



BIOFUELS: **FROM UNSUSTAINABLE** **CROPS TO** **DUBIOUS WASTE?**

**Analysis of
the European
biofuels
market**

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Author: Simon Suzan

With contributions from: Laura Buffet, Barbara Smailagic, Valentin Simon and Elias Achehboun Luthi

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Biofuels: from unsustainable crops to dubious waste?

Further information

Simon SUZAN

Transport energy and data analyst

Transport & Environment

simon.suzan@transportenvironment.org

www.transportenvironment.org | @transenv | fb: Transport & Environment

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Executive Summary

Europe pioneered the use of biofuels a decade ago as ‘renewable’ alternatives to fossil fuels. The consequences have been largely disastrous. Instead of reducing emissions it drove palm oil production, which ended up being worse than the fossil diesel it replaced.

Europe is gradually ditching palm oil in favour of other crops and so-called ‘waste’ feedstocks. In this report, T&E looks at Europe’s changing biofuels market and whether these new fuels represent a new start for biofuels or simply a repackaging of the same problems.

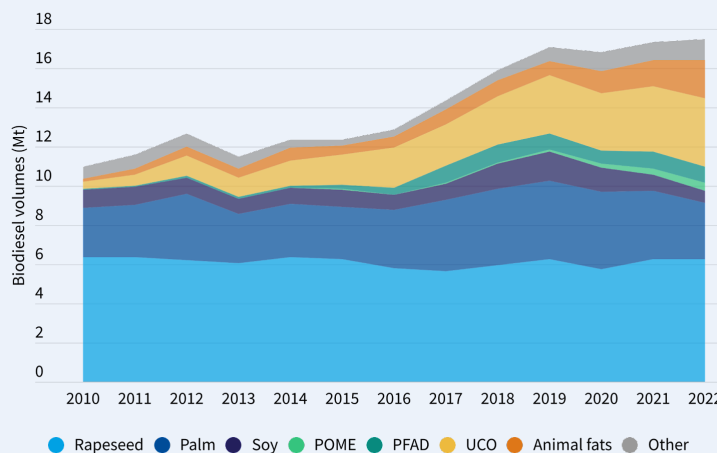
An increasing reliance on imports

Biofuels market data from 2022 show demand for biofuels in Europe is outpacing the continent’s supply. As a result, **the EU biofuels market has been increasingly relying on imports**, with biodiesel imports growing sixfold between 2015 and 2022 and now accounting for one fifth of the bloc’s consumption. Bioethanol imports have been following similar trends: they were multiplied by four in seven years and represented one third of the EU consumption in 2022.

A slow shift from crops to waste

Looking at the feedstocks used in biofuels, T&E’s analysis shows that waste-based products such as used cooking oil (UCO) and animal fats accounted for most of the increased biodiesel volumes and **reached one third of the EU consumption in 2022**. However, food crops still remain the dominant feedstocks used in the production of EU biofuels, both for biodiesel and bioethanol.

In parallel, the early phase-out of palm oil biodiesel in several member states led to a 27% decline in the use of this unsustainable biofuel between 2021 and 2022. Consequently **the average biodiesel emissions** have been reduced by 19% in the last two years but **remain 17% higher than fossil diesel CO₂ emissions**. On the other hand, **EU bioethanol still relies almost exclusively on crops**, with corn, wheat and sugar beet feedstocks accounting for almost 80% of the consumed volumes in 2022.

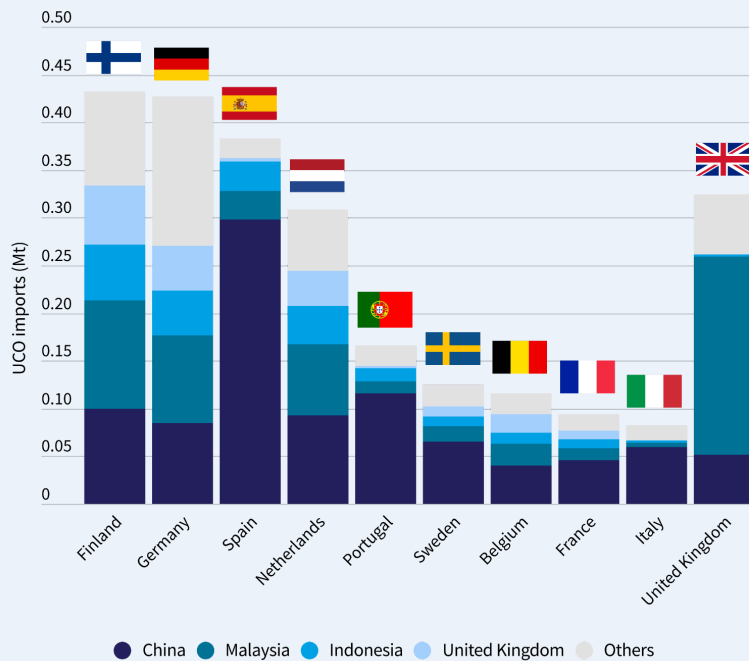


Source: Transport & Environment, based on data from Stratas Advisors (2023)

While crops still make up the majority of biodiesel feedstocks, used cooking oil and animal fats now represent one third of EU biodiesel

A growing use of dubious waste

The consumption of used cooking oil biofuels more than doubled between 2015 and 2022. But Europe's ability to collect waste oil is being outpaced by demand. The continent is now reliant on imports, mostly from Asia, for 80% of its UCO. China alone represents 60% of those imports.



Source: Transport & Environment, based on data from Comtrade (2023)

Imports of UCO from Asia to European countries in 2022

An increasing number of cases uncovered by investigations and denounced by the EU biofuels industry suggest that **a large share of UCO imports would be fraudulent and potentially repurposed virgin palm oil**. This led several member states such as Germany and Ireland to launch their own official investigation. In addition, in August 2023 the European Commission promised to investigate suspicions of fraudulent Indonesian biodiesel potentially transiting through China and the United Kingdom to circumvent taxes.

Market data also indicate a 60% increase in animal fats consumption in EU biofuels between 2021 and 2022, probably driven by the implementation of new biofuels laws in Germany. Furthermore, an increasing gap between biodiesel consumption and production suggests **the EU could be more and more reliant on animal fat biofuels imports**, raising concerns about the sustainability of the feedstocks used.

A recent uptake of palm oil derivatives such as **Palm Oil Mill Effluent (POME) and Palm Fatty Acid Distillate (PFAD) cancelled about 40% of the decrease in palm oil between 2020 and 2022**. Commonly but incorrectly labelled as “waste” or “residues”, PFADs are in fact by-products of the palm industry associated with significant environmental impacts and indirect land use change as for conventional palm oil. In 2022, POME and PFADs represented respectively 13% and 29% of all palm biofuels.

No end in sight for crop biofuels

Despite much fanfare around waste biofuels, crops will continue to be the dominant feedstock in Europe's biofuels. Forecasts suggest that **crops would represent more than half of biodiesel demand and two thirds of bioethanol demand in 2030 in the EU**. Other feedstocks include advanced biofuels such as UCO and animal fats, which dubious imports raise concerns about their sustainability.

More biofuels for planes

According to industry forecasts, half of the announced biofuels production in Europe is planned for the aviation sector, which represents the biggest growth market for biofuels. However, **aviation biofuels are set to only represent 10% of the total biorefining capacity in 2030 and 19% in 2050**. The majority of biofuels will likely continue to be used in cars and trucks despite direct electrification being greener and cheaper.

Recommendations

- **Phase-out immediately deforestation driving biofuels such as palm and soy and end the use of all crop-based biofuels by 2030 at the latest.**
- **Guarantee palm and soy feedstocks are not reintroduced through the back door via other problematic “advanced” and “waste” feedstocks** such as fraudulent imported UCO in case of palm oil.
- **Place additional restrictions around the support and use of “advanced and waste biofuels”,** such as the adoption of a strict limit on the share of UCO and animal fats that can be used in transport fuels, including in aviation, and strengthening the monitoring and verification mechanisms for biofuels supply chains, especially for imports.
- **Focus on the potential of sustainable feedstocks at national and EU level and reduce the dependence on imports from outside the EU.**
- **Ensure truly sustainable advanced and waste biofuels eventually go to the right markets.** At the moment, sustainable advanced feedstocks are mainly used for biofuels in the road sector and quantities remain extremely limited. These biofuels should eventually be used in hard-to-decarbonise sectors such as aviation, while road transport is being electrified.
- **Greener options exist outside of biofuels.** The availability of waste based biofuels will remain extremely limited and these should not be seen as a panacea to solve our climate problem. More efforts are needed to reduce energy demand in transport. Direct electrification should be prioritised for road transport and hydrogen based fuels - renewable fuels from non biological origin (RFNBOs) - should be prioritised in aviation and shipping.

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1. Introduction

Produced from biomass materials, such as crops or residues of different processes, biofuels have been widely promoted across the European Union since the adoption of the Renewable Energy Directive (RED) in 2009. As a result, renewables reached 8.7% of the transport energy consumed in 2022 at the EU level, according to preliminary figures from the European Environmental Agency [1], almost twice as much compared to 2009.

Rather than reducing the climate impact of transport fuels, previous analysis conducted by Transport & Environment showed that biofuels policies increased the EU's reliance on unsustainable feedstocks that actually increase the emissions, such as palm and soy, because of their indirect land use change impacts [2]. In 2018, the revised version of the RED attempted to reduce the share of biofuels with indirect land use change risks and announced a phase-out of palm biofuels by 2030, however still allowing soy and other unsustainable crops.

In spring 2023, the European Parliament and the Council agreed to increase the EU's RED target to 29% of renewables in transport by 2030 [3]. While this new version of the RED promotes for the first time the use of renewable electricity and Renewable Fuels from Non Biological Origin (RFNBOs), the increased overall transport target will likely in practice drive additional demand for biofuels [4].

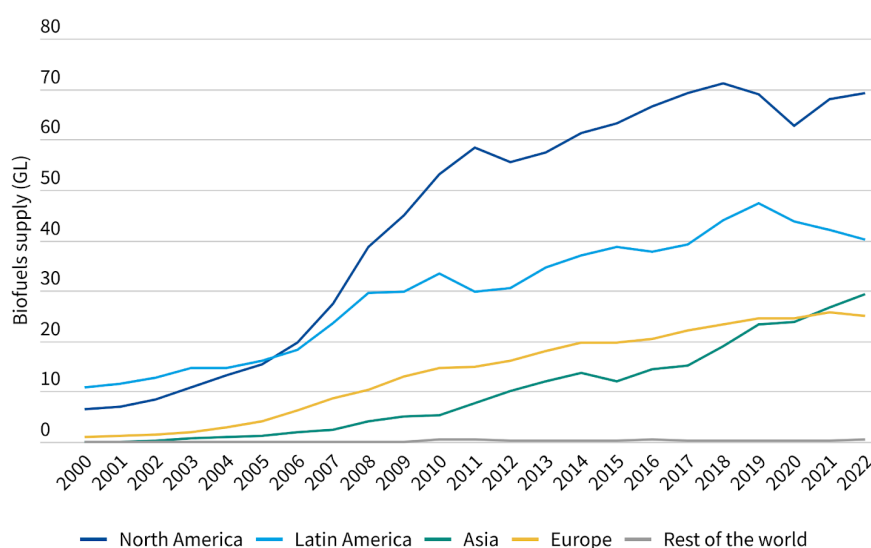
In this report, T&E analyses most recent biofuels data and takes a deeper look into the EU biodiesel and bioethanol markets, comparing the uptake of different feedstocks as well as monitoring domestic production and imported volumes. A focus on key feedstocks such as used cooking oil, animal fats or palm oil derivatives, labelled as “waste” or “advanced”, is also presented. Finally, an overview of different forecasts tries to assess how new biofuel pathways could be developed in the years to come.

2. Current biofuels trends in the EU

2.1. Global biofuels market

With many countries seeing biofuels as a key alternative for decarbonising transports, these fuels reached a record high 4% of global transport energy consumption in 2022 according to the International Energy Agency (IEA) [5], six times more than twenty years ago.

