SUPPLY CHAIN SUSTAINABILITY SCHOOL

Responsible Sourcing of HVO

A Comprehensive Guide

Delivered by **Action Sustainability** on behalf of **Supply Chain Sustainability School**

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actionsustainability

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0. Executive Summary

This Guidance document has been developed for and on behalf of a group of Supply Chain Sustainability School Partners who want to better understand the sustainability complexities of procuring and using hydrotreated vegetable oil – HVO – as an alternative to conventional fossil diesel, in particular, as one of the potential routes to net zero carbon. The Guidance therefore advises on how to manage and mitigate potential sustainability risks and impacts in the HVO supply chain.

HVO is one kind of biofuel that contractors and fleet operators can use in place of diesel with a view to reducing their carbon emissions. At first sight it seems a straightforward change to make as we progress to low and zero carbon forms of power. Indeed, there are many sources of HVO – from the Renewable Fuel Accreditation Scheme (RFAS) in particular – that have strong sustainability credentials, giving the purchaser confidence in its provenance and reduced carbon emissions. But while HVO can be a 'transition' fuel in this sense, there are, however, sustainability risks in where and how the feedstocks for HVO are produced. We do not want to be reducing one set of sustainability impacts, only to inadvertently create another set.

The research behind this Guidance involved a desktop review of a wide range of existing literature on the sustainability impacts and dynamics of the biofuel and, more specifically, HVO markets, enhanced by discussions with a wide range of stakeholders from across the value chain.

The outcome is a document that takes you through:

- The sustainability benefits and impacts of biofuels and HVO in particular
- The scale of availability and the size of the HVO market
- How that market can be distorted
- Mechanisms to mitigate such risks

It is brought together with advice on how to use this information to inform your procurement decision-making process, should you wish to procure HVO. The decision on whether to procure HVO at all and/or how to procure it will depend on the purchasers' position on three key risks:

- **Reputation risk**
- **Risk of incomplete carbon accounting**
- **Security of supply**

The section on Procuring HVO provides guidance on how to manage these risks whilst bearing in mind that none of them can be fully mitigated.

The information and guidance found in this report can be condensed into a series of recommendations that support the reader, potential purchaser and user of HVO to make an informed decision and thereby manage and mitigate the potential sustainability impacts as far as possible. The detail and rationale behind these recommendations is provided in this Guidance document.

For clarity, the purpose of this Guidance document is neither to promote the use of HVO, nor to dissuade organisations from using it. Its aim is simply to present the facts, as far as they are known, with relevant procurement guidance applied to that knowledge to advise the reader.

Recommendation 1. It is recommended that only second-generation biofuels made from waste feedstocks are purchased, rather than first-generation biofuels made from virgin oil food crops. All RFAS (Renewable Fuel Accreditation Scheme) approved HVO is certified as from waste input feedstocks: as described in the section on Renewable Fuel Assurance Scheme – RFAS, the feedstock(s) used in the fuel's manufacture are explained in the Renewable Fuel Declaration (RFD) documentation.

Recommendation 2. Carbon footprint information is available in the RFAS Renewable Fuel Declaration (RFD) that accompanies the supply of HVO, and it should be used in carbon accounting, as it is specific to the batch of fuel to hand. However, other scope 1 emissions from N_2O and the 'out of scopes' information also need to be calculated and reported for comprehensive and comparable reporting that is aligned to Department for Energy and Net Zero (DESNZ), The Greenhouse Gas Protocol (GHGP) and Science Based Targets Initiative (SBTi). If the data is not available, then the recommendation is to use the default values provided by DESNZ.

Recommendation 3. The HVO supply chain should be included in your procurement risk register with a clear action plan of what your organisation needs to undertake to identify risks and manage and reduce them. This will include using due diligence and product certifications, such as getting Renewable Fuel Declarations from your suppliers. It should also include a process for how you proceed with supplier relationships if the risk and/or reality of modern slavery is identified, depending on where in the supply chain that risk or reality is in relation to you.

Recommendation 4. Understand that legal market displacements, such as animal feed and the oleochemical industry, are an unquantified indirect land use change (iLUC) risk, albeit a low one compared to first-generation biofuels. Therefore, build that in as part of your risk assessment process, but with the knowledge that the probability of identifying and connecting HVO production directly to instances of iLUC is low.

