fuel premium (Section 2.2.3), we considered a slightly higher GHG intensity for HEFA (+3.5gCO_2/MJ), compared to HVO. This number was calculated on the basis of extra amounts of hydrogen required for the isomerisation of HEFA, based on Pearlson et al. (2013), combined with the GREET emission factor for hydrogen produced out of Steam Methane Reforming.

The Netherlands

The first biofuel mandate in the Netherlands was introduced in 2007. This was an obligation on fuel suppliers to supply at least 4% of their fuel, on an energy basis, from biomass by 2010. In 2011 the mandate was raised to 4.25% with the aim of reaching 10% by 2020[4]. As a consequence of the ILUC Directive, in 2018, the Dutch government updated national obligations on biofuels. The new mandate for the transport sector aims to achieve 16.4% of the energy use from biofuels by 2020, with double counting being implemented. A sub-target is applied to advanced biofuels starting at 0.6% in 2018 and rising to 1% in 2020. Advanced biofuels are defined as those produced from feedstocks listed in Annex IX Part A of the RED. Other biofuels fall under two categories; (i) conventional biofuels produced from agricultural and energy crops and (ii) 'other' biofuels produced from feedstocks listed in Annex IX Part BIX Part B of the RED. Production of biofuels generates tradable renewable fuel units, HBEs (Hernieuwbare Brandstof Eenheden), which allow suppliers to demonstrate that they have met their biofuel obligations. HBEs are divided into three types depending on the feedstock that has been used to produce the biofuel (e.g. HBE Advanced for Annex IX Part A feedstocks)[5]. One HBE represents 1 gigajoule of renewable energy that has been delivered to the transport market.

Alongside these targets, the recent regulation imposes a limit on conventional biofuels starting at 3% and reaching a limit of 5% by 2020. The obligation applies to road and rail transport. Fuels for the aviation sector are not currently obligated, but aviation fuel suppliers can opt-in and benefit from the biofuel certificate trading scheme. The fuels considered in this study are produced from waste oils and fats and are considered as 'other' biofuels under the Netherlands policy and benefit from double counting[6]. If the aviation multiplier were introduced in the Netherlands, then distributors of bio-jet fuels would receive 1.2 HBE certificates for single-counted HEFA and 2.4 certificates for double-counted HEFA.

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[3] https://www.argusmedia.com/en/news/1734517-german-biofuel-ticket-market-to-get-a-boost

[4] https://www.emissieautoriteit.nl/onderwerpen/algemeen-ev-2018/ontwikkelingen-ev-2018

[5] https://www.emissionsauthority.nl/topics/general---energy-for-transport/renewable-energy-units

[6] https://www.emissionsauthority.nl/topics/claiming-deliveries---energy-for-transport/feedstocks-and-double-counting

Spain

Spain implements its obligations regarding renewable energy in transport via a biofuel quota system, which will run until 2020 (Gobierno de España, 2008). This obliges fuel distributors to incorporate an increasing percentage of biofuels (by energy content) in the annual mix of fossil fuels delivered. The following table shows the objectives of biofuel incorporation as per the Royal Decree 1085/2015 (Ministerio de Industria, Energía y Turismo, 2015a). The objectives are no longer differentiated between biodiesel and bioethanol, as was done previously. Aviation biofuels are not included in the quotas and, according to personal communication, fuel retailers are not allowed to opt in to account for aviation biofuels on a voluntary basis.

Table 1: Mandatory biofuel blending targets for fuel distributors (Source: RD 1085/2015)

	2017	2018	2019	2020
Minimum biofuel percentage	5 %	6 %	7 %	8,5 %

Compliance is verified through the issuance of certificates by the National Commission for Competitions and Markets (CNMC), with one certificate for each tonne oil equivalent produced. As confirmed by the Circular 1/2019 (Comisión Nacional de los Mercados y la Competencia, 2019), fuel distributors selling double-counted biofuels receive two certificates.

If a similar mechanism was to be implemented for RED II, and aviation biofuels included, distributors of bio-jet fuels would receive 1.2 certificates for single-counted HEFA and 2.4 certificates for double-counted HEFA. Each year, fuel retailers must demonstrate that they have collected a number of certificates corresponding to their biofuel obligations. Fuel retailers who fail to achieve their respective objectives must pay a penalty of EUR 763 per certificate (Ministerio de Industria, Energía y Turismo, 2015b). The CNMC redistributes the penalties collected from underperforming companies to the companies which have exceeded their obligations. Certificate holders may also trade certificates directly with other companies. Biofuel certificates generally trade (Table 2) at between 330 and 600 EUR, which is significantly less expensive than the penalty that would be applied by the CNMC if biofuel targets are not achieved.

Table 2: Biofuel certificate transfers and prices over the past 8 months (Source: CNMC[7])

Year	Month	No transferred Biodiesel Certificates	Indiv. certificate price (EUR/toe)
2018	July	2,000	635
2018	August	50	580
2018	September	933	495
2018	October	1,697	333
2018	November	2,600	389
2018	December	1,300	475
2019	January	3,921	497
2019	February	1,375	352
Average certificate price (in EUR/toe)			470
Average certificate price (in EUR/tonne fuel)			FAME: 423 HVO/HEFA: 494

[7] https://www.cnmc.es/estadistica/estadistica-de-biocarburantes

Certificate prices fluctuated considerably over the past 8 months and trade significantly below the buy-out price (penalty). To calculate a renewable fuel premium for Spain, an 8-month average was used as the basis for single-counted premium and combined with x2 or a x2.4 multiplier.

Spain started implementing a double-counting mechanism for advanced feedstocks, including UCO and animal fats in 2018, following Royal Decree 235/2018 (Ministerio de Industria, Energía y Turismo, 2018). Biofuels based on food crops are capped at 7%, which is also the total biofuel target in 2019. Therefore, the annual biofuel target will exceed the 7% conventional biofuel cap from 2019 onwards (See Table 1), which could incentivise the use of double-counted feedstock.

Personal communications from aviation experts in Spain reveal that the country is considering setting a specific obligation for sustainable aviation fuels, jointly with the implementation of RED II, which could constitute an additional driver for the increase of bio-jet consumption.

Finland

Finland has a blending obligation for road fuels that applies to fuel distributors[8]. The level of blending increases progressively to reach 20% by 2020. A double-counting mechanism is in place until 2020 for biofuels derived from waste and residues, along with a sub-target of 0.5% for feedstocks on Annex IX A (i.e. the sub-target does not apply to UCO and animal fats), which will increase to 10% in 2030. The list of eligible feedstocks for double counting is based on Annex IX of the iLUC Directive (EU 2015/1513), including used cooking oil and animal fats. No provision has been made to further implement double counting after 2020. Crop-based biofuels can only fulfil 7% of the obligation. A penalty (EUR 0.04/MJ) is applied to fuel distributors who fail to meet their obligation. Certificates of compliance can be traded between companies exceeding targets and those who fail meeting targets. Details of certificate prices could not be found in the public domain but are expected to be lower than the above buy-outs.

In addition to the biofuel mandates described above, taxes are levied on every energy source based on its energy content, CO_2 emissions and supply security (stockpile). All transport fuels (fossil and bio-based) are covered by this tax, except for aviation fuels.

Biofuels are treated differently from fossil fuels, based on their energy content and CO_2 emissions. Biodiesel derived from RED-compliant double counted feedstock (incl. UCO and tallow) benefits from a larger tax reduction than conventional biodiesel, as illustrated in Table 3.The tax reduction is not doubled for fuel from double counted feedstocks. Paraffinic biodiesel (e.g. HVO or HEFA) benefits from a lower energy content tax than non-paraffinic biodiesel (e.g. FAME).

[8] http://www.res-legal.eu/search-by-country/finland/single/s/res-t/t/promotion/aid/biofuel-quota-distribution-obligation-system/lastp/127/

Table 3: Fuel tax regime (excise duty) in Finland as of January 2019 (in euro cents/L)[9]

Product	Product category	Energy content tax	CO_2 tax	Strategic stock fee	Total
Biodiesel oil (non EU RED compliant)	52	30.04	18.24	0.35	48.63
Biodiesel oil R (EU RED compliant)	53	30.04	9.12	0.35	39.51
Biodiesel oil T (EU RED compliant + double count.)	54	30.04	0.00	0.35	30.39
Paraffinic Biodiesel oil (all cat.)	55, 56, 57	25.95	Same as above	Same as above	26.30 – 45.09
Diesel oil	50	32.77	19.90	0.35	53.02

Aviation fuels used for commercial purposes are exempt from excise duty, including both kerosene and HEFA.

Certificates are also expected to be traded at values significantly higher than the tax breaks that are also used to incentivise the use of biofuels. Without access to traded certificate values it has not been possible to calculate a reliable policy premium for Finland.