While biofuels are being traded all over the world, like other liquid fuels, some regions account for a larger share of the global market. In 2022, North American countries supplied more than 40% of the global biofuels volumes, followed by Latin America (25%) and Asia (18%), as shown in Figure 1. Europe¹ represented more than 15% of global volumes, but its supply seems to plateau with only a 2% increase between 2019 and 2022. On the other hand, **biofuels supplied by Asian countries rose by 26%** over the same period.



Source: Transport & Environment, based on data from Stratas Advisors (2023)

Figure 1: Historical biofuels supply in the world

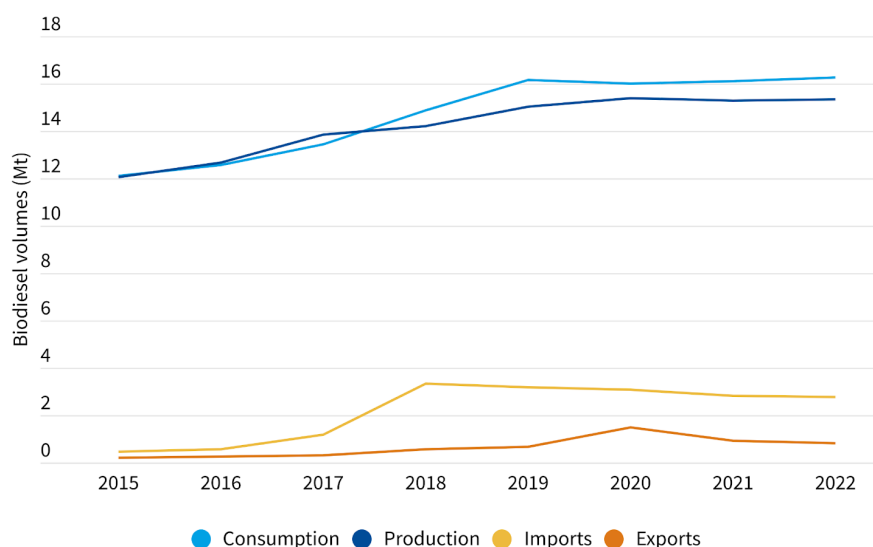
Looking at the demand side, the United States, Brazil, Europe and Indonesia accounted for 85% of biofuels volumes in 2022 according to the IEA [5]. With a 9% increase in demand between 2019 and 2022, European countries are the second driving region after Asia (+26%) according to data from Stratas Advisors. **It results in Europe's demand for biofuels being 15% higher than its supplied volumes, leading to an increasing need for imported volumes from other regions.**

¹ Europe here refers to the continent, meaning EU as well as the United Kingdom, Norway, Turkiye and other Balkan countries.

2.2. Biodiesel: from crops to waste feedstocks?

2.2.1. Production and consumption

Biofuels can be made out of many different feedstocks. They can be refined domestically from local or imported feedstocks or imported directly as refined final products. Figure 2 shows the consumption, domestic production, imports and exports of refined biodiesel² in the European Union. After a five year steady increase in consumption and production, biodiesel volumes seem to have stabilised since 2019, plateauing around 16 million tonnes in consumption. While imports only represented 4% of the consumed volumes in 2015, **refined biodiesel supplied from third-countries reached 17% in 2022, equivalent to a sixfold jump in volumes over seven years.** This increase mostly happened until 2018. On the other hand, exports of biodiesel from the EU were also multiplied by four over the same period, but, as a comparison, only accounted for 5% of the consumed volumes in 2022.



Source: Transport & Environment, based on data from Stratas Advisors, OilWorld and Comtrade (2023)

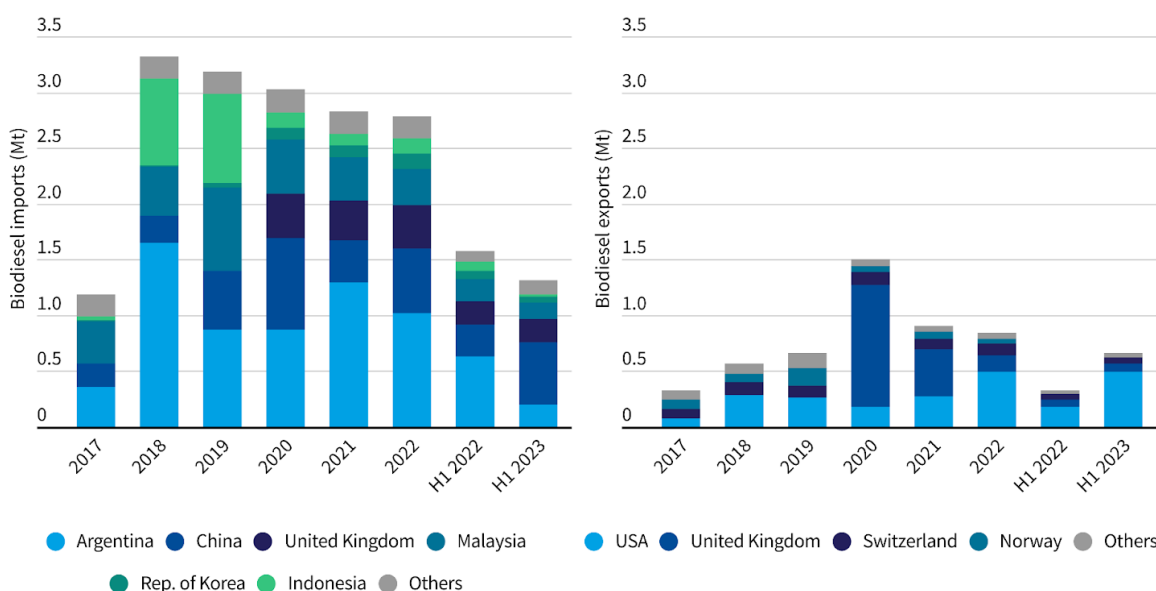
Figure 2: Biodiesel volumes in the EU

Historically, most of the imported biodiesel came from three main countries: Argentina, Indonesia and Malaysia, respectively accounting for 50%, 24% and 13% of the EU imports in 2018. With the two South-Asian countries being the two largest producers of palm oil and Argentina one of the main producers of soybean oil, the EU biodiesel imports were mainly made from these feedstocks.

More recently, other countries started supplying the EU with refined biodiesel (Figure 3). **In 2022, Chinese imports represented 21% of the imported volumes, three times more than in 2017.** This trend seems to keep increasing in 2023, with imported volumes from the first half of the year already exceeding 2022 records. During the first six months of 2023, imports of biodiesel from China more than doubled compared to the same period in 2022. Market analysts estimate that most of these imported volumes are advanced or waste biofuels and more specifically processed from used cooking oil [6]. With the very low

² Unless specified differently, in this report biodiesel refers to conventional Fatty Acid Methyl Ester (FAME), as well as Hydrotreated Vegetable Oil (HVO) and Hydroprocessed Esters and Fatty Acids (HEFA) bio-based diesel.

market prices of these fuels and the large amounts being shipped, EU biodiesel producers and traders raised concerns about fraudulent products [7]. More on this in Section 3.1.



Source: Transport & Environment, based on data from Comtrade (2023)

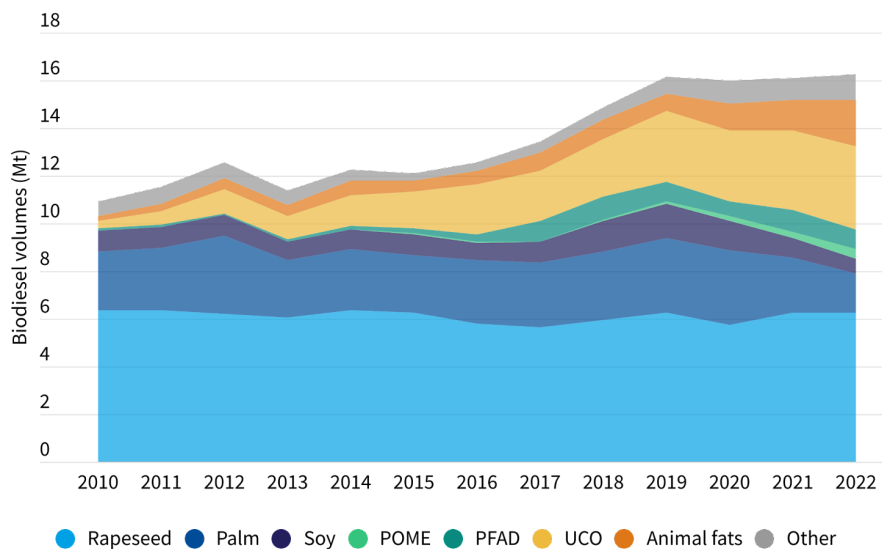
Figure 3: Origin and destination of EU biodiesel imports and exports

On the other hand, as mentioned above, the EU is exporting more and more biodiesel to third-countries. As shown in Figure 3, **custom records indicate a surge in exports from the EU to the United States, which were multiplied by seven between 2017 and 2022**. Early 2023 data suggest this trend is continuing, with export volumes to the US already three times higher in the first half of 2023 compared to H1 2022. US trade records indicate that these increased exports come mainly from Germany and more specifically from one of the largest biofuel producers in the world, Archer Daniels Midland, which produces both rapeseed and soy biofuels in Germany [8].

2.2.2. Feedstock trends

As Transport & Environment showed in previous reports, biodiesel fuels have been historically processed from agricultural crops, such as palm kernels, soybeans or rapeseed [2]. Over the past few years, biodiesel made from waste and residues, such as used cooking oil and animal fats started to be used in EU transports as well. Palm derivatives such as palm oil mill effluent (POME) and palm fatty acids (PFAD) are also more and more used, despite PFADs being falsely labelled as residues (see Section 3.3).

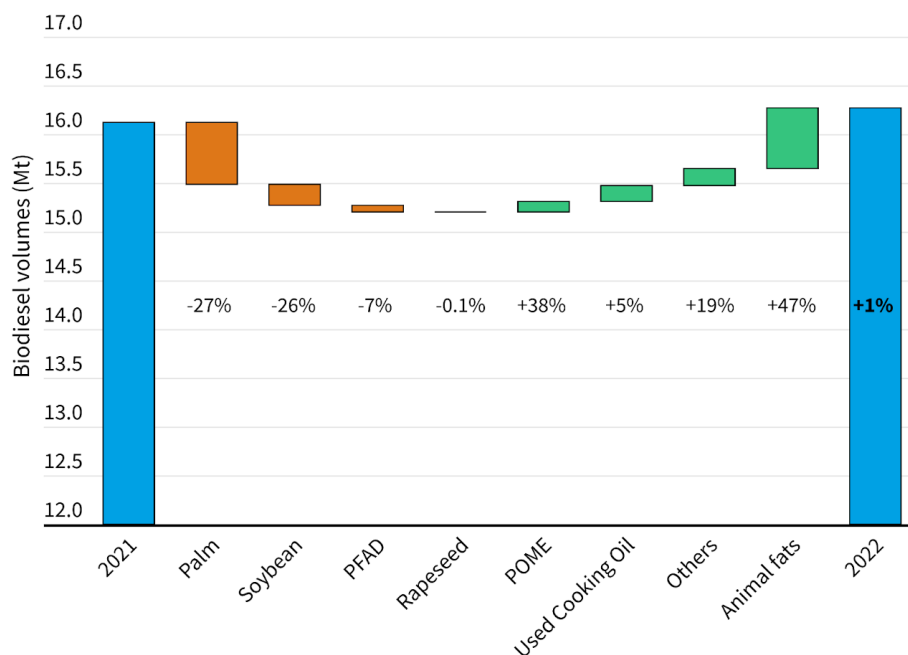
While the share of crop-based biofuels decreased from more than 90% to 60% between 2010 and 2022, Figure 4 shows that the volumes of crops converted into biodiesel kept increasing until late 2019. **In parallel, the consumption of waste-based biodiesel has multiplied by eleven since 2010**, making up a third of the overall EU biodiesel consumption in 2022. Such results vary largely across European countries. For instance, the UK, the Netherlands and Italy have among the lowest shares of crop-based biofuels (8%, 8% and 31% respectively) in 2022, mainly using UCO and animal fats as biofuels feedstocks. Detailed feedstock consumption for key countries can be found in the Annex.