0. Executive Summary

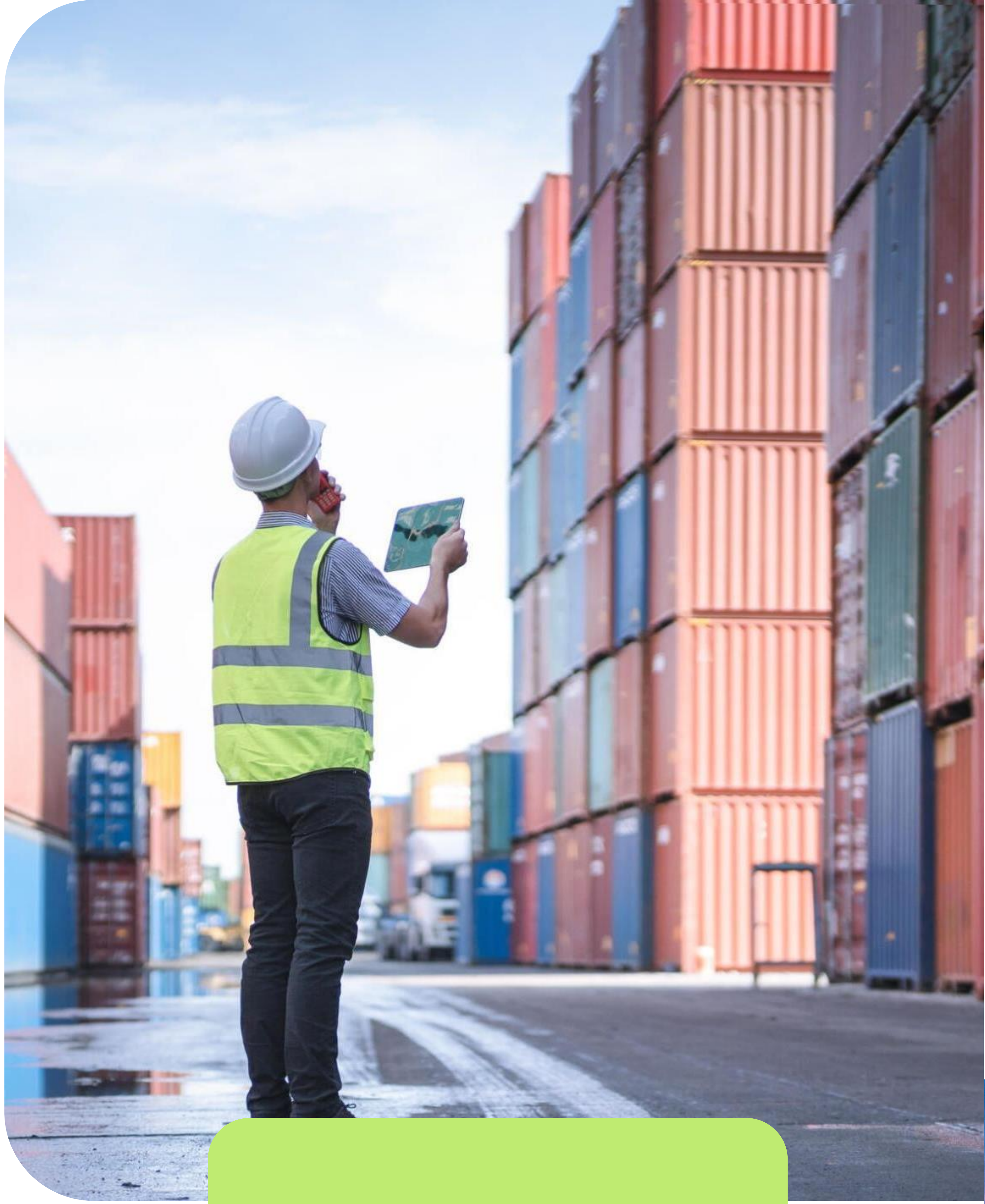
Recommendation 5. To mitigate the risk of fraudulent and falsified HVO, or the used cooking oil (UCO) that makes it, source HVO from certified suppliers that have robust supply chain certification describing the provenance and ingredients of the HVO. The predominant route in the UK is through RFAS Renewable Fuel Declarations (RFD) linked to the Renewable Transport Fuel Obligation's (RTFO) approval of sustainable fuels.

Recommendation 6. Although palm fatty acid distillate (PFAD) is believed to be a low risk for iLUC, and could be coming from a sustainably verified source, it is a co-product of palm oil production, according to RTFO. Therefore, if you are concerned about feedstocks coming directly from palm oil production, check with your fuel supplier to see if it is a feedstock in the HVO you are purchasing, as listed in the Renewable Fuel Declaration (RFD). If it is, check that it has been correctly included in carbon reduction calculations as a co-product.

Recommendation 7. Palm oil mill effluent (POME) is a waste product from palm oil production with low economic value, classified as such by the RTFO and, like PFAD, is believed to be a low risk for iLUC. However, if you are concerned about feedstocks coming directly from palm oil production, check with your fuel supplier to see if it is a feedstock in the HVO you are purchasing, as listed in the Renewable Fuel Declaration (RFD).

Recommendation 8. When procuring HVO, ensure that it is from an RFAS-approved supplier registered on their website, and that supporting evidence documentation – the Renewable Fuel Declaration – is requested from the supplier. Also, evaluate and include the 'out-of-scopes' (biogenic) carbon emissions in your carbon reporting.