Norway

As part of the European Economic Area (EEA) Agreement, Norway implements the EU Renewable Directives, including renewable energy inclusion targets and sustainability criteria for biofuels. Regulation 1122 from 2013 (Norwegian Government, 2013) further defines biofuel targets and implementation modalities as follows:

- The objective for renewable energy in transport is set at 10% in Norway's Renewable Energy Action Plan, but Regulation 1122 requires fuel distributors to ensure 20% of fuels in transport are biofuels.
- Waste and residues (similar list as in the EU iLUC Directive 2015/1513) are double counted
- A sub-target is set for advanced biofuels, which increases to 4% in 2020.
- The same sustainability criteria (land-use and greenhouse gas) apply as in the RED.

Biodiesel is taxed at a lower level than diesel, as described below. No distinction is made between FAME and HVO.

Road tax: Diesel is taxed between 3.81 and 3.87 NOK/L, i.e. 0.4 EUR/L. Biodiesel is taxed at 3.81 NOK/L.

CO_2 *excise tax:* Diesel pays an extra 1.35 NOK/L tax on CO_2, i.e. 0.14 EUR/L. Biodiesel is exempt from the CO_2 tax

[9] https://www.vero.fi/en/businesses-and-corporations/about-corporate-taxes/excise_taxes/valmisteverolajit/nestemaiset_polttoaineet/nestem%C3%A4isten-polttoaineiden-verotaulukko/

Sulphur tax: An additional tax is levied on mineral oil with sulphur content of 0.05% (by weight) and above. Since EURO 4 standards and the following emission standards require sulphur content in diesel to remain at 50 ppm and below, it is assumed that no diesel used in Norway must pay the sulphur tax.

Table 4: Fuel tax regime (excise duty) in Norway as of January 2019[10] (in euro/L)

Product	Road tax	CO_2 tax	Sulphur tax	Total
Diesel	0.4	0.14	0	0.54
FAME/HVO (EU RED compliant)	0.4	0	0	0.4
Aviation fuel (incl. HEFA)	0	0	0	0

Aviation fuels are tax exempt. In 2018, Norway set a specific target for advanced bio-jet fuels, which should represent 0.5% of jet fuels in 2020[11]. The objective is to ensure that 30% of jet fuels are derived from RED-compliant biomass by 2030. Palm-derived fuels cannot be used. Among all possible technology pathways to produce bio-jet fuels, a study on the Nordic region considers that Fischer-Tropsch and Alcohol-to-Jet production based on domestic forest biomass are seen as the most viable options for Norway (Ramboll, 2013). HEFA is not considered such an attractive option due to the limited availability of domestic oil and fat feedstock, compared to the abundance of wood and sugar-based feedstock. However, there is no differentiation between fuel types within the policy mechanism[12].

Based on trading data provided by one supplier, the potential biofuel premium for double counted HVO is ~850 EUR/tonne. However, this far exceeds the potential tax incentives laid down by Norwegian policy, which would equate to 179 EUR/tonne for HVO. It is possible that biofuels in Norway are priced off neighbouring markets rather than internal incentive mechanisms. Without access to more trading data for each of the biofuels of interest it has not been possible to calculate WTP values for the Norwegian market.

2.2.3 Indicative renewable fuel premiums

This section uses the current policy mechanisms in the selected countries to anticipate how much future renewable fuel premiums could be worth in each country for FAME, HVO and HEFA. In general, the calculated premiums assume that the full value of double counting is passed back from the obligated supplier to the biofuel producer. In practice, this is often not the case, with the obligated fuel supplier capturing some of the value of certificates, particularly if the market for fuel is long. Given that in most countries, all these fuels count towards the same target, they are all in the same market. In theory the obligated supplier's willingness to pass back the premium should be equivalent for all fuel types, and so should not differentially affect the premiums below. However, given that the price is a matter of negotiation between obligated fuel supplier and biofuels producer, it may be that there

[10] https://www.skatteetaten.no/en/business-and-organisation/vat-and-duties/excise-duties/about-the-excise-duties/road-tax-on-fuel/

[11] https://www.regjeringen.no/en/aktuelt/mer-avansert-biodrivstoff-i-luftfarten/id2643700/

[12] Requirements for the sale of advanced biofuels for aviation https://translate.google.com/translate?sl=no&tl=en&u=https%3A%2F%2Flovdata.no%2Fdokument%2FLTI%2Fforskrift%2F2019-04-30-555

are cases when the obligated fuel supplier is prepared to pass on a higher proportion of the premium to HVO or HEFA suppliers in order to secure supplies for particular customers.

Table 5: Estimates of renewable fuel premiums in selected countries

Country	Fuel type (assuming UCO/ tallow)	Policy category	Maximum renewable fuel premium (EUR/t)
United Kingdom	FAME	Double counted RTFC	343
	HVO	Double counted RTFC	387
	HEFA	Double counted RTFC (potential future 1.2 multiplier)	483
	HEFA+	Double counted RTFC (potential future 1.2 multiplier)	483
Germany	FAME	CO_2 savings certificate	505
	HVO	CO_2 savings certificate	578
	HEFA	CO_2 savings certificate (incl. 1.2 multiplier)	694
	HEFA+	CO_2 savings certificate (incl. 1.2 multiplier)	694
The Netherlands	FAME	Double counted HBE Other	663
	HVO	Double counted HBE Other	765
	HEFA	Double counted HBE Other	922
	HEFA+	Double counted HBE Other	918
Spain	FAME	Double counted certificate	855
	HVO	Double counted certificate	988
	HEFA	Double counted certificate (+ potential future 1.2 multiplier)	1185
	HEFA+	Double counted certificate (+ potential future 1.2 multiplier)	1185

2.3 Fossil fuel prices

Biofuels are priced off their respective fossil fuel comparator, in this case diesel for FAME and HVO and kerosene for HEFA and HEFA+. The diesel and kerosene commodity prices used in the study were 494

EUR/tonne and 524 EUR/tonne respectively (OPIS, 2019). These fossil fuel prices were held constant in the willingness to pay calculations.

2.4 Results: willingness to pay for feedstock prices

The total willingness to pay for feedstock for each biofuel producer type was calculated as follows:

WTP =	Revenue (fossil fuel price + policy premium)	-	Conversion costs

The difference in willingness to pay for feedstock between HVO, HEFA, HEFA+ and FAME is shown below using three different FAME conversion cost scenarios covering medium, low and high conversion costs (135 EUR/tonne, 90 EUR/tonne and 400 EUR/tonne). These scenarios were chosen to represent the range of conversion costs exhibited by EWABA members without compromising member confidentiality.

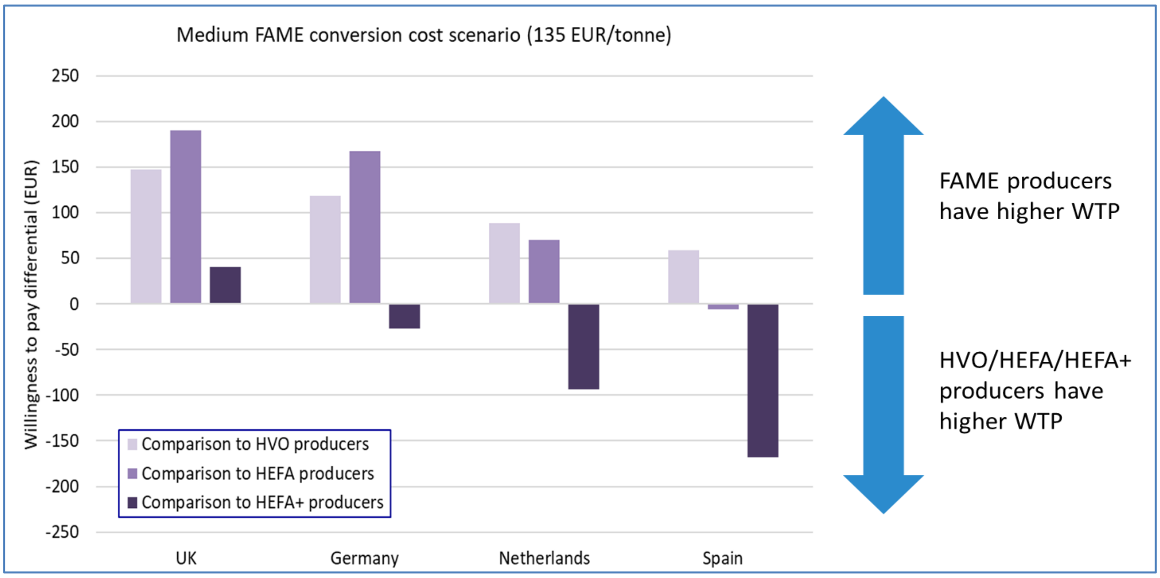

Figure 3: Difference in willingness to pay for feedstock between FAME producers and HVO, HEFA and HEFA+ producers with a 135 EUR/tonne FAME conversion cost.