Source: Transport & Environment, based on data from Stratas Advisors (2023)

Figure 4: Biodiesel consumed in the EU by feedstock of origin

Looking more closely at the feedstocks used, rapeseed biodiesel has been the most consumed feedstock since 2010, with almost constant volumes over the past decade, and represented 40% of biodiesel volumes in 2022. **While palm oil biodiesel represented the second largest feedstock used in European biodiesel until 2021, it was replaced by UCO biodiesel in 2022.**



Note: for each feedstock, the percentages correspond to the increase or decrease of the respective biodiesel consumption between 2021 and 2022.

Source: Transport & Environment, based on data from Stratas Advisors (2023)

Figure 5: Changes in biodiesel consumption between 2021 and 2022 in the EU³

Between 2021 and 2022, **palm oil biodiesel consumption declined by 27% across the EU**, as shown in Figure 5. This decrease can be explained by early phase-outs of palm oil biofuels enforced by several member states. At the same time, 2022 data suggest that **a surge in the consumption of animal fats (+47%) and used cooking oil (+5%) as well as an increase of POME compensated for this decrease in conventional palm oil biodiesel** (see Section 3 for more details). The consumption of other feedstocks, including sunflower oil, also increased over the same period.

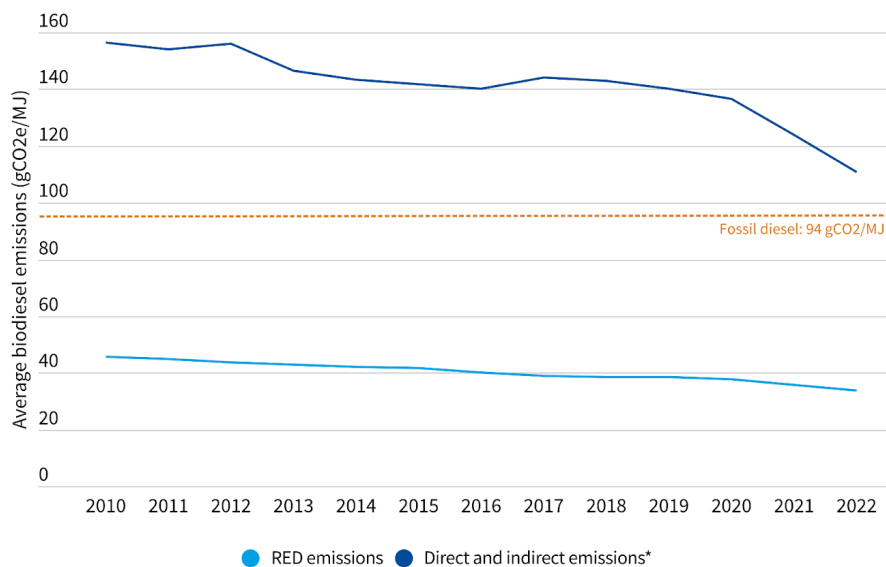
2.2.3. Emissions

Estimating the emissions associated with biofuels is a complex question. While the official CO₂ emissions used in the Renewable Energy Directive include emissions from the cultivation, the processing, the transportation and the distribution of biofuels feedstocks, some indirect aspects are not taken into account. For instance, this is the case of increased emissions resulting from indirect deforestation or peat destruction related with crop-based biofuels production, so-called indirect land-use change emissions (ILUC). Taking these effects into consideration, **total biofuels emissions can be up to five times higher than the RED typical values according to the most recent ILUC study at the EU level** [9].

³ Other feedstocks for instance include sunflower oil.

On the other hand, **even waste-based biofuels can be associated with indirect emissions**, for example if competing uses lead to displacement of current uses towards less sustainable materials, notably palm oil as the cheapest biofuel feedstock [10]. The detailed emission values can be seen in Annex I.

Taking into account these different emission types, Figure 6 shows the evolution of average biodiesel emissions between 2010 and 2022. While RED values always led to emission savings compared to fossil diesel, taking into account direct and indirect emissions does not bring any savings. **The average emissions of biodiesel have been up to 66% worse than fossil diesel.**



*indirect emissions include indirect land-use change for crop-based biodiesel based on Globiom modelling and displacement effects for advanced biofuels such as used cooking oil and animal fats based on ICCT modelling.

Source: Transport & Environment, based on data from Stratas Advisors (2023)

Figure 6: Average biodiesel emissions in the EU

However, it can be noticed that average biodiesel emissions have been decreasing over the years. On one hand, RED biodiesel emissions declined by 24% between 2010 and 2022, resulting in official average emission savings of 63% in 2022 compared to 51% twelve years earlier. On the other hand, **total biodiesel emissions decreased by 30% over the same period, but remained 17% above fossil diesel emissions in 2022.** This emission reduction has been particularly strong between 2020 and 2022 (-19%) and can be explained by the decrease in palm oil consumption, the most emitting biodiesel feedstock, and an increase in waste-based biofuels as explained previously.

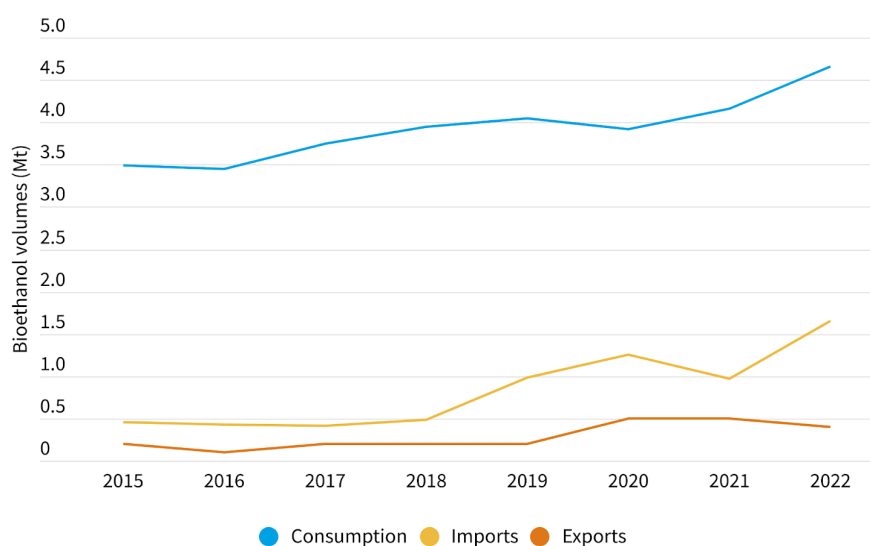
2.3. Bioethanol: still almost exclusively crops

2.3.1. Consumption

As for biodiesel, bioethanol can be refined domestically from local or imported feedstocks, or imported directly as refined final products. The amounts of domestic consumption, imports and exports of refined biodiesel in the European Union can be seen in Figure 7.

While bioethanol consumption has been steadily increasing by around 2% per year until 2020, more **recent data show a jump in bioethanol volumes with a 10% yearly increase between 2020 and 2022**. This sharp increase seems to be reflected in ethanol imports, which reached 36% of the bioethanol volumes consumed in 2022 from 13% in 2015. **Ethanol volumes imported in the EU have indeed been multiplied by four in seven years.**

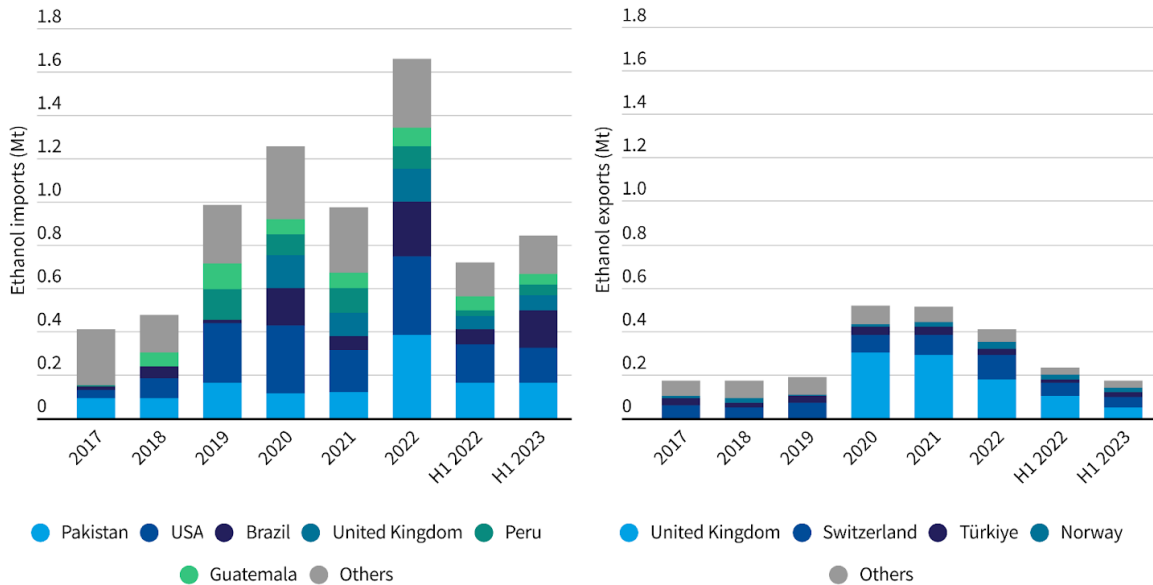
In addition, exports of bioethanol from the EU to other regions grew twofold between 2015 and 2022 but, as a comparison, represented less than 9% of the volumes consumed.



Source: Transport & Environment, based on data from Stratias Advisors and Comtrade (2023)

Figure 7: Bioethanol volumes in the EU

In contrast to biodiesel imports, ethanol imports have been historically coming from a more diverse range of countries. Figure 8 however indicates that a couple of countries have been particularly increasing their exports to the EU: **altogether, imports from Pakistan, the US and Brazil reached 60% of the total ethanol imports in 2022**, from less than 40% in 2021. Brazilian ethanol had the largest surge with volumes multiplied by almost four in a year, followed by Pakistan (x3) and the US (x2).



Source: Transport & Environment, based on data from Comtrade (2023)

Figure 8: Origin and destination of EU ethanol imports and exports⁴

Early 2023 data suggest that this increasing trend is continuing, with ethanol imports 18% higher in the first semester of 2023 compared to the same period one year ago. **In particular, ethanol imports from Brazil tripled in a year, reaching 20% of all ethanol imports in H1 2023**, with the country’s ethanol production mainly based on sugarcane [11]. Following this jump in imports and concerns about a competition with European bioethanol producers, the European Commission introduced retrospective surveillance tools to monitor imports of renewable ethanol for fuel [12].

Finally, almost 90% of the exported volumes of ethanol from the EU were directed towards EU neighbouring countries, such as the United Kingdom from 2020, Switzerland, Norway and Turkey.