Recommendation 9. When procuring HVO, ensure that it is from a supplier who can provide RFAS-approved HVO, in the form of Renewable Fuel Declarations. This is backed by the RTFO process that checks supply chain evidence in the form of Proofs of Sustainability from schemes such as ISCC (International Sustainability & Carbon Certification; other accreditations are available, but ISCC accounts for 97% of all RTFO-accredited renewable fuels by volume). If further due diligence is required, check the ISCC website that the certificates of suppliers further up the supply chain haven't been suspended (a temporarily invalid certificate), expired (validity has run out and a new audit is required), withdrawn (prematurely cancelled by the Certification Body due to a non-compliance) or excluded. Note that although the website is updated daily, as with any system there can be a time lag between certificates being added or withdrawn. Any interested parties, i.e. purchasers, should sign up to the ISCC Email Notification Service about suspended or withdrawn certificates.



Introduction

SUPPLY CHAIN SUSTAINABILITY SCHOOL

1. Introduction

It is firmly established that there is a climate and biodiversity crisis. There is an equally important issue of global inequality for the people of this planet. As we move to address these challenges, leading us to a lower carbon and more inclusive society, we need to consider the impact of everything we do and buy, so we can take action to reduce them as much as possible.

A crucial first step is to understand where these impacts lie and what their magnitude is. But equally important is investigating the impacts of the *alternative* solutions on offer. Every choice we make will have an impact, at some point, somewhere. It is therefore incumbent on us to know what the impacts are of these alternatives, and how they compare with the conventional way of working – we don't want to find ourselves inadvertently 'solving' one problem, only to cause another – so-called 'burden shifting'.

HVO – hydrotreated vegetable oil – is a case in point. It is an alternative to conventional diesel that offers potential sustainability benefits compared to its fossil fuel counterpart. There has been growing awareness of this, leading to an increase in its use as part of decarbonisation strategies. This has been driven in part by initiatives such as the Construction Leadership Council's target to reduce diesel use on construction sites by 78% by 2035 through its *Zero diesel sites route map*[1]. In contrast, however, there has been an increasing understanding that it might not be as straightforward as it first appears.

Borne out of this concern, several of the Supply Chain Sustainability School's Partners believed it necessary to explore the intricacies of HVO production, supply, and use, to assist themselves and others in making informed decisions when it comes to purchasing HVO to avoid risks of burden shifting. This Guidance document is the culmination of that endeavour.

Based on a process of an independent review of the literature and engagement with key stakeholders, the document below sets out the sustainability aspects of HVO manufacture, from raw material through processing and shipping, up to the point of final use. It then provides guidance on how to use this information in procurement decisions.

The purpose of this Guidance document is neither to promote the use of HVO, nor to dissuade organisations from using it. Its aim is simply to present the facts, as far as they are known, with relevant procurement guidance applied to that knowledge to advise the reader.

It is for you as the reader to understand this information in the context of your organisation and embed it into your procurement processes according to your risk management approach.

2. Biofuels, their Feedstocks and Production

Hydrotreated Vegetable Oil (HVO) is one of several kinds of biofuels that can be made from a variety of feedstocks via different production methods. It is good to understand these differences before sustainability, market and other issues are discussed. The following sections describe these for context before we focus in on HVO specifically.

Feedstocks

First-generation biofuels, often called 'conventional' biofuels, are made from food and animal feed crops, grown specifically to become a biofuel. These include palm, soy, rapeseed and sunflower, as well as corn, sugarcane and wheat.

Second-generation biofuels, often called 'advanced' biofuels, are made from a wide range of waste products from agriculture, forestry, food production and preparation. They include feedstocks such as straw, bagasse (the residue from pulping sugarcane), forestry residues, used cooking oil (UCO), and other fats, oils and greases (FOG) from animal and vegetable sources. They can also be made from non-food crops grown solely for biofuels, e.g. *miscanthus, camelina*, and short rotation coppice[2].

Production

There are three main kinds of biofuels that can be made from these feedstocks, differentiated by their physical, chemical and performance properties: HVO, FAME, and bioethanol.

Hydrotreated Vegetable Oil – HVO – Also known as 'renewable' diesel to distinguish it from FAME (see below), can be made from both first- and second-generation feedstocks[3]. The oils are treated with hydrogen, which removes the oxygen and other chemical parts of the feedstock, to produce aliphatic (straight chain) hydrocarbons. Its performance properties are similar to fossil diesel, meaning it can be used as a direct replacement to fossil diesel, or blended in any proportion. As a paraffinic fuel, HVO has its own specific standard allowing its use instead of diesel – see Box 1.

While HVO can be made from crops grown for human consumption and animal feed, it is increasingly being made from second-generation waste materials, primarily UCO and animal fats: 91% of biodiesel (HVO and FAME) in the UK in 2020 was produced from wastes, growing to 93% in 2022, with UCO accounting for 75%[4].