In the medium FAME conversion cost scenario (Figure 3), FAME producers have a higher ability to pay for feedstock than HVO and HEFA (even when including the 1.2x multiplier) in all the countries. The exception to this is in Spain where the policy premium would allow HEFA production to gain price parity with FAME for feedstock. In contrast HEFA+ production achieved a higher ability to pay for feedstock than FAME in Germany, the Netherlands and Spain. In these calculations the only differences between HVO and HEFA+ are the fossil fuel they have been priced against (diesel or jet fuel) and the 1.2x aviation multiplier. The difference in fossil price between diesel and jet fuel is only 30 EUR/tonne indicating that most of the difference seen in willingness to pay between HVO and HEFA+ is due to the 1.2x multiplier. The multiplier would therefore lead to a WTP difference between HEFA+ and HVO of 107, 145, 183 and 227 EUR/tonne in the UK, Germany, Netherlands and Spain respectively.

A similar trend is seen in the low, 90 EUR/tonne FAME conversion cost scenario (Figure 4). However, the ability for FAME to pay more for feedstock is increased by 45 EUR/tonne compared to the medium scenario. This shift also led to FAME achieving an advantage over HEFA+ for feedstock in the German market.

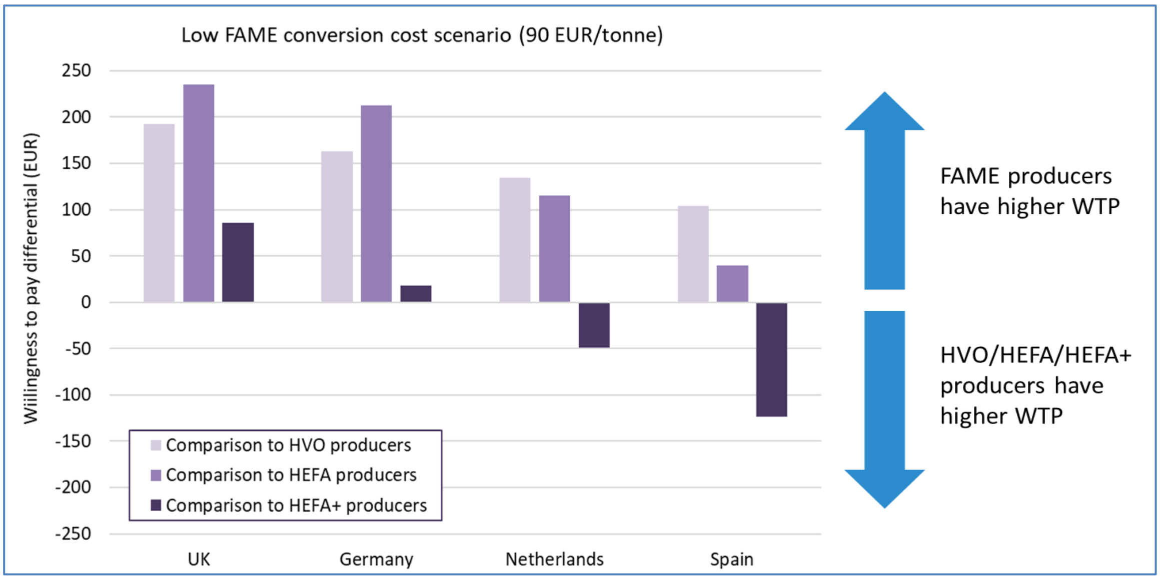

Figure 4: Difference in willingness to pay for feedstock between FAME producers and HVO, HEFA and HEFA+ producers with a 90 EUR/tonne FAME conversion cost.

The final scenario shows the impact of a higher FAME conversion cost (400 EUR/tonne), which reflects actual conversion costs for a small number of EWABA members (Figure 5). These producers currently compete by using the lowest quality, and therefore cheapest, waste FOGs to offset high production costs. In general, hydroprocessing can tolerate FOG feedstocks with higher free fatty acid content than transesterification, which means FAME producers with conventional technology have less interest in low quality FOGs than HVO producer. However, it is expected that advanced biodiesel production technologies (e.g., various esterification processes, glycerolysis, etc.) will be able to accommodate a wider range of FFA and impurities than HVO/HEFA processes. Additional research would be required to determine which FOG feedstock advanced FAME producers would be able to process, compared to HVO producers. For the purpose of the cost calculations conducted in this study, it was assumed that HVO/HEFA producers can use these low-quality FOGs without significant increases to their production costs. In turn, the increased conversion cost for conventional FAME producers has a significant negative impact on their ability to pay for feedstock compared to other biofuels.

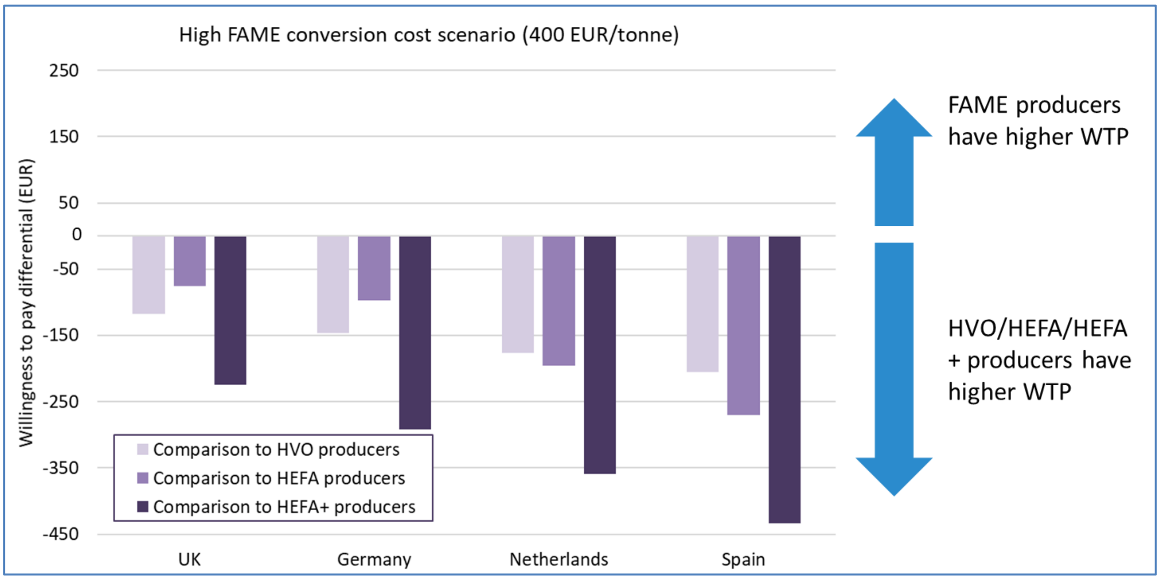

Figure 5: Difference in willingness to pay for feedstock between FAME producers and HVO, HEFA and HEFA+ producers with a 400 EUR/tonne FAME conversion cost.

Overall the FAME producers that provided data for this study had a wide range of conversion costs which influences the risk they face from feedstock price competition with other biofuel producers. There is a significant risk to those producers with the highest conversion costs of being out competed for feedstock by HVO, HEFA+ and HEFA producers. In the medium and low conversion cost scenarios FAME producers could outcompete HEFA producers for feedstock even with the introduction of a 1.2x aviation multiplier (except in Spain in the medium cost scenario). However, if HEFA+ is certified for use as an aviation fuel its lower production cost, along with the 1.2x multiplier means it poses a significant feedstock supply risk to medium cost FAME producers. It could even put pressure on low cost FAME producers, depending on the markets into which they are able to sell their products.

3 Task 2 – Factors affecting risks to FAME feedstocks

Task 1 showed that there are several cases where HEFA+ production could outcompete FAME producers for feedstock, and some cases where this would also be the case for HEFA producers. However, the extent to which this might happen in practice, and the timescale over which this might happen, will also depend on a range of other factors, considered in this section.

Several factors increase the risk to FAME producers:

- Certification of HEFA+
- Implementation of Annex IX Part B cap
- Palm oil bans
- Additional policy or commercial drivers for aviation biofuels
- Growing HVO capacity in Europe

We also consider factors that reduce the risk, or have little expected effect:

- Speed and variability of policy changes
- Tariffs on feedstocks and fuels

3.1 Certification of HEFA+

As described in Task 1, the gap in production costs between FAME and HEFA remains large enough to keep FAME ahead of HEFA in terms of feedstock price competitiveness, except when higher FAME processing costs are anticipated or in specific countries like Spain. The situation regarding HEFA+ is different, as it could be at par with FAME in terms of production costs or even cheaper in a wider number of situations (See Section 2.1). Therefore, ASTM Certification of HEFA+ (also referred to as HFP[13]-HEFA or Green Diesel) potentially represents an important game changer.