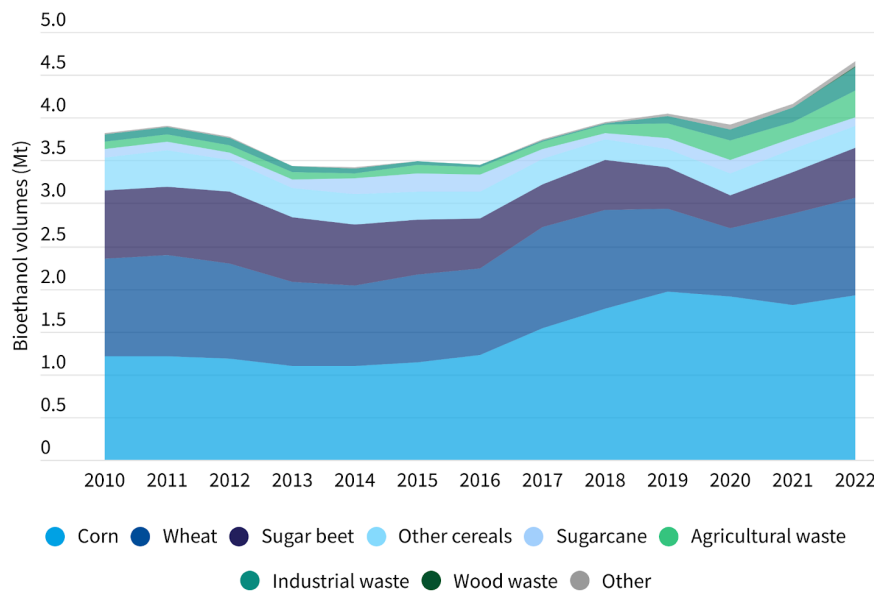
2.3.2. Feedstock trends

Bioethanol has been traditionally produced from the fermentation of sugars or starch molecules contained in crops, such as corn, wheat or sugar beet. New pathways can extract and process bioethanol out of cellulosic molecules present in agricultural, industrial or wood materials.

Unlike biodiesel, **the share of crop-based bioethanol only slightly declined over the past decade, reaching 85% of bioethanol volumes consumed in 2022**, compared to 95% in 2010. During this period, corn bioethanol remained the most dominant feedstock, increasing by almost 60% and accounting for up to 40% of all feedstocks in 2022. Wheat and sugar beet followed with respectively 25% and 13% shares in 2022.

⁴ UK imports and exports only appeared after 2020 because of Brexit.

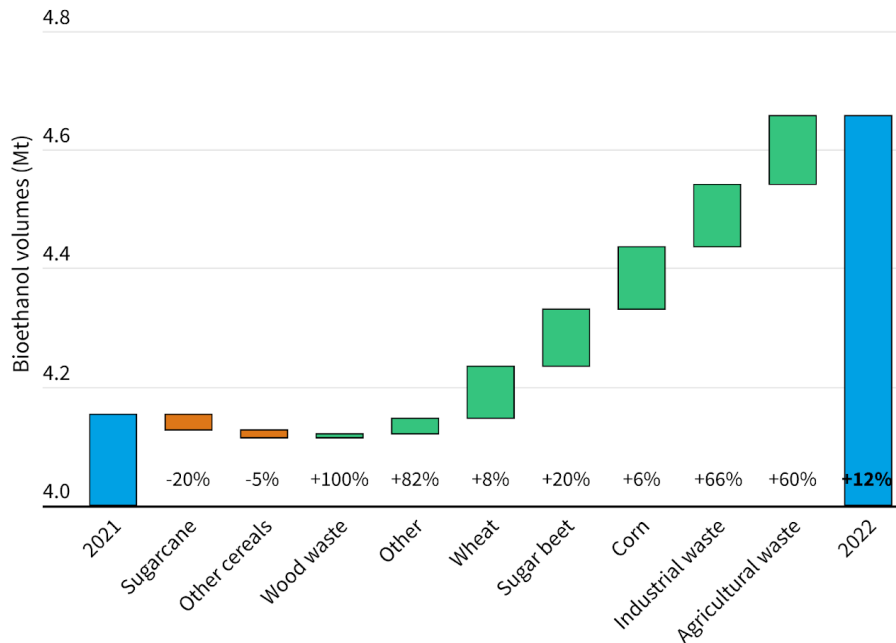
In addition, Figure 9 shows a recent and limited uptake of waste-based feedstocks, which combined volumes were multiplied by three since 2010, making up to 13% of the bioethanol volumes consumed in the EU in 2022.



Source: Transport & Environment, based on data from Stratas Advisors (2023)

Figure 9: Bioethanol consumed in the EU by feedstock of origin

Looking more closely at recent trends, waste-based feedstocks accounted for almost half of the increase in bioethanol consumption between 2021 and 2022 (Figure 10). While the highest increase can be observed in industrial and agricultural waste (+66% and +60%), **traditional crop-based bioethanol kept increasing** with sugar beet, wheat and corn volumes respectively growing by 20%, 8% and 6% in a year.



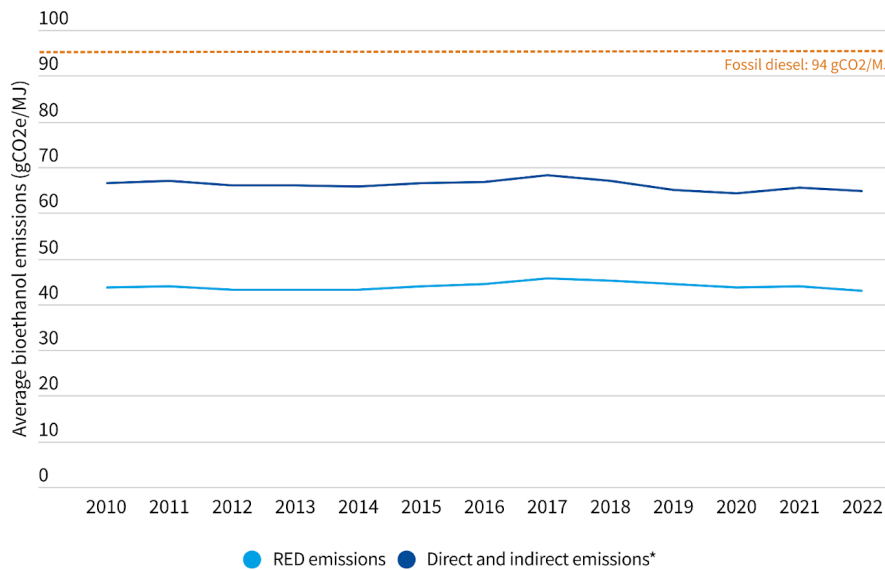
Note: for each feedstock, the percentages correspond to the increase or decrease of the respective bioethanol consumption between 2021 and 2022.

Source: Transport & Environment, based on data from Stratas Advisors (2023)

Figure 10: Changes in biodiesel consumption between 2021 and 2022 in the EU

2.3.3. Emissions

Similarly to biodiesel emissions, bioethanol emissions are quite different if both direct and indirect emissions are taken into account (Figure 11). While according to RED values bioethanol feedstocks brought more than 50% emissions savings compared to fossil fuels, **actual bioethanol emission savings turn out to be limited to 30% when indirect land use change emissions are accounted for.**



*indirect emissions include indirect land-use change for crop-based biodiesel based on Globiom modelling and displacement effects for advanced biofuels such as used cooking oil and animal fats based on ICCT modelling.

Source: Transport & Environment, based on data from Stratas Advisors (2023)

Figure 11: Average bioethanol emissions in the EU

Finally, **bioethanol emissions do not seem to be decreasing** due to the continuous increase of crops associated with limited emission savings. For instance, bioethanol made out of wheat is on average as CO₂ emitting as fossil fuels when ILUC emissions are considered (detailed emission factors in Annex).

3. Focus on key feedstocks

In this section, a more detailed analysis will look at specific advanced biodiesel feedstocks, such as used cooking oil, animal fats and palm oil products, which account for an increasing share of biofuels in the EU and are often presented as more sustainable feedstocks. A recent T&E analysis also looked in more detail at soy biofuels trends, its impacts and the current political context [13].

3.1. Increased reliance on imported used cooking oil

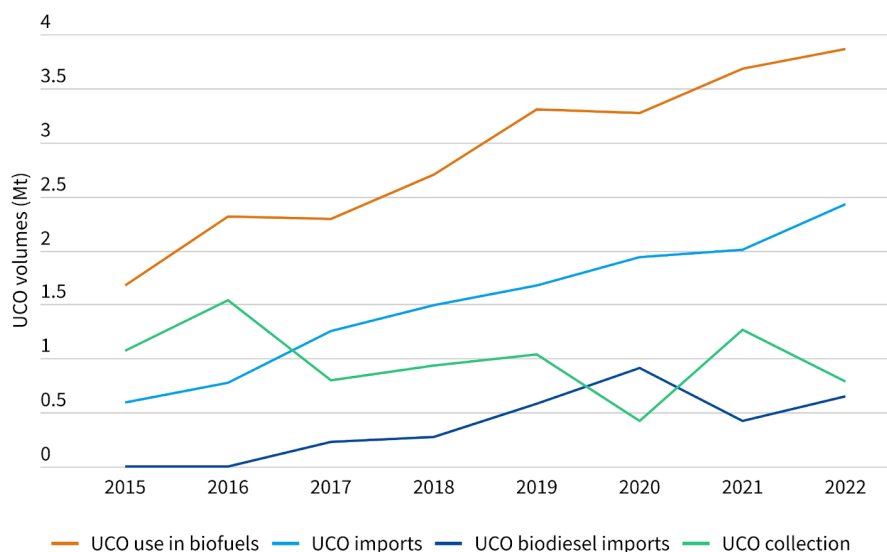
As shown in Section 2.2, the consumption of UCO-based biodiesel more than doubled between 2015 and 2022 in the EU, incentivised through a double-counting mechanism in the Renewable Energy Directive⁵.

Figure 12 compares the increased UCO consumption in biofuels with the imports of UCO feedstocks from third-countries and estimates of UCO volumes collected in the EU. It indicates that consumption and imports followed very similar trends, **with more than 80% of the increased use of UCO in biofuels**

⁵ This mechanism enables certain advanced biofuels in the Annex IX of the RED to be counted twice their energy content towards the RES-T target, effectively promoting them.

coming from an increase in UCO imports between 2015 and 2022. Imports of UCO were indeed multiplied by four during this period, while EU collection only increased by 20%⁶.

Taking into account presumably UCO-based imports of refined biodiesel from China⁷, the total share of imported volumes almost reached 80% of the UCO biodiesel consumption in 2022, while it was only 36% in 2015.



Note: collection of UCO in the EU is estimated based on the difference between consumption and imports, assuming no exports.

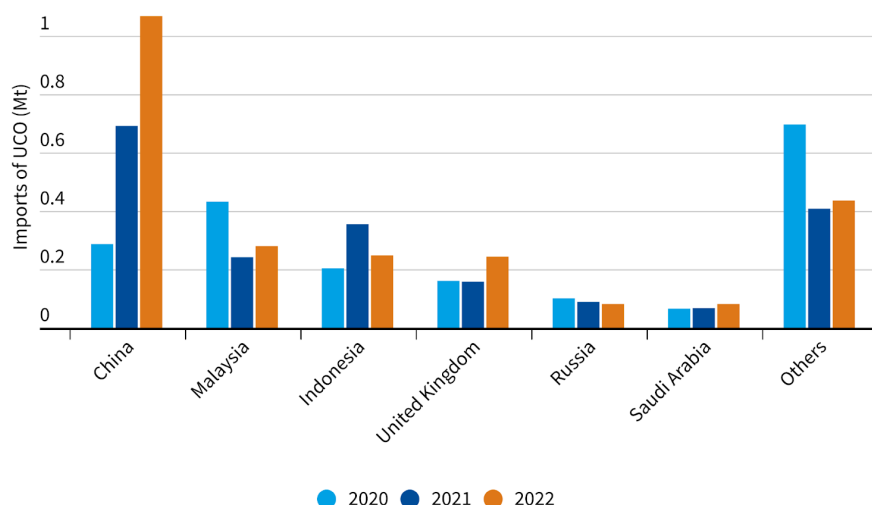
Source: Transport & Environment, based on data from Comtrade and Stratas Advisors (2023)

Figure 12: Imports, collection and use of used cooking oil in EU biofuels

Looking at the origin of foreign UCO, it can be seen that China represented the largest share of UCO imports with 44% in 2022 (Figure 13). **UCO imports from China were indeed multiplied by 70 between 2015 and 2022 and almost quadrupled since 2020.** Other countries such as Malaysia and Indonesia were also significant exporters of UCO to the EU in 2022 (respectively 11% and 10% of the imports) but their share has been decreasing over the years, probably because of the competition with Chinese UCO.