In terms of UK consumption, HVO amounted to 1% of verified renewable fuels supplied in the UK in 2020[5]. This rose to 8% in 2022[6], all of which was imported due to there being currently no UK-based production of HVO.

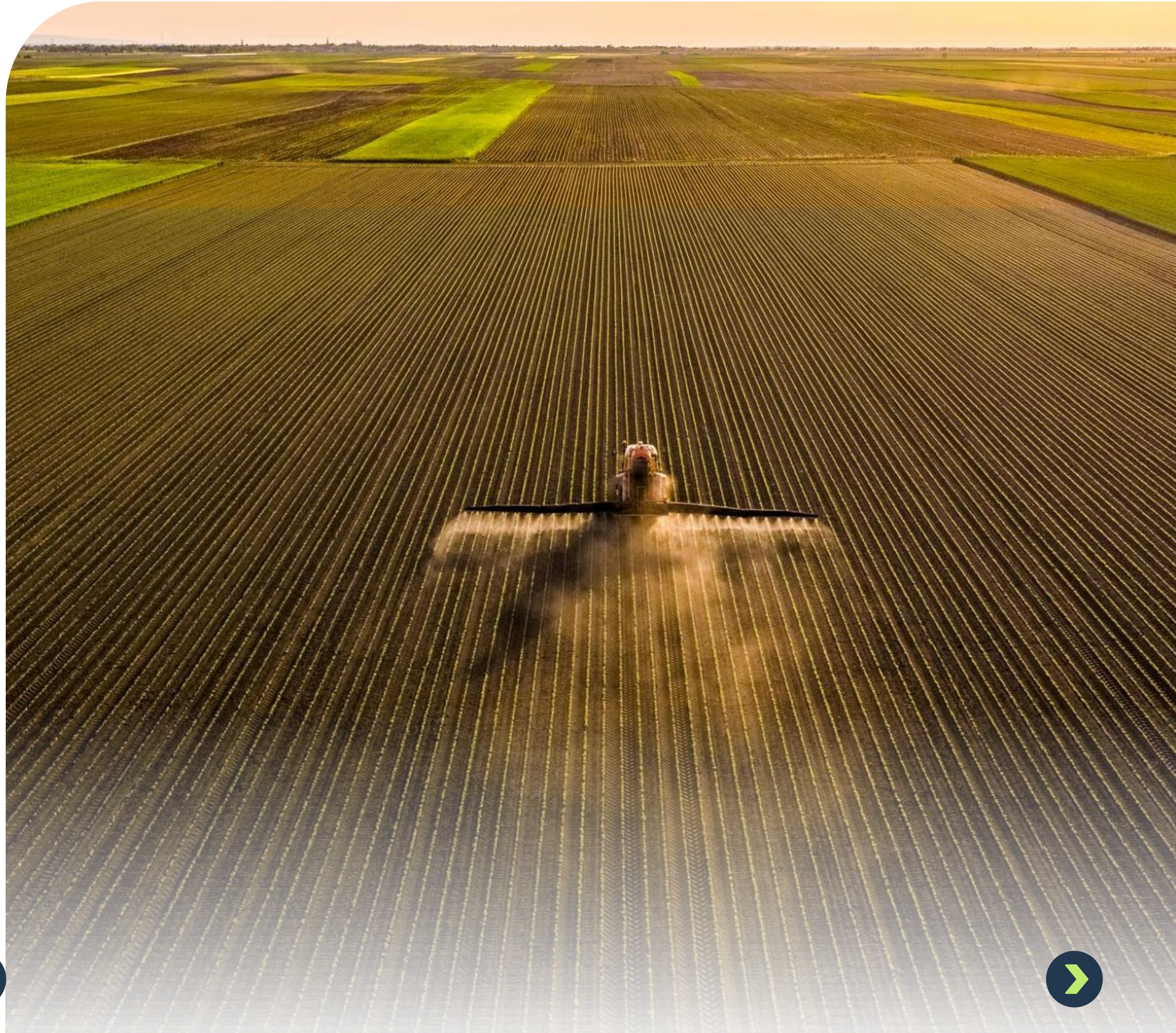
It is worth knowing that HVO has some other terms to describe it. It is sometimes also called HEFA – hydroprocessed esters and fatty acids – as it can be made from sources other than vegetable oils, including waste fats and oils from animal processing, such as tallow. The term is often used in the aviation sector. In other places it is described as 'XTL', which refers to a variety of resources (X) that are transformed (T) into liquid (L) fuels. This report, however, uses the term HVO throughout as it is the most widely used and understood.

Box 1. Standards

EN 590 is a European standard that describes the physical and chemical properties, such as low sulphur content, that all automotive diesel fuel must meet in order to be sold in the European Union and several other European countries. Regular fossil diesel that contains up to 7% FAME blend (B7) or up to 30% HVO is covered by this Standard. The equivalent in the USA is ASTM D975.