Figure 6 provides an overview of the ASTM certification process for jet fuels, as well as the status of candidate alternative fuels as of December 2018. HFP-HEFA can be seen between Phase 1 and Phase 2, currently undergoing OEM review and Tier 3&4 requirements.

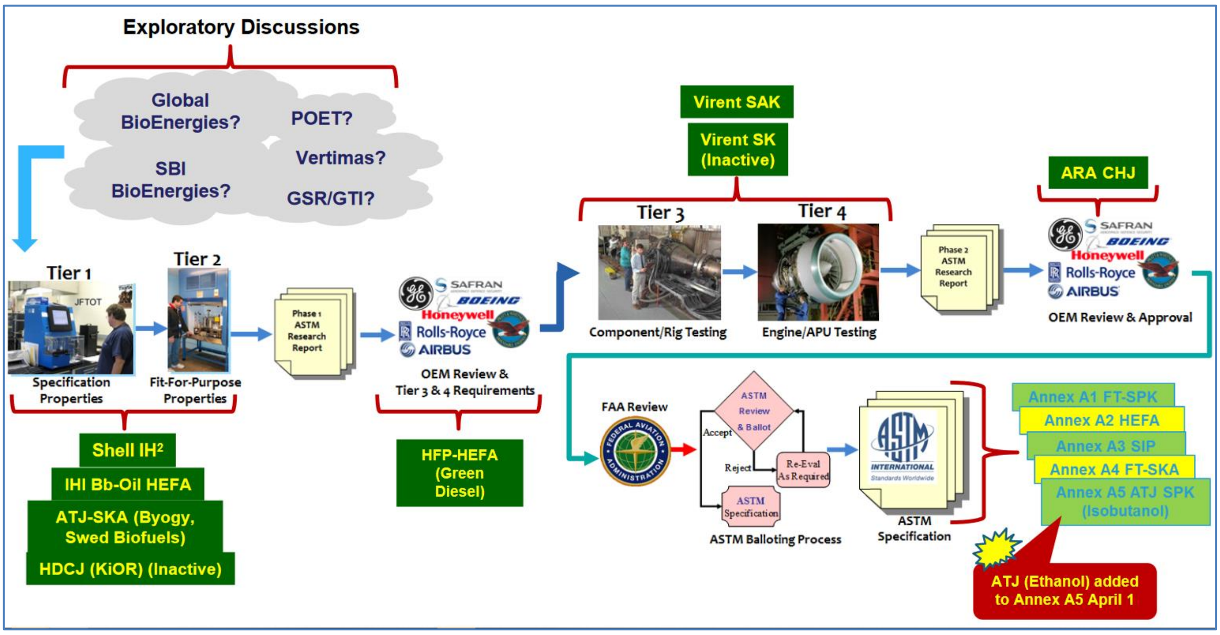

Figure 6: Overview of the ASTM certification process and HFP-HEFA status as of 12/2018 (Source: CAAFI, 2018)

Personal communications with aviation experts indicate that HFP-HEFA has not advanced further over the past few months. This means that a number of important steps are yet to be completed, including Tier 4 and Tier 4 testing requirements (component and engine testing), which may potentially take several years. This is likely to be followed by a fairly lengthy administrative process culminating with the ASTM decision to accept or reject the proposal to add HEFA + as an annex. The aviation sector's interest in HEFA+ has decreased, following the fast-tracking of co-processing through the ASTM process. It should be noted that co-processed A1 jet may also compete with FAME producers for similar feedstock and therefore constitute a potential threat. It is however unclear whether the use of co-processing could be limited by the 5% blend wall imposed on A1 Jet, which would *de facto* apply to all refinery co-products, including road diesel. This aspect was not investigated in this study.

[13] HFP = High Freezing Point

Personal communication indicates that the earliest for remaining steps of HEFA+ certification to be completed would be around the middle of year 2020, although there is no guarantee that the process will eventually be completed. Should this forecast prove realistic, HEFA + would not be commercially available for use in aviation before the end of 2020, beginning of 2021. As mentioned in Section 2.1, HEFA+ production will require an extra fractionation step, which would increase HEFA + production costs.

To show the order of magnitude of this demand, note that the EU demand for aviation fuel in 2017, including domestic and international flights, was 57Mtoe[14]. If HEFA+ were certified at 15% blend, the maximum demand for biofuels in aviation would be 8.6Mtoe.

3.2 Annex IX Part B cap

A specific cap was added to RED II, which limits the contribution of biodiesel derived from Annex IX Part B feedstocks, namely UCO and animal fats, to 1.7% of the total renewable energy consumption in transport. However, RED II also mentions that this cap may be raised by member states upon approval by the European Commission, taking feedstock availability into account. Personal communications indicate that several member states are already in the process of applying for an increase of the cap. As mentioned in the above sections, large amounts of unrecovered UCO exist, as per Informa report. Potentially available amounts would largely exceed demand, but would require significant investments from public authorities and a deep change in behaviour from citizens of member states.

In the case of a strict application of the 1.7% cap, the risk for FAME producers would be that all 1.7% were achieved with HVO, therefore leaving no market for UCOME or TME at all. As an example, 1.7% of the 2017 road and rail transport demand (the RED denominator) is equivalent to 5.3Mtoe, which is considerably smaller than the HVO/HEFA/HEFA+ capacity projected in section 3.5.

As an alternative, a higher share of Annex IX Part A feedstocks could be used by FAME producers, but a risk exists that Annex IX Part A feedstocks would be more limited in quantity (e.g. tall oil pitch) or involve higher feedstock / processing costs (e.g. algae, sewage sludge). A general increase in the Annex IX Part B cap by Member States would automatically drive larger amounts of UCO and animal fats towards FAME, HVO/HEFA+ or HEFA, which could potentially drive feedstock prices up.

3.3 Palm oil bans

Palm oil remains one of the most widely used feedstocks (either as crude palm oil or as palm fatty acid distillates) in certain EU countries like Spain or France. It is also the main feedstock used in Neste's Singapore plant, which produce renewable diesel destined to the European Union. As mentioned in previous sections, however, the phasing out of "high iLUC feedstocks" in EU RED II or strict ban on palm oil use for biodiesel production as in France may significantly impact feedstock patterns in these countries. It is currently unclear whether the phasing out or bans will concern crude palm oil only, or all palm oil derivatives, incl. PFADs and POME. In the latter case, biodiesel feedstock demand will be redirected onto other biodiesel feedstocks such as UCO and animal fats, thus adding to the price

[14] 2017 data from EU Commission Energy Datasheets April 2019 https://ec.europa.eu/energy/en/data/energy-statistical-pocketbook

pressure. It should also be noted that FAME producers may only opt for a narrow range of alternative FOG feedstocks. This is due to the fact pre-processing and processing setups, as well as the properties of biodiesel (e.g. cloud point) depend on the composition of feedstocks, i.e. fatty acid contents and impurities. HVO production processes are less sensitive to the feedstock composition and may therefore more easily shift towards other feedstocks, should palm and derivatives be banned.

3.4 Additional policy or commercial drivers for aviation biofuels

Other factors that could lead to demand even without the policy changes above are:

- Introduction of aviation biofuels mandates in individual Member States. For example:
  - The Norwegian mandate of 0.5% in 2020. The objective is to reach 30% of RED-compliant aviation biofuels by 2030[15].
  - The proposed Swedish mandate of 1% in 2021. For reference, 1% of the current Swedish jet fuel demand is 0.011 Mtoe[16].
- Individual airlines willingness to pay more than the fossil jet fuel price plus any policy support premium for aviation biofuels. Although there are cases of this in operation today, in E4tech's experience of working with the aviation sector this is likely to be very limited, for example for test flights or corporate promotions, given that fuel is a major cost to airline operation
- An additional driver from the CORSIA mechanism. From our discussions with stakeholders from the aviation sector, and from reports on the topic[17], the current price gap between carbon offsets and sustainable aviation fuels is so large that CORSIA is unlikely to create a significant push for aviation biofuels, especially if countries do not agree on a biofuel sub-target, which is currently the case. Therefore, it is anticipated that airlines will largely stick to buying carbon offsets rather than sourcing biofuels, at least until 2030.

The demand ramp-up could be limited by airlines ability to work with fuel suppliers and airports to enable biofuel supply, for example through building new storage infrastructure.