⁶ Between 2015 and 2021, as 2022 estimates suggest a decrease in collected volumes.

⁷ As explained in Section 2.2.1, recent years saw a significant increase in biodiesel imports from China which volumes are assumed to be mostly refined from UCO feedstocks, according to market analysts.



Source: Transport & Environment, based on data from Comtrade (2023)

Figure 13: Origin of imported UCO in the EU

While the consumption of used cooking oil is highly promoted in the RED and supposed to lead to high emission savings compared to fossil fuels, cases of fraudulent materials are being increasingly unveiled.

INFO BOX: Fraudulent UCO?

With the significant surge in UCO biofuels mostly originating from non EU countries and more specifically from China, there have been growing concerns over fraudulent materials being imported. **Certified used cooking oil could be blended with virgin vegetable oil such as unsustainable palm oil and then processed as fake waste-based biofuels.**

While NGOs such as Transport & Environment have been warning against dubious imports of UCO for years [14], a recent investigation conducted by journalists uncovered some **organised trafficking of UCO to the EU** [15]. In addition to that, in its 2023 annual biofuels report the US Department of Agriculture highlighted fraud concerns associated with imports from China, as the country does not allow witness audits of their sustainability certification [16]. On the other hand, EU biofuels producers and UCO collectors have been fearing unfair competition with cheap biofuels imports from China [17] and EU biofuels industry groups even filed an official complaint to the European Commission [18].

Following the numerous suspected fraud cases denounced by many stakeholders, several Member States and the European Commission recently launched their own official investigations:

Country	Type of fraud investigated	Action taken	Time of fraud and investigation
Netherlands	concerns that biofuels that have not been	not resolved yet	November 2020, investigation carried

	sustainably produced are registered and sold as a sustainable fuel		out by the Human Environment and Transport Inspectorate [19]
Germany	suspicion of fraudulent biofuels imported from China, with palm oil cited as an example of feedstock	official request for prosecution completed by the Federal Agency of Agriculture and Food (BLE)	March 2023, complaint by the German biofuels industry [20] June 2023, the Federal Government announced to start an official investigation [21]
Ireland	suspicion of “palm oil [...] being passed off as used-cooking oil” [22]	Irish Department of Transport set up working group "to progress a voluntary vulnerability assessment of the current and projected future biofuels supply into Ireland, with a view to identifying scope for risk of biofuel fraud (leading to high ILUC-risk) and other indirect impact" [23]	Working group set up at the end of 2023
EU	suspicion that Indonesian biodiesel is transiting through China and the UK to circumvent taxes	not resolved yet	August 2023, official investigation ongoing confirmed by DG Trade [24] May 2024, expected “decisive measures” by the Commission [25]

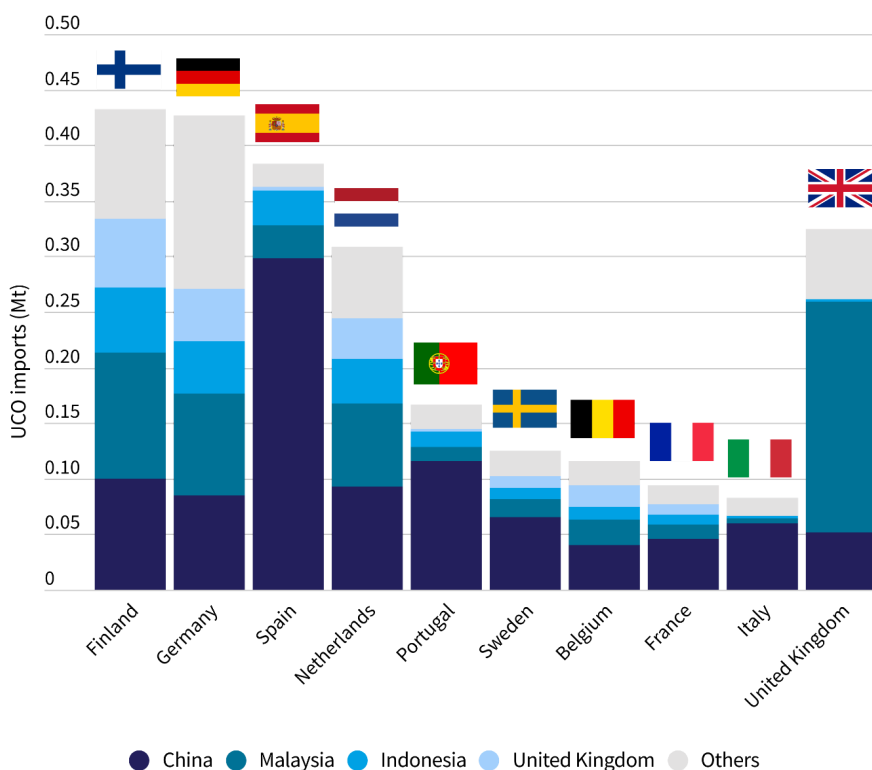
Table 1: Examples of past and ongoing investigations related to potential UCO fraud cases

Looking at a more granular level, trade data indicate that **UCO feedstock imports are mainly coming in the EU through the Netherlands and Spain**, which respectively represented 50% and 29% of extra-EU UCO imports in 2022.

Figure 14 shows the extra-EU imports of UCO per country, with an allocation of imports from the Netherlands and Spain⁸. For instance, while Finland’s direct extra-EU imports are close to zero, the country imports more than 0.4 million tonnes of UCO from the Netherlands, which is then taken into account as indirect extra-EU imports.

In 2022, Finland had the largest jump in UCO imports in terms of volumes (+70%), followed by Sweden (+500%) and the United Kingdom (+60%). Other countries such as Belgium or Bulgaria also significantly increased their imports of UCO from third countries.

Moreover, some countries appear much more reliant on Chinese UCO than others. For instance, 96% of imports to Bulgaria were originating from China in 2022, while it was 78% for Spain, 74% for Italy and 70% for Portugal. In the UK, 60% of UCO imports were coming from Malaysia in 2022.



Note: imports include an allocation of extra-EU UCO imports from the Netherlands and Spain and re-exported to other EU countries, since these are the main entry points of UCO to the EU. Imports of UCO-based biodiesel are not considered here.

Source: Transport & Environment, based on data from Comtrade (2023)

Figure 14: 2022 extra-EU UCO imports per countries

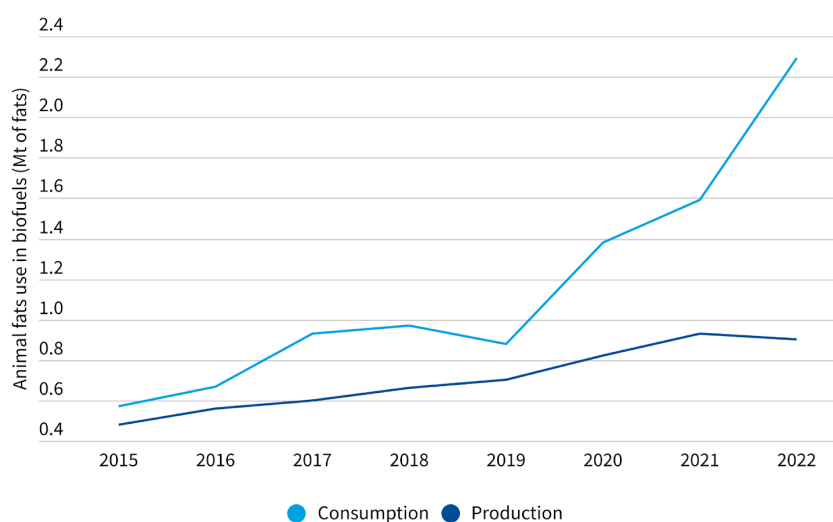
⁸ This is assuming that the distribution of extra-EU volumes imported to the Netherlands and Spain is the same to EU countries which re-import from these main entry points. These re-exported volumes are subtracted from direct extra-EU imports to the Netherlands and Spain. Potential exports of UCO collected domestically are not considered.

3.2. Animal fats in biofuels, the next UCO?

Between 2021 and 2022, preliminary market data suggest animal fats biofuels increased by almost 50%, exceeding 1.9 Mt of fuel consumed in the EU as indicated in Section 2.2. According to data obtained from Stratas Advisors, **most of this increased consumption would come from Germany**, where animal fats have only been allowed to count towards the RED target since early 2022 [26].

Figure 15 compares the evolving consumption and production of animal fats biofuels between 2015 and 2022, based on data from Stratas Advisors and OilWorld. **It can be observed that the animal fats consumption grew twice as fast as the biofuels production over the period**, the former being multiplied by four and the latter by less than two in seven years. 2022 data indicate the consumption of such biofuels was almost three times greater than what was produced in the EU. **This suggests that the growing demand for animal fats biofuels would be met with increased imports** from third-countries.

While it is hard to estimate the exact origin and volumes imported, Brazil and Australia are known exporters of biodiesel produced from animal fats [16]. In particular, an investigation showed that biodiesel processed from Brazilian beef tallow and exported to the EU was connected to deforestation in the Amazon [27].



Source: Transport & Environment, based on data from Stratas Advisors and OilWorld (2023)

Figure 15: Consumption and production of animal fats biofuels in the EU

As shown in a study commissioned by Transport & Environment, these by-products from the meat rendering industry have existing uses in other sectors [28]. While the lowest quality fats, classified in categories 1 and 2, are already mostly processed into transport biofuels, category 3 animal fats are still being used as feedstocks in the oleochemistry and animal feed sectors. **The growing demand for animal fats in transport is putting pressure on supplies and especially on category 3 fats, and can lead to increased CO₂ emissions** in other sectors, if less sustainable alternatives such as palm oil are being used in those sectors. In addition, some mismatch recently identified between volumes supplied by the

industry and officially reported by Member States could suggest some mislabelling of category 3 fats into double-counted categories 1 and 2.

As a result, the potential high increase in imports of animal fats biodiesel in the EU would require specific attention in order to avoid becoming reliant on uncertain and suspicious imports as is the case for UCO.

3.3. Palm biofuels, is the story really over?

As shown in Section 2.2, palm oil consumption in biofuels has been decreasing for the past few years, following the early adoption of a palm oil phase-out by several Member States⁹ in advance of the overall 2030 EU phase-out. However, other palm oil derivatives such as palm oil mill effluent (POME) and palm fatty acids (PFAD) are still incentivised in the Renewable Energy Directive¹⁰.

Incorrectly considered as waste or residues from the production of palm oil, PFADs are in fact lower quality palm oil by-products that can be processed into biofuels and other products¹¹. Because of competition with existing uses, the high demand for PFADs in biofuels can lead to displacement effects and increase the use of unsustainable palm oil elsewhere. For instance, a study by Cerulogy estimated that **the emissions of PFAD biofuels can reach up to 221 gCO_{2e}/MJ in the worst case, more than twice the emissions of fossil diesel** [30], quite close from the emissions of palm oil biofuels (285 gCO_{2e}/MJ). On the other hand, POME is a wastewater generated from palm oil milling activities which can be used to produce biodiesel [31]. Such waste is hard to trace and could be used for local biogas production rather than biodiesel.