EN 15940 is another European Standard for automotive fuels, called paraffinic diesels, that are made from synthesis rather than direct fossil sources (e.g. GTL – gas-to-liquid – made from natural gas) or via hydrotreatment (e.g. HVO from renewable feedstocks). As with EN 590, it describes the necessary properties and test methods for the fuel to meet the Standard.

EN 14214 is the European Standard for FAME biodiesel. As with other standards it describes the properties of the fuel and the test methods needed to demonstrate compliance.



2. Biofuels, their Feedstocks and Production

Fatty Acid Methyl Ester - FAME biodiesel – Is the second most common biofuel globally. It is what is blended in forecourt fuels to a level of up to 7% with fossil fuel diesel – B7. It is manufactured through a process called transesterification where the feedstock oil, first- or second-generation, is reacted with methanol to create the FAME biofuel, as well as glycerol and other byproducts. First generation feedstocks have historically been the source for FAME production, but this has changed in recent years with the introduction of crop caps in the EU Renewable Energy Directive to limit virgin oil crop usage in favour of UCO. In order to distinguish second-generation feedstock-sourced FAME, it is sometimes called UCOME – 'used cooking oil methyl ester'.

Bioethanol – Is the most common biofuel globally by volume. It is made via fermentation from first-generation food or animal feed crops – corn, sugarcane, wheat and others – and from second-generation feedstocks including straw, bagasse, and forestry residues. It is used a lot in the USA and South America, Brazil in particular, but less so in Europe. Other than providing production data in Table 1 for comparison reasons, this report does not consider bioethanol any further from this point as it cannot be used in compression ignition engines.

Figure 1 depicts the variety of feedstocks and the different routes they can be processed into biofuels.