3.5 Growing HVO capacity in Europe

The extent to which HEFA/HEFA+ producers will compete for feedstocks with EU FAME producers in the near term will depend strongly on the EU installed capacity for HEFA/HEFA+ and FAME production. As UCO and AF feedstocks are sourced globally, HEFA/HEFA+ production anywhere in the world could affect the price of these feedstocks. However, as competition will be strongest for feedstocks produced in the EU, or imported to the EU, we have focused on the capacity for HEFA/HEFA+ production in the EU. This section is largely based on the report from Informa Agribusiness Consulting (HVO Market Report), which was confidentially shared by EWABA. It should be noted that the Informa report also includes co-processing units in its inventory of current HVO plants, some of which may no longer be in operation.

[15] https://www.regjeringen.no/en/aktuelt/mer-avansert-biodrivstoff-i-luftfarten/id2643700/
[16] 2017 data from EU Commission Energy Datasheets April 2019 https://ec.europa.eu/energy/en/data/energy-statistical-pocketbook
[17] ICCT https://www.theicct.org/blog/staff/corsia-carbon-offsets-and-alternative-fuel

Additional sources are used as comparators, since estimates for future HVO production and installed capacity tend to vary across studies.

3.5.1 Production processes for HEFA and HEFA+

As explained above, HEFA+ and HVO are considered as outputs from similar hydrotreatment setups (unlike HEFA), and so plants selling HVO to the road market could also sell HEFA+ to the aviation market. HVO/HEFA+ can be produced in stand-alone plants or through co-processing at refineries.

HEFA can be produced at existing HVO plants, as in addition to HVO, hydrotreatment units also produce LPG, naphtha, propane and small amounts of HEFA. Alternatively, the production process can be adjusted to increase the share of HEFA over HVO, which entails an extended hydrocracking process at the isomerisation stage. To the best of our knowledge, this setup is not widespread in the EU (nor in the US) given the currently limited demand for HEFA, which is largely met by amounts produced as by-products from HVO production. In addition, HEFA volumes are lower when maximising HEFA outputs than HVO volumes when maximising HVO production, and other co-products (naphtha, propane and LPG) are produced in higher amounts. The extra hydrogenation steps required to produce more HEFA increase processing costs, compared to maximising HVO production.

3.5.2 Installed capacity

According to Informa, the European Union currently represents about half of the world HVO installed capacity (2.3 of 4.8 million tonnes). More than half of the current EU installed capacity belongs to Neste, which operates two HVO units: a 450,000 tonne plant in Finland and a 950,000 tonne plant in the Netherlands. Other HVO producers currently include ENI (455,000 tonne unit in Italy) and UPM (97,000 tonne unit in Finland). More developments are underway (incl. a new dedicated 100,000 tonne HEFA plant in the Netherlands[18]), leading to a significant increase expected beyond 2020, although estimates vary according to sources:

- Internal estimates from one EWABA member foresees a total EU installed capacity of 4.7 million tonnes of HVO by 2023;
- Informa anticipates a 7.2 million tonne installed capacity by 2028;
- In its internal estimates, Prima evaluates the current HVO capacity in the EU at only 2.05 million tonnes, to reach 2.8 million tonnes by 2023 and 4.1 million tonnes by 2028. Unlike Informa, Prima anticipates a large increase in the HVO installed capacity in the US until 2030 as well.

One of the reasons for these variations in installed capacity estimates are the individual plants' capacities. For example, while Informa estimates Neste's Finish and Dutch facilities at 450,000 and 950,000 tonnes, one EWABA member reports respective installed capacities of 606,000 and 1,091,000 tonne for these two units. It should also be noted that Informa takes into account some co-processing units whereas the EWABA member and Prima keep them apart.

Most sources nevertheless anticipate a significant decrease in the installed capacity for FAME through decommissioning. Informa expects the current FAME capacity to decrease from 18.7 million tonnes today down to 13.4 million tonnes in 2028 (Figure 7). Regardless of the specific figures, a clear transfer

[18] https://skynrg.com/press-releases/klm-skynrg-and-shv-energy-announce-project-first-european-plant-for-sustainable-aviation-fuel/

of biodiesel production and therefore feedstock demand is expected between the FAME and the HVO sectors, regardless of specific incentives for aviation. The remaining FAME producers will likely be able to increase the utilisation of their installed capacity and increase production efficiency, which should be beneficial in terms of production costs.

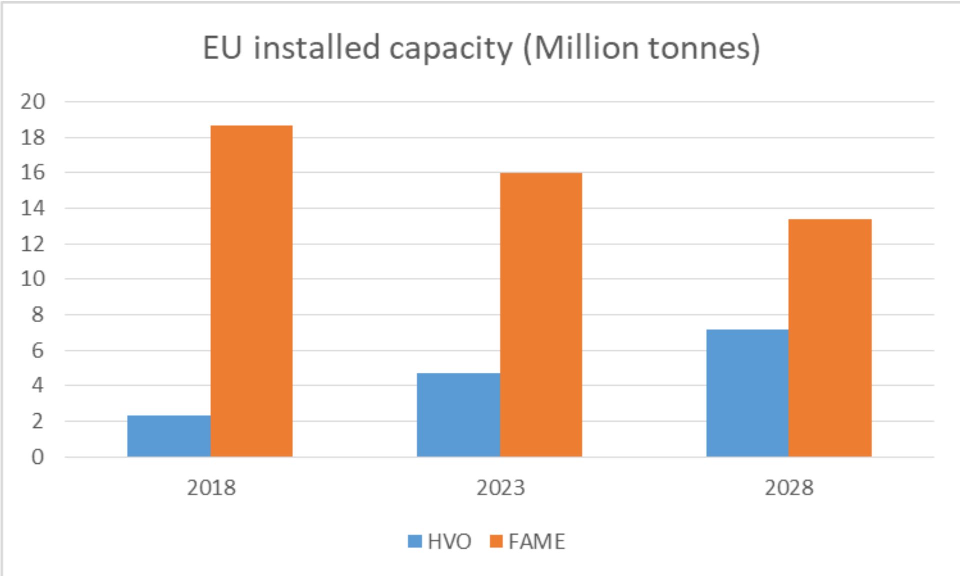

Figure 7: Current and future EU installed capacities for HVO and FAME (Source: Informa & EWABA Member)

3.5.3 Production

The European Union is currently the largest producer of FAME and HVO. The exact EU HVO production figures in 2018 are not precisely defined in the Informa report, as the estimate varies between different sections (2.3 vs 2.6 vs 2.9 million tonnes). Importantly, HVO production has been steadily increasing over the last 5 years (9% CAGR) while FAME production has plateaued (Table 6). Meanwhile, FAME imports have also increased substantially, following the removal of certain tariffs (see Section 3.6) at the expense of EU production (Figure 8).

Table 6: Current EU biodiesel balance sheet (in 1,000 tonnes)

	2014	2015	2016	2017	2018	2019[P]
Production	**12,934**	**13,005**	**13,160**	**14,233**	**13,522**	**14,918**
FAME	10,856	10,842	11,000	11,595	10,942	11,723
HVO	2,078	2,163	2,160	2,638	2,580	3,195
Imports	**708**	**653**	**810**	**1,605**	**3,768**	**1,640**
FAME	708	653	810	1,605	3,668	1,620
HVO	0	0	0	0	100	20
Exports	**217**	**206**	**460**	**669**	**855**	**482**
FAME	187	206	376	405	555	346
HVO	30	0	84	264	300	136
Use	**13,183**	**13,359**	**13,641**	**15,117**	**16,697**	**15,902**
FAME	11,377	11,288	11,434	12,795	14,054	12,997
HVO	1,806	2,071	2,207	2,322	2,643	2,905

Note: [P] – provisional estimates
Source: Informa Agribusiness Consulting

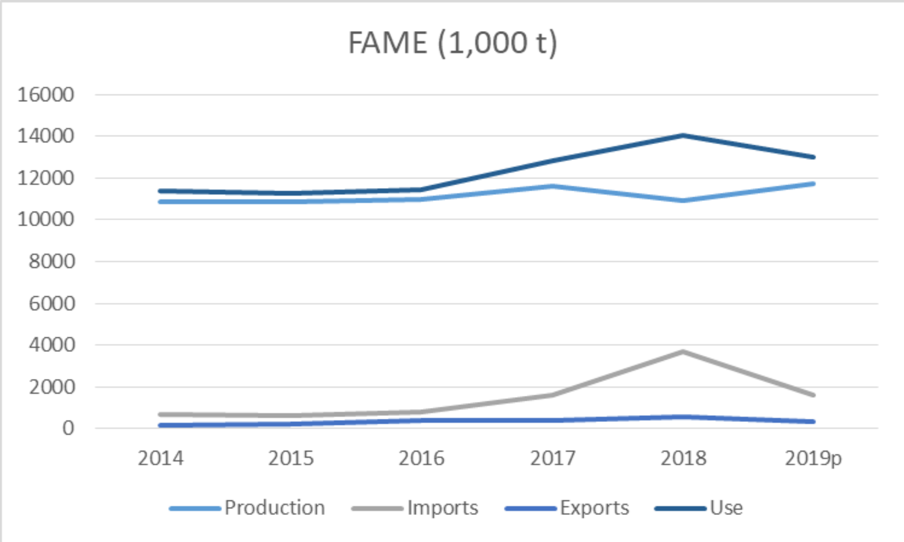

Figure 8: EU FAME balance sheet (Source: Informa Agribusiness Consulting)

Figure 9 shows that the use of HVO has increased steadily. Exports are expected to decrease in 2019 while EU production keeps increasing to respond to the increasing demand for HVO.