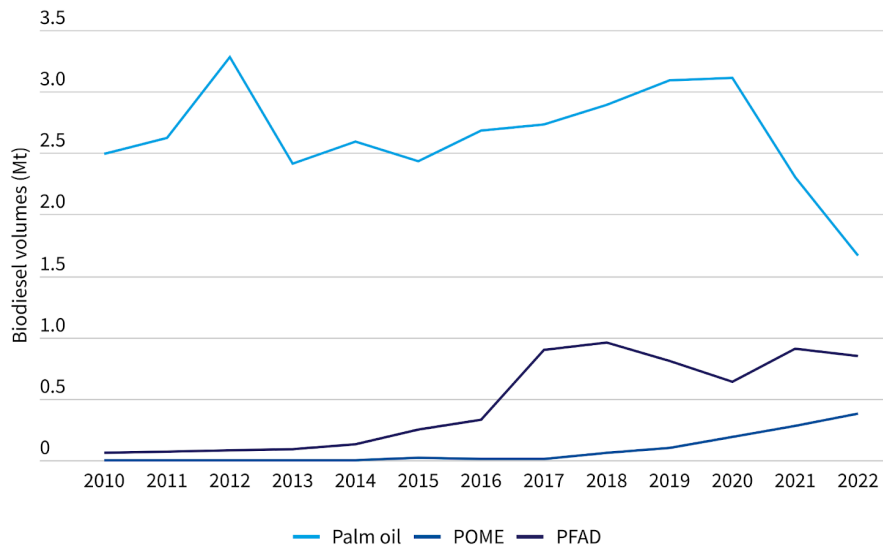
Figure 16 shows the consumption of conventional palm oil biodiesel alongside POME and PFAD use in biofuels. It can be seen that **a recent increase in POME and PFAD biodiesel cancelled about 40% of the decrease in palm oil between 2020 and 2022**. It resulted in an effective 26% decline in all palm products while conventional palm oil consumption decreased by 46% in two years.

The consumption of POME biofuels indeed almost doubled between 2020 and 2022, while PFADs increased by more than 30% over the same period. **In 2022, POME and PFADs therefore reached respectively 13% and 29% of all palm biofuels.**

⁹ France, Denmark and Austria in 2021 as well as Netherlands, Sweden and Portugal in 2022.

¹⁰ These feedstocks are indeed double-counted towards the transport target, as part of the Annex IX of the RED.

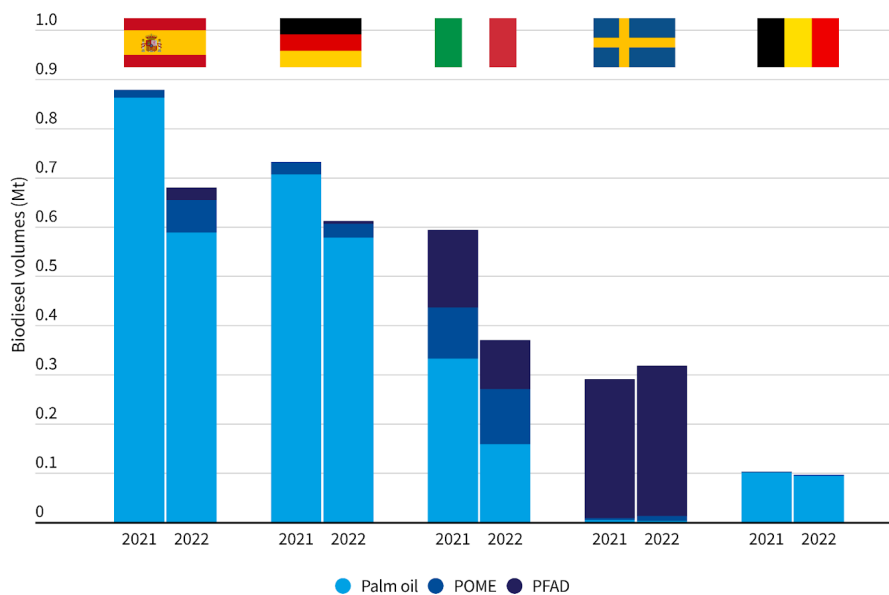
¹¹ For instance the classification of PFAD as a waste, a by-product or a co-product impacts significantly the life cycle assessment (LCA) scope and results, as the upstream emissions and indirect emissions are not considered for waste and residues [29].



Source: Transport & Environment, based on data from Stratas Advisors (2023)

Figure 16: Consumption of palm oil biofuels in the EU

In 2022, five countries represented around three quarters of the total palm oil biofuels consumption in the EU. **Spain alone consumed one quarter of the bloc’s palm products, which accounted for almost 50% of the country’s total biofuels volumes¹².** Germany and Italy followed with respectively 22% and 33% of their biofuels consumption covered by palm oil products.



Source: Transport & Environment, based on data from Stratas Advisors (2023)

Figure 17: Top five consumers of palm products in the EU

¹² Recent policy developments however suggest that Spain could ban palm biofuels by 2025 [32].

While it can be seen in Figure 17 that most countries decreased their overall use of palm products in biofuels, **a neat increase in POME and PFAD consumption can also be noted in countries such as Spain, Germany and Sweden** (+500%, +30% and +10% respectively). Sweden seems also to be an exception with 97% of its entire palm biofuels being PFADs.

Finally, similarly to palm feedstocks, soy biofuels have been promoted in the RED but their increased demand has been driving deforestation, especially in South American countries. T&E's recent briefing highlights new trends related to this feedstock, showing how the EU has been increasingly reliant on soy imports from Argentina, Brazil and the United States [13]. While some member states already tackled soy biofuels, the EU must phase them out immediately together with palm oil, because of their negative impacts on climate change, biodiversity and human rights.

4. Future of biofuels in the EU

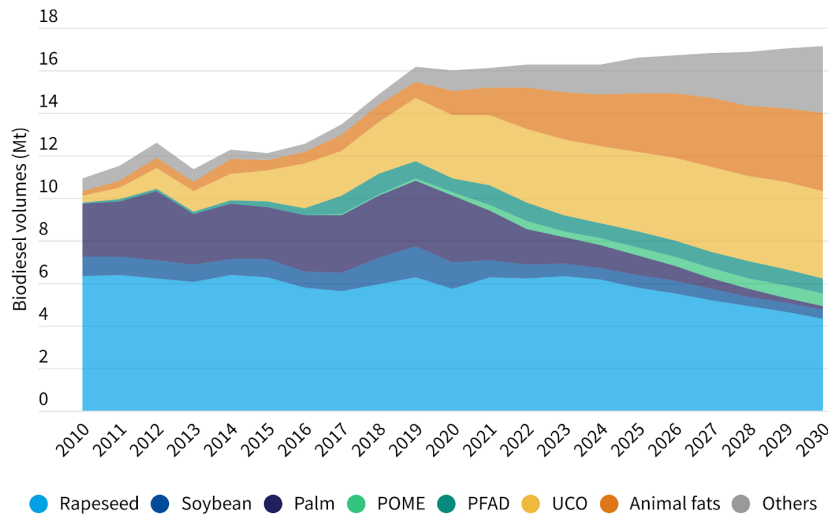
While the Renewable Energy Directive does not specify targets beyond 2030 and despite limited availability of sustainable feedstocks, many countries still see biofuels as a longer term solution to mitigate climate change. This section will present some biofuels forecasts for the EU.

4.1. Forecasted feedstock demand

As explained in Section 2, waste-based biodiesel such as UCO and animal fats have been increasing quite a lot in recent years and contributed for most of the growth in overall biodiesel volumes between 2010 and 2022.

Figure 18 shows Stratas Advisors' biodiesel demand forecast up to 2030. Based on future mandates and supply availability, this forecast expects biodiesel volumes to grow by only 5% between 2022 and 2030. **Waste and advanced feedstocks are foreseen to keep growing, reaching more than half of all biodiesel at the end of the decade** and partly replacing crop-based biofuels which will decline from 60% today to 47% in 2030.

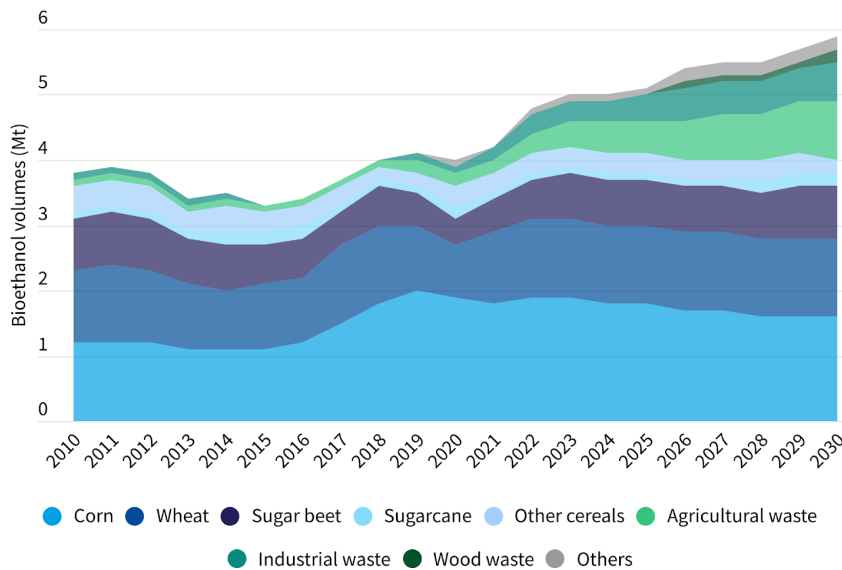
In particular, the demand for UCO biodiesel would increase by 18% by 2030, despite concerns over fraud and limited sustainable availability exposed in Section 3.1. Animal fats would almost double in the next seven years, probably also relying on uncertain imports because of their limited availability in the EU.



Source: Transport & Environment, based on data from Stratas Advisors (2023)

Figure 18: Forecasted feedstocks use in biodiesel consumption in the EU

Bioethanol consumed in the EU is expected to increase by 25% until 2030 (Figure 19). Despite many announcements made about novel alternative feedstocks, **conventional crop-based bioethanol would still represent 70% of bioethanol volumes in 2030**. However, advanced feedstocks such as agricultural, industrial and wood waste would contribute to most of the increase in overall volumes. These feedstocks would be multiplied by three and reach 28% of the consumption by 2030, from 13% today. As for biodiesel, advanced bioethanol feedstocks could lead to indirect emissions for instance in case of competition with other uses.



Source: Transport & Environment, based on data from Stratas Advisors (2023)

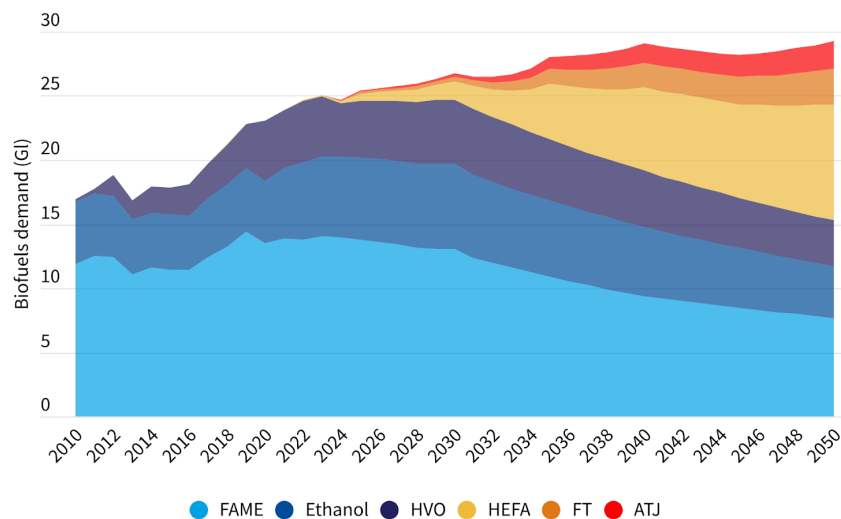
Figure 19: Forecasted feedstocks use in bioethanol consumption in the EU

4.2. A shift to non-road biofuels?

Because of limited availability and competition with cheaper and more sustainable solutions in road transport, biofuels are often promoted in hard-to-abate sectors such as aviation and shipping. In the EU, **the ReFuelEU aviation mandate sets a 6% target of sustainable aviation fuels (SAF) that need to be incorporated by fuel suppliers** [33]. Of this 6%, only 1.2% needs to be synthetic kerosene produced from green hydrogen, while the remainder can be a mix of additional synthetic kerosene and biofuels. Moreover, FuelEU Maritime regulation sets greenhouse gas intensity reduction targets that exclude food and feed biofuels [34].