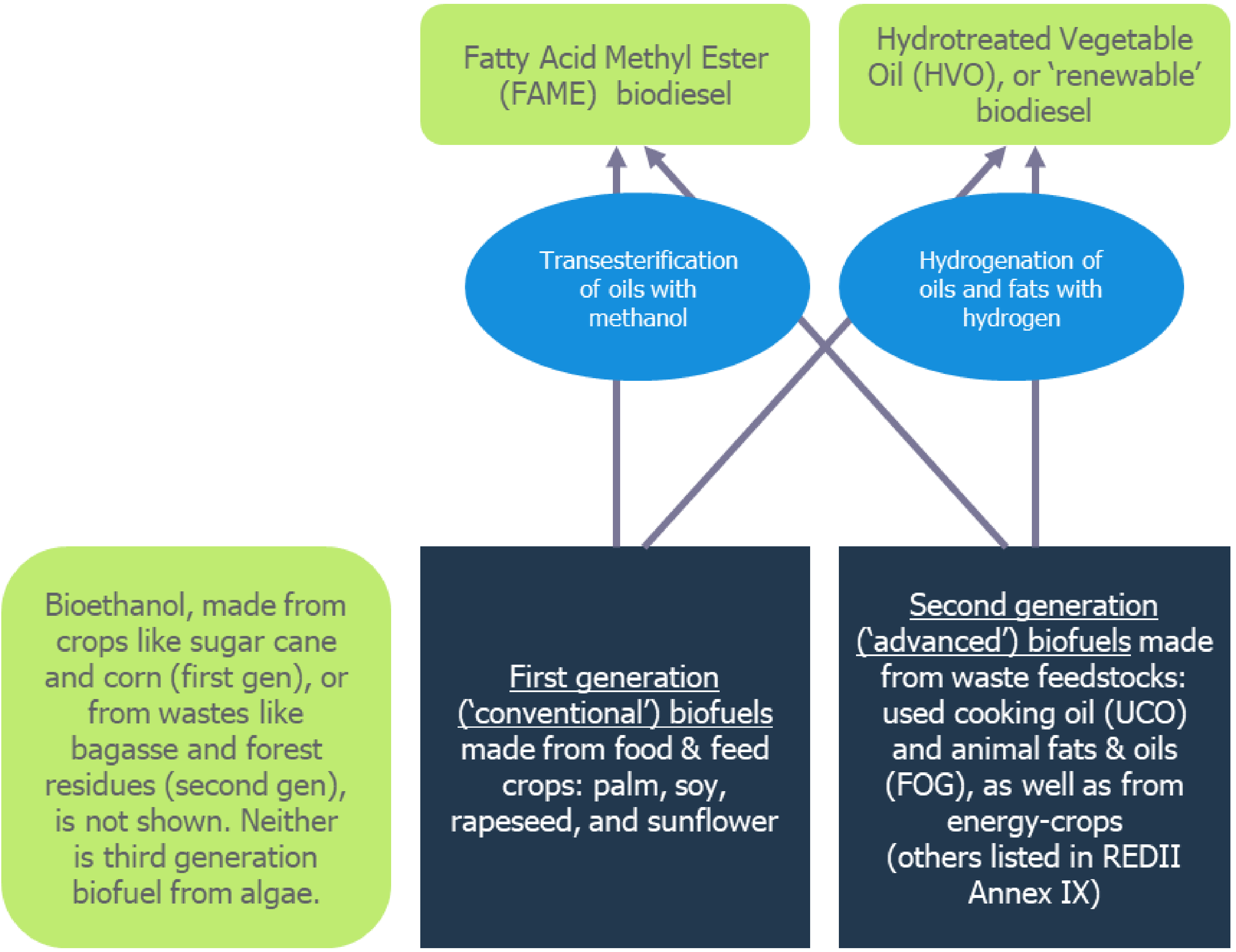


Figure 1. Production routes for HVO and FAME

Physical Properties of HVO compared with FAME

HVO is often described as a "drop-in" fuel, meaning it can be used as a direct replacement for fossil diesel without engine modification or flushing, either blended or in pure form. FAME biodiesel, on the other hand, can have several, well-described in-use problems that HVO doesn't have. These include:

Engine approval. FAME biodiesel can be blended with standard diesel up to varying percentages, often 30% (B30) or even 100% (B100). However, not all vehicles and engines are approved for these higher proportions[5]. Therefore, these higher levels tend to only be used in dedicated fleets. The current limit for FAME in fuels sold at forecourts that meet EN590, i.e. conventional diesel, is 7% by volume. It is recommended that you check with your OEM engine provider to understand compatibility.

"Cold plugging", where the fuel has been known to congeal at low temperatures causing blockages in the fuel pipes and hence an inability to start up properly. This can be treated with cold pour-point improvers.

Mould growth. Due to the chemical nature of FAME, it can absorb water allowing microbial growth leading to fouling of the engine and poor performance, albeit this can be prevented by the addition of antioxidants.

It is for these and other reasons of looking for alternatives to standard diesel that HVO has become more attractive in recent years[7].

Moreover, the "drop-in" nature of HVO as an alternative to fossil diesel means that any operational risks such as security of supply can be mitigated. For example, if supply is delayed, or sustainability risks in the supply chain are identified, the fuel user can easily and quickly switch back to conventional diesel until those issues are resolved.

3. Biofuel Markets and Production Volumes

Production and consumption - Globally

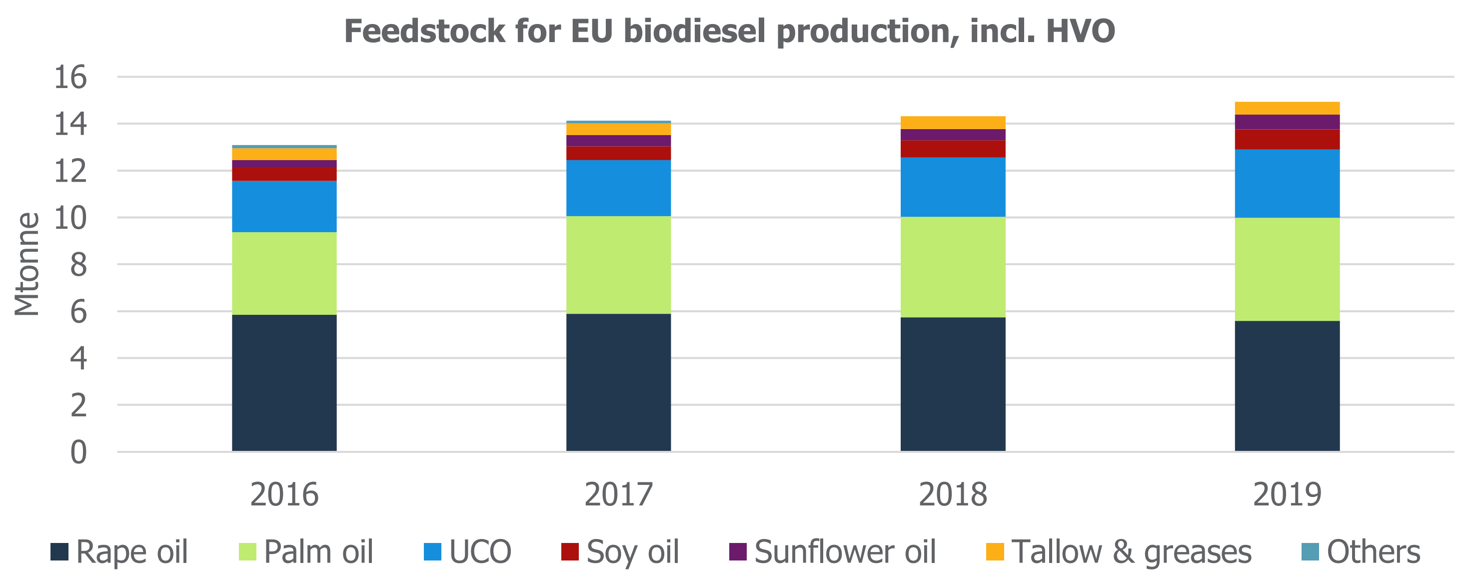
Table 1 shows the global production volumes of the three main biofuels in 2022 – HVO, FAME, and bioethanol. It is clear that both FAME and bioethanol dwarf the output of HVO – bioethanol being included here to give the wider context of biofuels.