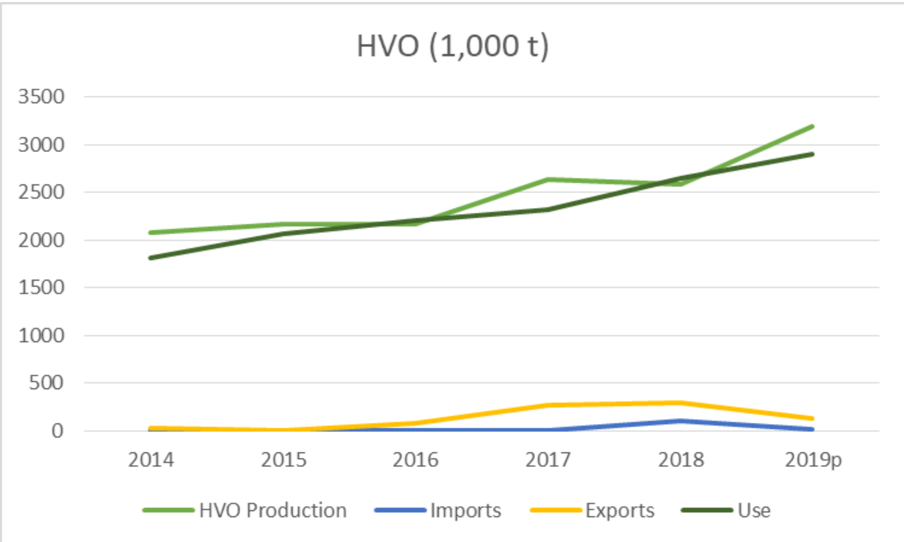

Figure 9: EU HVO balance sheet (Source: Informa Agribusiness Consulting)

As shown in Figure 10, the installed HVO capacity is utilised at a considerably higher rate than the FAME capacity (about 90% vs 60%) in the European Union. To meet its production forecast for 2028, Informa estimates that a significant share of the current FAME installed capacity will likely be taken out of operations while the HVO capacity is expected to significantly increase (+7.2 million tonnes). In the meantime, an important increase in imports (+4 million tonnes) is also expected to cope with the demand, but Informa does not specify the share of HVO in these imports.

2028 forecasts for direct imports of animal fats in Europe do not anticipate any significant increase. Similarly, no significant increases of UCO imports into the European Union is included in Informa's forecasts.

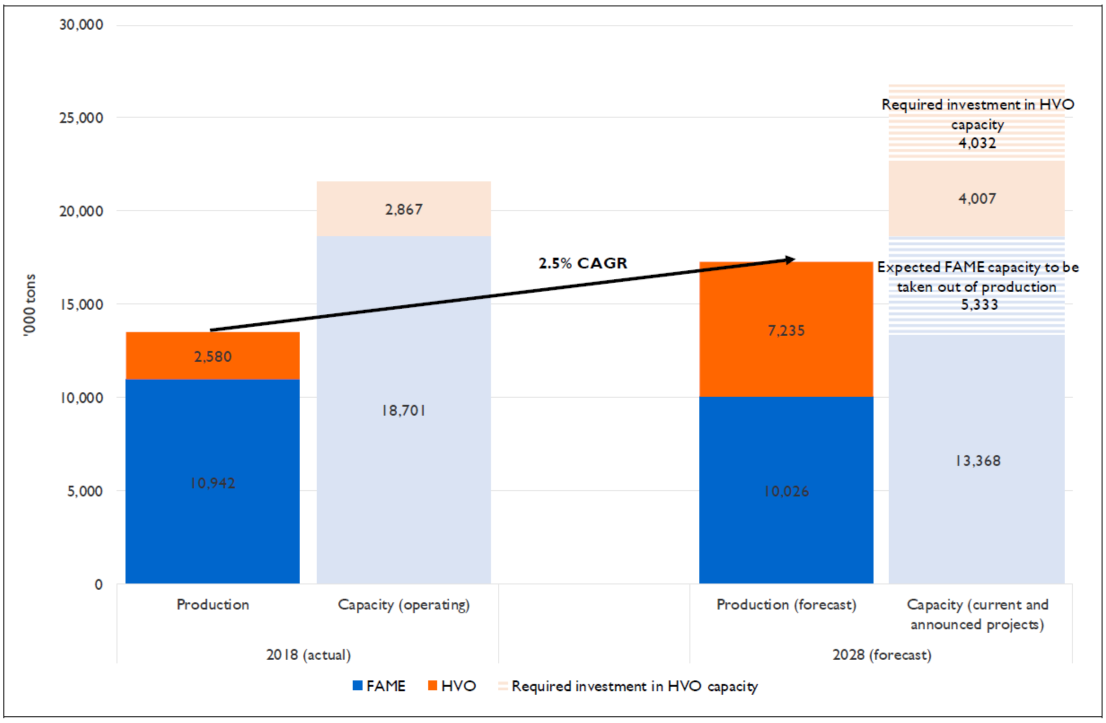

Figure 10: Current and future installed capacity and production of FAME and HVO in the European Union (Source: Informa)

3.5.4 Conclusions

A clear trend can be observed towards a significant increase in the installed capacity, production and use of HVO in the European Union. While the assumptions and modelling behind Informa's forecasts were not verified, the forecasts can be summarised as follows:

- HVO consumption in the European Union is expected to increase significantly to 2028;
- Most of the increased in HVO consumption is expected to be supplied by EU domestic HVO production, with an increased recovery and use of domestic UCO for biodiesel and a stable use of domestic animal fats;
- The gap between EU domestic production and consumption of HVO is expected to be fulfilled by imports, most likely from South America and Asia, but the share of HVO derived from animal fats or UCO (vs soy or palm) in these imports is unknown. Direct imports of animal fats or used cooking oil are not expected to increase significantly.

The scale of projected HVO/HEFA capacity in the EU is expected to increase significantly, contrarily to FAME capacity and production, which is expected to decrease. FAME producers are therefore at risk of being forced to scale down or decommission operations.

The capacity of biodiesel producers, and more specifically FAME producers, to source used cooking oil at competitive price will greatly depend on the EU capacity to increase the recovery of UCO across the continent. With potentially recoverable amounts of 6.7 million tonnes in 2028 and an actual use for biodiesel of 3.35 million tonnes, a surplus of UCO could exist, thus diminishing commercial pressure on UCO and other waste FOGs, even without any significant imports. A significant increase in the recovery of UCO will, however, require important investments and changes in consumers' behaviour in member states. Should such changes not be achieved, UCO and animal fats supply will not increase as fast as the demand, which, in absence of significant imports, will drive prices up. A price increase would not necessarily impact FAME producers harder than HVO/HEFA producers, except for FAME producers with higher processing costs, in which case HVO/HEFA producers would be able to sell to the aviation market, and capture a higher price premium and WTP for feedstock (See Section 2.1).

3.6 Speed and variability of policy changes

Accessing the economic incentives set out in Task 1 relies on Member States including aviation biofuels within their support policies, which is currently done in the UK and the Netherlands. An aviation biofuel obligation has been announced by Norway and the Swedish Government suggested a similar mandate, which is yet to be approved by the Parliament. More announcements may be expected as EU Member States are in the process of deciding how to transpose the RED II into national law. It also relies on Member States implementing the 1.2x multiplier within the support policy, rather than only within their reporting to the Commission. Policy changes of this type have been relatively slow (on the order of years), and highly variable between countries, as was seen with the varied introduction of double counting. The 2019 EU Parliament elections resulted in an increased number of representatives from green parties (e.g. in Germany, France and Finland), which may push climate change mitigation in transport higher up the EU policy agenda.

3.7 Tariffs on feedstocks and fuels

The capacity of the European Union to import significant volumes of FAME, HVO, HEFA, UCO and AF will impact feedstock prices. Imports of biodiesel and renewable diesel will reduce the utilisation of EU installed capacity and therefore the demand for feedstock from EU producers and therefore feedstock prices. Similarly, the EU capacity to import UCO or animal fats will reduce pressure over domestically sourced feedstock and its price. Imports may however be limited due to the implementation of duties and tariffs to protect EU industry. This section is therefore looking at the history of duties and tariffs applied to biodiesel imported from non-EU countries, evaluate the likelihood for similar duties/tariffs to be implemented in the future for HEFA/HEFA+ and estimate their impact on feedstock prices.