While ships could use different biofuel types such as marine biodiesel or biomethanol¹³, several bioenergy pathways are foreseen to produce bio-kerosene for planes. The most widely promoted at the moment are HEFA biofuels¹⁴, which similarly to HVO biodiesel can be produced from vegetable or waste oil and only require some additional refining steps to be used in aircraft engines. Fischer-Tropsch (FT) is another process to synthesise kerosene from either biogas or electrolytic hydrogen combined with a carbon source. Finally, the alcohol-to-jet (ATJ) pathway can also produce biokerosene, for instance using bioethanol as a feedstock.

Figure 20 shows the forecasted demand for each biofuel technology until 2050, as foreseen by Stratas Advisors. It can be seen that **biojet fuels are expected to be multiplied by 20 until 2030 and by 140 by 2050, growing from 0.4% of all biofuels volumes in 2022 to 8% in 2030 and 48% in 2050**. In parallel, biofuels for road applications are forecasted to decline by 40% in the next decades, but would still represent half of the volumes by 2050 despite electric vehicles being more a sustainable alternative. However, there is a risk that this apparent shift to aviation fuels would continue to increase the demand for unsustainable feedstocks as it has been the case until now.



Source: Transport & Environment, based on data from Stratas Advisors (2023)

Figure 20: Forecasted biofuels demand in the EU per type

¹³ In that case vessels should be either retrofitted or replaced with biomethanol-ready ships.

¹⁴ Hydrotreated Esters and Fatty Acids.

Among the three biojet technologies highlighted above, HEFA fuels are expected to represent 65% of the volumes, while FT and ATJ technologies would represent 20% and 15% of the volumes respectively. Other technologies not included in this forecast could also be developed for the aviation sector, such as synthesised iso-paraffins (SIP), pyrolysis or other thermochemical technologies [35]. On the shipping side, marine biofuels such as biomethanol could also be used but do not appear in this forecast.

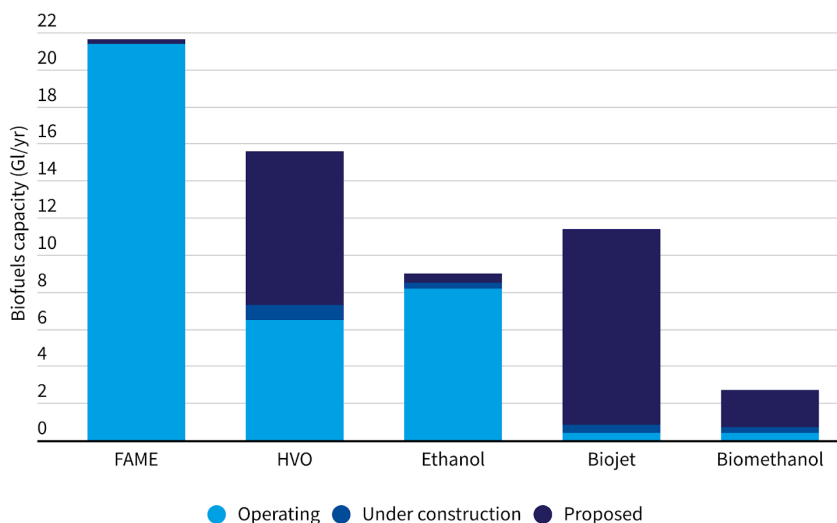
Finally, it is important to note that demand for different technologies is often complicated to model and that forecasts rely on a large number of assumptions, such as hard to anticipate ramp-up rates and policy mandates that could evolve. As a comparison, Transport & Environment published its own modelling of shipping fuels demand [34].

4.3. European biorefining capacity

While the demand for different types of biofuels can be to some extent hard to model, the analysis of the present and announced biorefining capacity gives another perspective. Stratas Advisors tracks operating biofuels plants as well as under construction and proposed facilities¹⁵.

Figure 21 shows the annual production capacity per biofuel technologies. It indicates that currently operating plants are mainly producing biodiesel (58% of FAME and 18% of HVO) and bioethanol (22%), while biojet and biomethanol capacities are both smaller than 1% of the EU capacity. However, **biojet fuels represent almost half of the proposed projects' capacity, followed by HVO (38%) and biomethanol projects (9%)**. Conventional ethanol and FAME projects would only represent 3% and 1% of the future plants' capacity.

Aviation biofuels capacity would therefore be multiplied by 17 between 2022 and 2030 and by 36 between 2022 and 2050, making 10% and 19% of the total capacity in 2030 and 2050 respectively.



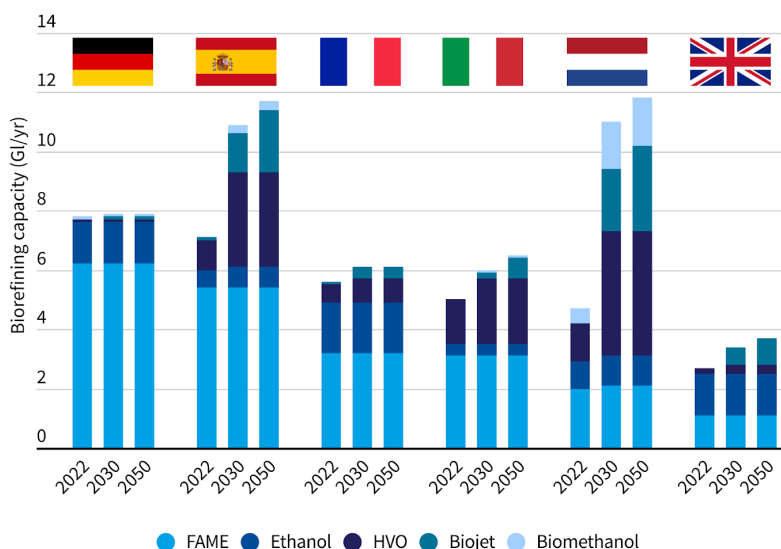
Source: Transport & Environment, based on data from Stratas Advisors (2023)

Figure 21: Existing and announced biorefining capacity in the EU

¹⁵ Data presented here correspond to Stratas' analysis of biorefineries, accessed in November 2023.

The high increase in the planned biojet and biomethanol capacity suggests a progressive shift from the use of biofuels in road transport to aviation and shipping. However, while biodiesel can be used in the shipping sector, the suggested doubling in HVO capacity also indicates that biofuels are still foreseen as a solution in certain road applications, such as trucks, despite direct electrification being cheaper and more sustainable [36] [37].

In 2022, six countries accounted for two thirds of the European biorefining capacity, with Germany and Spain having the largest facilities (Figure 22). Looking at proposed plants, it can be noted that **the Netherlands would have the highest biofuels capacity increase, more than doubling between 2022 and 2030**, followed by Spain (+54%). Germany’s capacity is foreseen to remain more or less similar as it is in 2022.



Source: Transport & Environment, based on data from Stratas Advisors (2023)

Figure 22: Forecasted biorefining capacity in major European producers based on announced projects

According to the planned projects, biojet would be responsible for most of the increased capacity in the United Kingdom (88% of the country’s increase) and in France (60%). However, **Spain, Italy and the Netherlands are expected to mostly expand their HVO capacity by 2050**, with respectively 48%, 47% and 41% of their additional capacity being HVO biofuels.

Finally, 70% of the biomethanol proposed capacity is expected to be located in the Netherlands, the rest being planned in Spain and Italy (20% and 10% respectively).

5. Conclusion and recommendations

In this report, T&E assessed recent biofuels market developments in the EU, comparing imports and domestic production of biofuels as well as analysing the feedstocks used and looking into future projections. Compared to previous years, these are the most important trends:

- **Demand for biofuels in Europe is outpacing the continent's supply, resulting in increased imports from third countries.** Biodiesel and bioethanol imports have been following similar trends, respectively being multiplied by six and four between 2015 and 2022.
- **Crop based biofuels still represent the highest share in biofuels feedstocks, both for biodiesel and bioethanol but biodiesel is moving more quickly to waste-based feedstocks than bioethanol.**
 - Waste-based products such as used cooking oil and animal fats accounted for most of the increased biodiesel volumes and compensated for the recent decline in palm oil. While average biodiesel emissions were consequently reduced in the last two years, EU biodiesel emissions remained higher than fossil diesel emissions.
 - EU bioethanol still relies almost exclusively on crops, such as corn, wheat and sugar beet. Unlike biodiesel, average bioethanol emissions did not decrease and only brought 30% CO₂ savings compared to fossil fuels.
- **The consumption of used cooking oil biofuels more than doubled between 2015 and 2022 but most of this increase came from growing imports of foreign materials, mostly from China.** An increasing number of cases uncovered by investigations and denounced by different stakeholders suggest that a large share of these imports could be fraudulent.
- **Market data also indicate a increased used of other 'advanced' biofuels:**
 - **Data indicate a sharp increase in animal fats consumption** in EU biofuels in 2022. However, an increasing gap between biodiesel consumption and production suggests the EU could be more and more reliant on animal fat biofuels imports, raising concerns about the sustainability of the feedstocks used.
 - A recent uptake of palm oil derivatives, such as Palm Fatty Acids (PFAD) and Palm Oil Mill Effluent (POME) cancelled about 40% of the decrease in palm oil between 2020 and 2022.
- **According to Stratias Advisors' forecasts, half of the proposed biofuels capacity would be dedicated to aviation biofuels in the EU,** suggesting a future shift from road to non-road biofuels applications. However, aviation biofuels would only represent a limited share of the total biorefining capacity forecasted in the decades to come, with HVO capacity still expected to increase, despite direct electrification being a greener and cheaper solution to decarbonise cars and trucks.