Global Fuel Production Volumes in 2022	Amount reported	Converted to Litres[8]
HVO[9]	9.47 million tonnes	12.14 billion litres
FAME[10]	40.62 million tonnes	45.64 billion litres
Bioethanol[11]	28.16 billion US gallons	106.60 billion litres

Table 1. Global fuel production of biofuels in 2022

Interestingly, the production of HVO had roughly doubled by 2022 from the levels in 2018 and 2019 when it was 4.54 million tonnes (5.82 billion litres) and 5.90 million tonnes (7.56 billion litres), respectively. This compares favourably with the values of 5.12 million tonnes (6.56 billion litres) produced in 2019 stated elsewhere[12]. Looking ahead, global production is projected to reach 13 billion litres in 2024[13].

Feedstocks for all biodiesel, including HVO, come from a range of first- and second-generation sources, including virgin palm, rape, soy and sunflower oils, as well as waste materials such as UCO collected from restaurants and food processing facilities, and tallow from animal fat wastes. Figure 2, reproduced from the CE Delft report[12], shows that UCO made up 11% of the feedstock into all biodiesels. Closer to home, 91% of feedstocks used in biodiesel in the UK (HVO and FAME) were from wastes[4].



Source: (ISTA Mielke GmbH, 2020).

Figure 2. Feedstock for EU biodiesel production, 2016 to 2019 (after CE Delft)

Driven by demand from various sectors including aviation, maritime and construction, published market research on the global market for HVO predicts that it is going to grow by over 22% year-on-year from 2023, when its value was calculated to be US$25 billion, to an estimated value of US$158 billion in 2032[14].

While this looks impressive, we have to be aware of competition from the other sectors referred to above, especially aviation: it is much harder to decarbonise airborne travel than land or sea vehicles. Hence, the use of HVO (in the form of sustainable aviation fuel – SAF – along with other sources) will be an important part in the route to decarbonising the aviation industry in the near-term[12, 15]. This will naturally lead to competition for resource. We therefore have to decide whether HVO is the best available option for decarbonising the construction sector over the same time period.

Production and consumption – Europe and the UK

European collection and use of UCO to make biofuels was 2.6 million tonnes in 2020 (3.33 billion litres), of which 1.9 million tonnes (2.44 billion litres), or 73% of the total, was imported from countries including Malaysia (20%), China (15%) and Indonesia (11%)[16]. Furthermore, an additional 1.2 million tonnes of waste animal fats were used in Europe in 2020 in the production of biofuels.

At this point, the nominal production capacity in Europe for HVO was 5.1 million tonnes (6.54 billion litres), with capacity predicted to almost double by 2025[16]. Whilst demand is predicted to grow to keep up with this capacity, estimated at over 6 million tonnes by 2030 (7.70 billion litres), supply of UCO to the EU is predicted to only rise to 3 million tonnes (3.85 billion litres)[12]. Some of this shortfall in supply will be met from other regions. For example, the USA produced some 4.4 million tonnes (5.6 billion litres) of HVO in 2022 and other countries outside of the EU and USA produced a further 1.8 million tonnes (2.3 billion litres) of HVO[17]. How much of this production is sold into Europe will determine if future demand for HVO exceeds supply[12].

So, whilst there will be growth in UCO supply and HVO production capacity on a global scale, it remains to be seen if it will keep up with demand, both from a lack of enough supply of the raw material and from competition from other sectors and geographies. This could restrict UCO availability for HVO in the UK and Europe, which could curtail demand.

As mentioned above, all HVO used in the UK is imported. It is brought into the country by large fuel traders who sell it to distributors who then sell it on to customers in their value chain. It is usually sold as a bunkered fuel, distributed to construction sites for use directly on site. It is also available at about 40 refuelling depots, as 100% HVO, as well as a small number of forecourts across the country.

3. Biofuel Markets and Production Volumes

Feedstock market value

UCO, crude palm oil (CPO) and the other major virgin oil crops (soy and rape) have mirrored each other in price per tonne for a long time.

CPO has generally, but not always, been worth more than UCO. From mid-2018, UCO became more valuable to the point that in May 2019 UCO was worth US$620 per tonne[18] and CPO US$530 per tonne, see Figure 3. This is in part due to the biofuels policies such as the Renewable Energy Directive II (RED II) and the Renewable Transport Fuel Obligation in the UK (RTFO) incentivising certain feedstocks, such as UCO, for manufacturing biofuels like HVO. It is also due to it being linked to the price of crude oil.