3.7.1 Current situation in the European Union

The European Union has historically imposed duties and tariffs on imported products. A generic 10.9% tariff applies to any imported product from third countries, as per the Council Regulation 2658/87 (Council of the European Communities, 1987). In addition, specific duties have been implemented over the past decade to protect the EU biodiesel industry from the competition caused by imports.

Temporary or definitive duties applied to biodiesel are the result of an in-depth investigation to demonstrate that the measure is justified and beneficial to the EU industry against an imbalanced situation

Three rounds of duties/tariffs were applied by the European Union to imported biodiesel at different times over the past decade:

- Based on an initial complaint lodged by the European Biodiesel Board (EBB), anti-dumping measures were set by the European Union against biodiesel imported from Argentina, which traded at below-market prices due to governmental support. Following a WTO ruling against the European Union, anti-dumping measures duties were reduced through Regulation 2019/244 (European Commission, 2019b), which currently imposes a 25-33.4% countervailing duty on Argentinean biodiesel. While it potentially covers FAME and HVO from any feedstock, it practically targets soy FAME (SME).

- Also based on an initial complaint filed by the EBB, Regulation 2015/1519 (European Commission, 2015) currently imposes a 211-237 EUR/tonne duty on biodiesel (both FAME and HVO/HEFA) imported from the United States or Canada, as the capacity of these countries to sell biodiesel surplus below market prices was considered as a risk to the EU industry.
- A 76 to 178.8 EUR/tonne anti-dumping duty was decided in 2013 by the European Council for biodiesel imported from Indonesia via Regulation 1194/2013 (Council of the European Union, 2013), as the Indonesian palm biodiesel could trade at a lower price than EU biodiesel due to governmental support to its biodiesel industry. The WTO forced the EU to suspend this duty and it was not replaced to date, although another investigation towards Indonesia is ongoing since 2018.

As shown in Figure 11, the application of duties on imported biodiesel in 2012-2013 drastically reduced imports from Argentina and Indonesia.

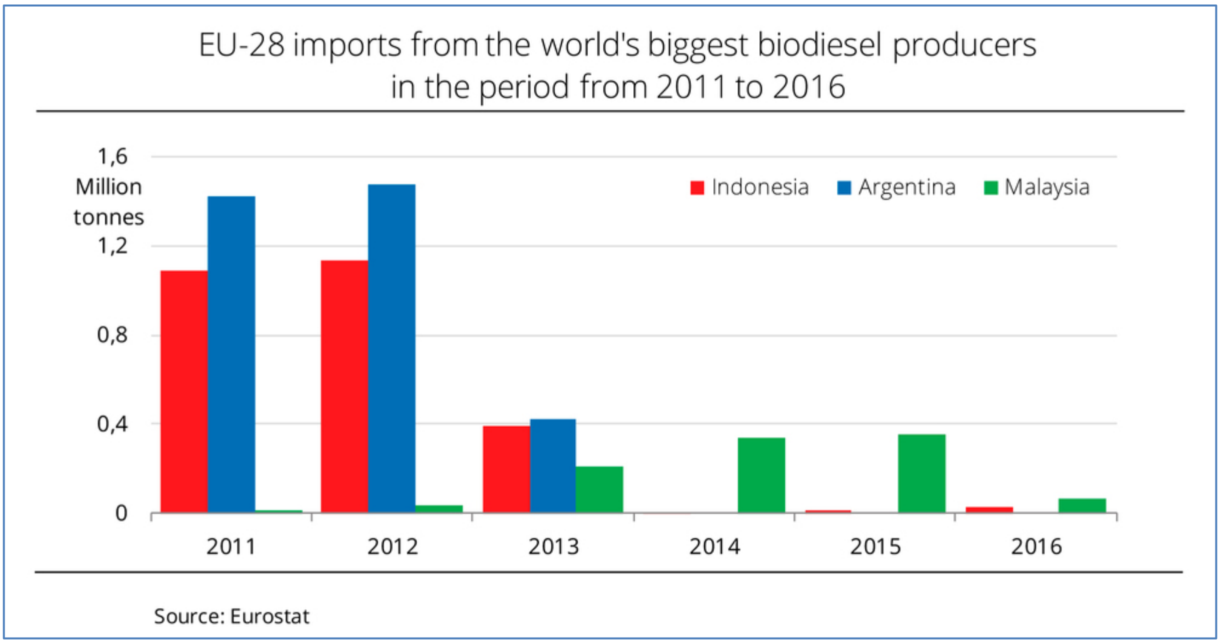

Figure 11: Biodiesel Imports in the EU between 2011 and 2016 (Source: Biodiesel Magazine[19])

The ruling by WTO against the European Union (World Trade Organisation, 2018) led to a rebound in 2017, followed by biodiesel imports in the EU nearly tripling in 2018, totalling 3,395 million tonnes, including 1,648 million tonnes from Argentina, and 786,000 tonnes from Indonesia (Table 7).

[19] http://biodieselmagazine.com/articles/2516142/eu-28-biodiesel-imports-likely-to-increase-significantly

Table 7: Biodiesel Imports in the EU between 2014 and 2018 (Source: Informa (2019))

Europe	Imports 2014	2015	2016	2017	2018
Argentina	0.0	18.8	0.0	386.3	1,647.8
Malaysia	339.7	350.5	269.7	387.3	563.3
Indonesia	2.2	12.6	31.1	25.1	785.7
China	5.4	0.5	38.2	196.7	254.0
Taiwan	6.2	11.0	28.8	33.6	52.9
Others	182.9	71.0	112.7	104.6	91.5
Total	**536.4**	**464.4**	**480.5**	**1,133.6**	**3,395.2**

3.7.2 Future impact on HVO/HEFA production in the European Union

The preceding section shows that the European Union is reactive to threats to its domestic market and industry. In the specific case of biodiesel, the EU industry has generally succeeded in triggering legal processes ending with the eventual application of a duty or tariff on imported biodiesel (both FAME and HVO/HEFA), although the calculation of the duty has led to WTO disputes (under the GATT agreement), which eventually forced the EU to lower down the duties, especially for producers in third countries cooperating with EU authorities.

As described in Section 3.5.3, the European Union is the second largest exporter of HVO after Singapore. In turn, the US and Canada are the largest importers. According to Informa (2019), however, the demand for HVO may increase faster than the EU installed capacity, thus leading to an increase in imports, most likely from South America (although no new development of HVO plant is currently in process – See Section 3.5.3) and Asia.

Our interpretation is that Informa's projections assume that most of the EU installed HVO capacity would be utilised, while imports would fill the remaining gap between the demand and domestic supply. Such a situation would make difficult to argue in favour of additional duties on imports, although existing duties applied to Argentina, if still in force, would apply. A possibility exists that a share of the EU production capacity and/or imports could include HEFA, should sufficient incentives be in place to offset higher production costs. This possibility would be reduced if HEFA + receives ASTM certification in the forthcoming years (See Section 3.1), as bio-jetfuel incentives could be seized while keeping production costs lower.

3.7.3 Conclusions

Should the demand for HVO/HEFA/HEFA+ increase significantly in Europe, as projected by Informa, additional investments in HVO/HEFA capacity would be required. Meanwhile, increased imports are also likely, but if the utilisation of EU capacity is high, additional tariffs/duties to protect the EU Industry are unlikely, as the impact of imported HEFA/HEFA+ on EU producers would likely be limited. Limited tariff restrictions would therefore reduce the price pressure on feedstocks, which could drive prices up.

4 Conclusions

This study shows that producers of FAME derived from UCO or animal fats could maintain cost competitiveness for feedstock against HVO and HEFA where they have low or medium FAME production costs. However, FAME producers with higher production costs face a significant risk to their feedstock supply from HVO and HEFA producers. HVO is a direct competitor, primarily as a road transport fuel under current incentives, due to the absence of a blend wall, cold weather performances and high-value co-products. Jet fuel could also become a significant competitor in the 2020s. This competition will exist if the following actions take place:

- Certification of HEFA + as a jet fuel by ASTM.
- Changes to Member State policies: expansion of policy incentives to include aviation biofuels and introduction of the 1.2x aviation multiplier.
- Specific strong drivers for aviation biofuels are put in place, albeit with small demand volumes, such as national aviation mandates or individual airline commitments.