Recommendations

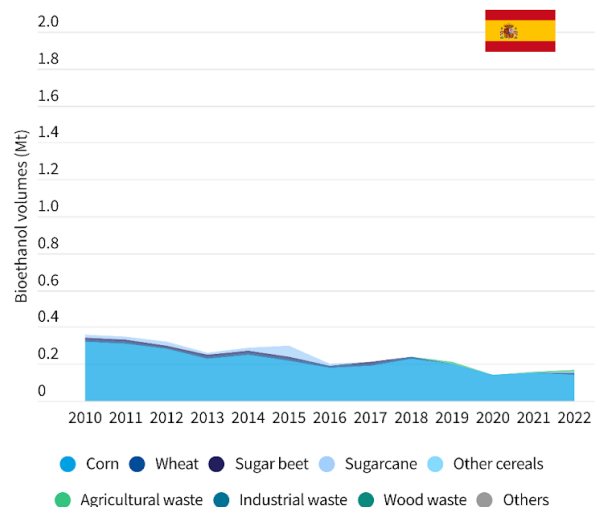
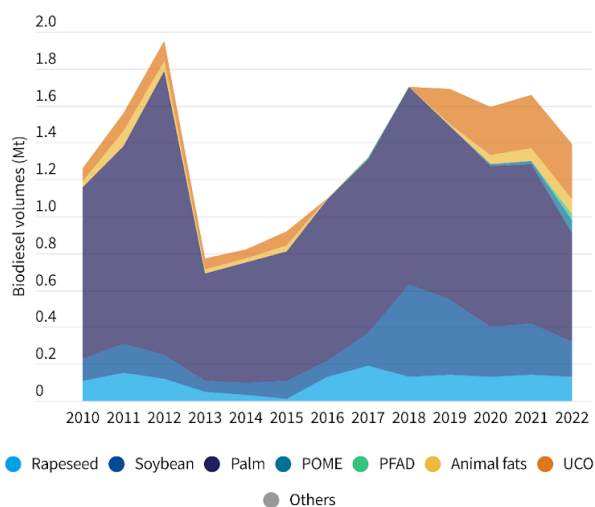
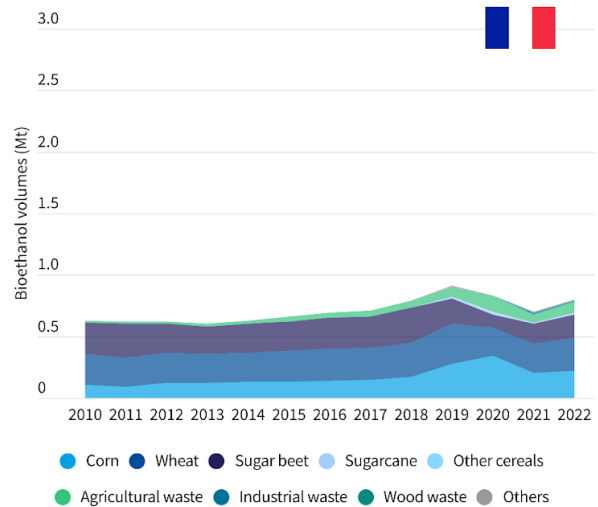
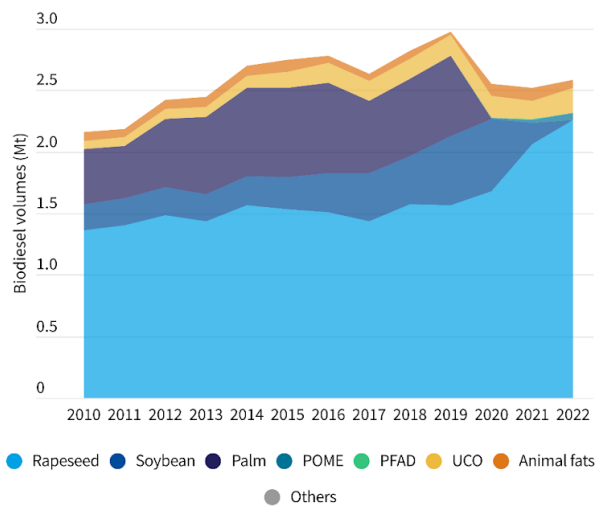
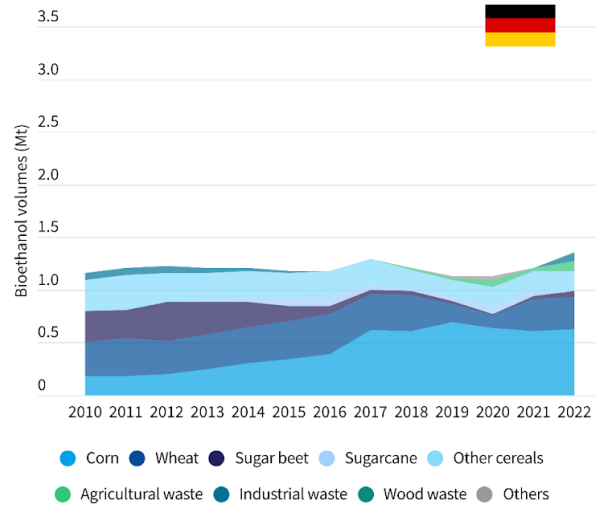
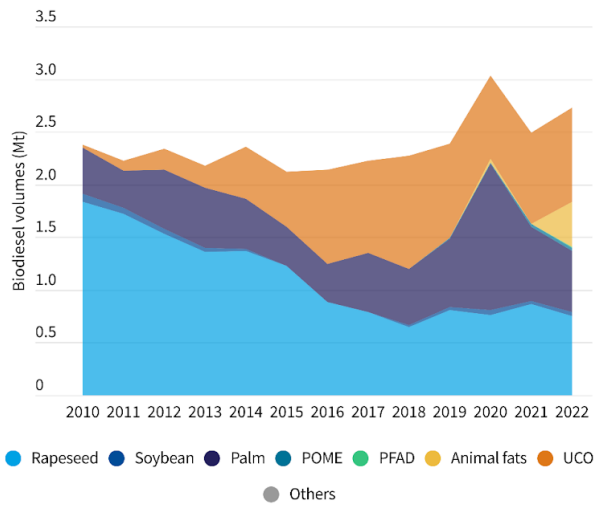
The analysis presented in this report shows that, despite some restrictions in place, unsustainable biofuels are still very much present in the European market and even increasing, when considering potential fraudulent feedstocks. In view of climate and environmental objectives, T&E recommends the EU and EU member states to:

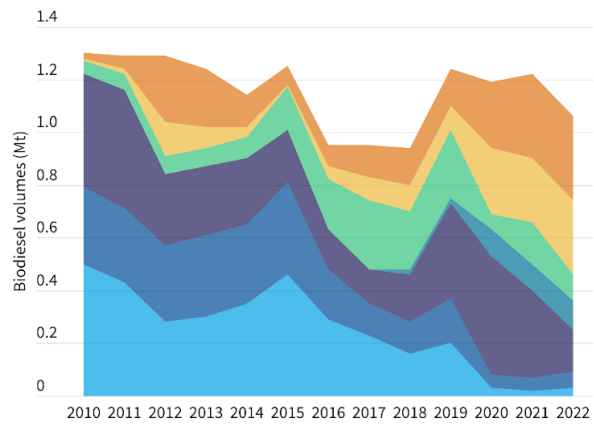
- **Phase-out immediately deforestation driving biofuels such as palm and soy and end the use of all crop-based biofuels by 2030 at the latest.**

- **Guarantee palm and soy feedstocks are not reintroduced through the back door via other problematic “advanced and waste” feedstocks** such as fraudulent imported UCO in case of palm or intermediate crops in case of soy.
- **Place additional restrictions around the support and use of ‘advanced and waste biofuels’¹⁶:**
 - Implement a strict limit on the share of UCO that can be used in transport fuels, including aviation.
 - End the support to Palm Fatty Acid Distillates and other palm related feedstocks.
 - Strengthen monitoring and verification mechanisms for biofuels supply chains, especially for imported UCO.
 - Ensure full transparency and public disclosure of relevant information about biofuels use at EU and national level.
- **Focus on the potential of sustainable feedstocks at national and EU level and reduce the dependence on imports from outside the EU.** Advanced or waste-based biofuels should be limited to sustainably available volumes from the EU.
- **Ensure truly sustainable advanced and waste biofuels eventually go to the right markets.** At the moment, sustainable advanced feedstocks are mainly used for biofuels in the road sector and quantities remain extremely limited. These biofuels should eventually be used in hard-to-decarbonise sectors such as aviation, while road transport is being electrified.
- **Greener options exist outside of biofuels.** The availability of waste based biofuels will remain extremely limited and these should not be seen as a panacea to solve our climate problem. More efforts are needed to reduce energy demand in transport. **Direct electrification** should be prioritised for road transport and **hydrogen based fuels** - renewable fuels from non biological origin (RFNBOs) - should be prioritised in aviation and shipping.

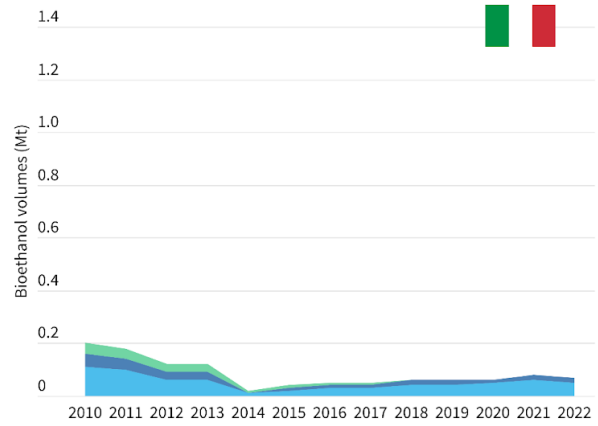
¹⁶ See T&E’s briefing on advanced biofuels in the context of the RED for more information [31].

Annex 1. Biofuels consumption in key countries

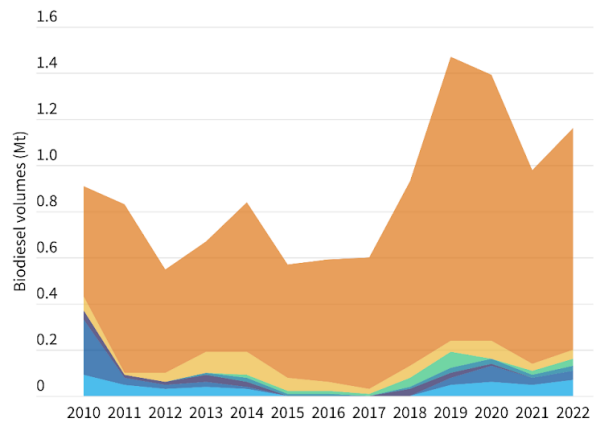




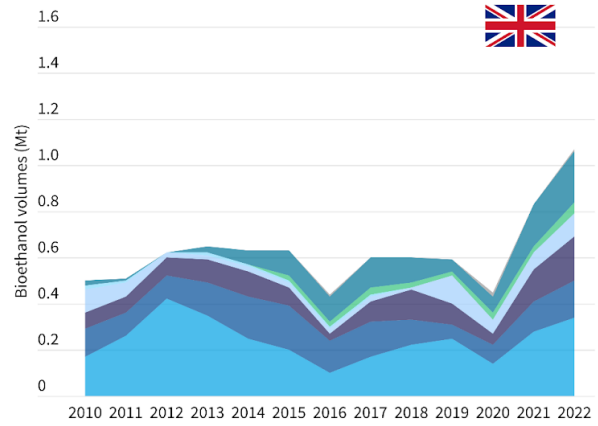
● Rapeseed ● Soybean ● Palm ● POME ● PFAD ● Animal fats ● UCO
● Others



● Corn ● Wheat ● Sugar beet ● Sugarcane ● Other cereals
● Agricultural waste ● Industrial waste ● Wood waste ● Others



● Rapeseed ● Soybean ● Palm ● POME ● PFAD ● Animal fats ● UCO
● Others



● Corn ● Wheat ● Sugar beet ● Sugarcane ● Other cereals
● Agricultural waste ● Industrial waste ● Wood waste ● Others

Figure 23: Biodiesel and bioethanol consumption in key European countries

Annex 2. Biofuels emissions factors

The emission factors assumed for this report are presented below. These are based on values for direct emissions from the RED and indirect emissions either from the most recent ILUC Globiom model or from the ICCT. The biofuels industry often claims higher “direct” emission savings based on “actual” values [38] compared to the RED default values. And the European Environmental Agency (EEA) reports former ILUC values from the RED, not the most recent ones [39]. This explains why emission factors below may differ from other sources.

	RED typical values ¹⁷	Indirect emissions	Total
Rapeseed oil	45.5 [40]	65.0 [9]	110.5
Palm oil	54.9 [40]	231.0 [9]	285.9
Soy oil	42.2 [40]	150.0 [9]	192.2
Animal fats	11.2 [40]	34.8 [10]	46.0
Used cooking oil	15.3 [40]	13.2 [10]	28.5
PFAD ¹⁸	47 [30]	included in total	221 [30]
POME ¹⁹	27 [41]	0	27

Table 2: Biodiesel emission factors used in this report

	RED typical values ²⁰	Indirect emissions	Total
Corn	44.5 [40]	14.0 [9]	58.5
Sugar beet	27.3 [40]	15.0 [9]	42.3
Sugarcane	28.1 [40]	17.0 [9]	45.1
Wheat	57.0 [40]	34.0 [9]	91.0
Other cereals ²¹	46.2 [40]	36.0 [9]	82.2
Wood waste	14.9 [40]	67.0 [30]	81.9
Industrial waste	10.3 [40]	25.0 [30]	35.3

Table 3: Bioethanol emission factors used in this report

¹⁷ An average has been used when different cases are considered in the RED.

¹⁸ PFAD emissions not being detailed in the RED, a direct emission factor from Cerulygy has been used. Total direct and indirect emissions are also from Cerulygy.

¹⁹ POME emissions not being detailed in the RED, a direct emission factor from the ICCT has been used. Potential indirect emissions related to POME biofuels are not known as of today.

²⁰ An average has been used when different cases are considered in the RED.

²¹ An average of emissions from wheat and barley has been assumed here based on available data, while the volumes considered also include limited quantities of rye, triticale, rice, sorghum and cassava.

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