If these actions took place, there is expected to be sufficient growth capacity for HVO plants in the EU to allow production of HEFA+ to meet growing HEFA+ demand. It should be noted, however, that an additional fractionation stage might be required for HEFA+, which could increase HEFA+ production costs and reduces HEFA+ cost-competitiveness compared to FAME. If the Annex IX Part B cap is implemented at 1.7%, rather than increased by Member States with approval by the Commission, this further increases the risk that hydrotreating routes take up the cap volume, squeezing FAME plants out of the market for waste oils and fats. Potential palm oil bans would further increase the pressure on alternative feedstocks. Significant volumes are also expected from imports, but since the European Union is expected to use most of its HVO installed capacity, additional tariffs/duties appear less likely than in the current situation.

Given this potential for disrupting the existing FAME industry policy makers will need to decide whether the benefits of using waste oils and fats in the aviation sector outweigh the disadvantages.

Waste oils and fats give the aviation industry access to a low cost sustainable biofuel option in the near-term, whilst other aviation biofuels routes are in development, with slower ramp up expected. This may be seen as important to engaging the industry in this decarbonisation option.

However:

- Using waste oils and fats in aviation leads to lower greenhouse gas savings today from HEFA/HEFA+ compared to FAME (according to default values in REDII) due to a more intensive conversion process.
- There is significant potential for disruption of the existing FAME industry from an increased use of drop-in paraffinic fuels such as HVO or HEFA+ as described above.
- There is limited future potential for aviation decarbonisation at scale through waste oils and fats derived biofuels compared with fuels derived from Annex IX Part A feedstocks.

- Concerns exist that the CORSIA mechanism could reduce the willingness of policy makers and players in the aviation sectors to push for aviation biofuels, given that carbon offsets are considerably cheaper than biofuels (abatement costs)[20].

5 References

Assemblée Nationale (2018). *Sous-Amendement N° 1431 à l'Amendement N° 967 de la Commission des Finances à l'Article 60 de la Loi de Finance 2019.* Available at: http://www.assemblee-nationale.fr/dyn/15/amendements/1490/AN/1431

CAAFI (2018). *Fuel Certification and Qualification*. Presentation by Mark Rumizen. Available at : http://www.caafi.org/resources/pdf/2.12_ASTM.pdf

Census Energy (2019). *[RE] fuel Report*. (9). Available at: https://www.energycensus.com/.

Comisión Nacional de los Mercados y la Competencia (2019). *Circular 1/2019, de 13 de marzo por la que se regula la gestión del mecanismo de fomento del uso de biocarburantes y otros combustibles renovables con fines de transporte.* Available at : https://www.boe.es/boe/dias/2019/03/20/pdfs/BOE-A-2019-3995.pdf

Council of the European Communities (1987). *Council Regulation N° 2658/87 of 23 July 1987 on the tariff and statistical nomenclature and on the Common Customs Tariff.* Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:31987R2658&from=EN

Council of the European Union (2013). *Council implementing Regulation (EU) No 1194/2013of 19 November 2013imposing a definitive anti-dumping duty and collecting definitively the provisional duty imposed on imports of biodiesel originating in Argentina and Indonesia.* Available at: https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2013:315:0002:0026:EN:PDF

Department of Transport (2018). *The Renewable Transport Fuels and Greenhouse Gas Emissions Regulations 2018*. Available at: https://www.gov.uk/guidance/renewable-transport-fuels-obligation.

European Commission (2015). *Commission implementing Regulation (EU) 2015/1519 of 14 September 2015 imposing definitive countervailing duties on imports of biodiesel originating in the United States of America following an expiry review pursuant to Article 18 of Council Regulation (EC) No 597/2009.* Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=uriserv:OJ.L_.2015.239.01.0099.01.ENG

European Commission (2019a). *Commission Delegated Regulation (EU) 2019/807 of 13 March 2019 supplementing Directive (EU) 2018/2001 of the European Parliament and of the Council as regards the determination of high indirect land-use change-risk feedstock for which a significant expansion of the production area into land with high carbon stock is observed and the certification of low indirect land-use change-risk biofuels, bioliquids and biomass fuels.* Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:L:2019:133:FULL&from=EN

European Commission (2019b). *Commission Implementing Regulation (EU) 2019/244 of 11 February 2019 imposing a definitive countervailing duty on imports of biodiesel originating in Argentina.* Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=uriserv:OJ.L_.2019.040.01.0001.01.ENG

[20] https://www.theicct.org/blog/staff/corsia-carbon-offsets-and-alternative-fuel

Gobierno de España (2008). *Orden ITC/2877/2008, de 9 de octubre, por la que se establece un mecanismo de fomento del uso de biocarburantes y otros combustibles renovables con fines de transporte.* Available at : https://www.boe.es/eli/es/o/2008/10/09/itc2877

Informa (2019). *Hydro- treated vegetable oils (HVO) Market Report.* Informa Agri-business (Not public)

IRENA (2017). *Biofuels for Aviation: Technology brief. International Renewable Energy Agency*. (January), pp. 79–88. Available at: https://www.irena.org/publications/2017/Feb/Biofuels-for-aviation-Technology-brief

Jong, S. de *et al*. (2015). *The feasibility of short-term production strategies for renewable jet fuels - a comprehensive techno-economic comparison*. Biofuels, Bioproducts and Biorefining, 9, pp. 778–800.

Ministerio de Industria, Energía y Turismo (2015a). *Real Decreto 1085/2015, de 4 de diciembre, de fomento de los Biocarburantes.* https://www.boe.es/buscar/act.php?id=BOE-A-2015-13208

Ministerio de Industria, Energía y Turismo (2015b). *Orden IET/2786/2015 - Modifica la Orden ITC/2877/2008, Mecanismo de fomento del uso de biocarburantes y otros combustibles renovables con fines de transporte*. Available at : https://www.ecolex.org/details/legislation/orden-iet27862015-modifica-la-orden-itc28772008-mecanismo-de-fomento-del-uso-de-biocarburantes-y-otros-combustibles-renovables-con-fines-de-transporte-lex-faoc154568/

Ministerio de Industria, Energía y Turismo (2018). *Real Decreto 235/2018, de 27 de abril, por el que se establecen métodos de cálculo y requisitos de información en relación con la intensidad de las emisiones de gases de efecto invernadero de los combustibles y la energía en el transporte.* https://boe.es/diario_boe/txt.php?id=BOE-A-2018-5890

Nikita, P., Searle, S. and Christensen, A. (2019). *The cost of supporting alternative jet fuels in the European Union*. The International Council on Clean Transportation, (March). Available at: www.theicct.org

Norwegian Government (2013). *Forskrift om begrensning i bruk av helse- og miljøfarlige kjemikalier og andre produkter (produktforskriften). Kapittel 3. Omsetningskrav for biodrivstoff og bærekraftskriterier for biodrivstoff og flytende biobrensel.* Available at: https://lovdata.no/dokument/SF/forskrift/2004-06-01-922/KAPITTEL_4#%C2%A73-4

OPIS (2019). *OPIS Europe jet, diesel & gasoil report*. OPIS. Available at: https://www.opisnet.com/wp-content/uploads/2019/01/europe-jet-report-sample.pdf.

Pearlson M, Wollersheim C. and Hileman J (2013). *A techno-economic review of hydroprocessed renewable esters and fatty acids for jet fuel production.* Available at: https://onlinelibrary.wiley.com/doi/abs/10.1002/bbb.1378

Ramboll (2013). *Summary of the main report "Bærekraftig biodrivstoff for luftfart"(Available inNorwegian only).* Available at: http://renewablejetfuels.org/sites/renewablejetfuels.org/files/resources/reports/Sustainable%20Aviation%20Biofuels%20in%20Norway.pdf

Ramboll (2017). *Sustainable aviation biofuel: Status 2017.* Avinor, (May). Available at: http://www.greenaironline.com/photos/Ramboll_Norway_Sustainable_Aviation_Biofuel_Report_August_2017_EN.pdf.

Stamatis, K. *et al*. (2018). Building up the future cost of biofuel. European Commission, (June), pp. 1–71. Available at: https://publications.europa.eu/en/publication-detail/-/publication/13e27082-67a2-11e8-ab9c-01aa75ed71a1/language-en/format-PDF

Stortinget (2018). *Innstilling til Stortinget fra finanskomiteen. Meld. St. 1 (2018–2019), Prop. 1 S (2018–2019) og Prop. 1 S Tillegg 1–3 (2018–2019)*. Available at: https://www.stortinget.no/globalassets/pdf/innstillinger/stortinget/2018-2019/inns-201819-002.pdf

(S&T) Consultants Inc. (2018). *Description and data collection on biofuel technologies*. Danish Energy Agency. Available at: https://ens.dk/sites/ens.dk/files/Analyser/renewable_fuels_technology_catalogue_revised_draft_report.docx.

World Trade Organisation (2018). *European Union – Anti-dumping measures on biodiesel from Indonesia. Report of the Panel.* Available at: https://www.wto.org/english/tratop_e/dispu_e/480r_e.pdf