In early 2022 prices reached US$1,700 per tonne of CPO[19] and UCO attained US$1,500 per tonne[20] but they have since levelled off. In 2024, CPO has been trading in the range US$900 to US$1,100 per tonne[19], whereas UCO is trading at about US$900 per tonne[21]. The prices of the two commodities are therefore linked and can swap back and forth between which is the cheaper at any given time.

Figure 3. Price of crude palm oil (CPO) compared to use cooking oil (UCO), 2017 – 2019 (after NNFCC)

With each commodity mirroring the other in price, it is clear to see that there is potential for them to be interchangeable as feedstocks, depending on spot prices. This could lead to a potential risk further up the supply chain that, if the market conditions are right, there is the temptation at the start of the supply chain to use virgin oil instead of UCO and claim it as such. This is a concern expressed by some client-side stakeholders and has been cited in the literature quoted in this Guidance. This point is expanded in the section on Market displacement effects and fraud and the potential negative impacts on the environment and society that come with this. It also states the actions that the sector is taking to mitigate this risk.

4. Sustainability Benefits and impacts of HVO and other Biofuel Production

Climate and carbon

One of the main attractions of biofuels is the potential for reduced greenhouse gas (GHG) emissions over the lifecycle of the product when compared to standard fossil fuels. The literature[22, 23] contains many studies that make the comparison between a variety of first- and second-generation FAME and HVO biofuels against a fossil fuel benchmark.

This doesn't mean that the biofuels do not emit any carbon when burnt. Far from it; they are still hydrocarbons that emit CO_2 when burnt, the same as any regular fuel. The nuance though is the carbon emissions from burning a biofuel are counted as zero in scope 1, because it is accepted that the carbon dioxide emitted is the same as was taken up through photosynthesis in the growth of the plant, so-called "biogenic carbon" – see Box 2.

Box 2. Biogenic Carbon

"Biogenic carbon" refers to carbon dioxide that has been absorbed by a plant and turned into vegetable matter during its growth, such as wood in the case of timber, or oil in the case of food crops like palm, sunflower and soy. It is important to make the distinction between fossil carbon and biogenic carbon. Fossil carbon was removed from the atmosphere millions of years ago, and its release now, through combustion, is the main driver of climate change. It is a large part of what we account for in carbon footprints. The removal of biogenic carbon is much more recent however, generally within decades. If it is subsequently released, again through combustion or decomposition, its release is counted as zero overall – the amount taken up the plant is equal to the amount released a few years down the line. As you will see later on, an organisation emitting biogenic carbon nonetheless still needs to account for it in its reporting, albeit in a different way to fossil carbon.

However, there are other impacts that complicate the picture that affect all biofuels to a greater or lesser extent, making them still have some carbon emissions overall, and not net zero. This section explains what they are in principle:

- Combustion always produces other trace GHGs at the tailpipe as well as CO_2, primarily nitrous oxide, N_2O, from the oxidation of nitrogen in the air.
- There are upstream (scope 3) climate impacts in the production of the biofuels, so-called well-to-tank emissions:
  - For first generation biofuels these include the growth of the crops (e.g. fertilisers), harvesting (e.g. agricultural equipment), processing and refining (e.g. electricity and other fuels to power equipment) and transport (e.g. trucks and ships). While some of the power demand is provided by using waste residues, there is also a fossil fuel demand.
  - Second generation biofuels made from waste sources still have processing and refining (e.g. electricity and other fuels to power equipment) and transport e.g. (trucks and ships) impacts.
- More widely there is the potential for climate impacts from land-use change (LUC):
  - Direct land-use change (dLUC) is where primary forest or savannah is cleared to make space for growing crops and rearing animals, giving rise to GHG emissions[24].
  - Indirect land-use change (iLUC) is where existing farmland for food and animal feed crops is displaced by crops for fuel production. The need for food crops is then met by clearing additional primary forest and thus the demand for fuel crops indirectly leads to a change of land use and the associated carbon and other sustainability impacts.
  - Moreover, iLUC can be caused by displacement effects where a product, such as UCO is diverted to a new use, but the previous need still has to be met. This demand could be replaced by virgin oils and hence the risk of iLUC. More on this later.

As explained below, life cycle assessment studies have shown that it is iLUC that is the deciding factor when it comes to determining if a biofuel has lower overall carbon emissions when compared to conventional fossil fuels.

These studies[22, 23] show that when iLUC is not included in the calculations, first-generation biofuels have a lower global warming impact than the fossil fuel reference. However, when iLUC is included, all first-generation biofuels have a higher global warming impact than the fossil fuel reference, i.e. they are worse. This is especially the case for biodiesel made from palm, soy, rape, and sunflower crops. Although dependent on crop type, location and land type, and production method, it has been shown that first-generation palm-derived biodiesel has three times the overall carbon impact that its fossil fuel counterpart has. Soy-derived biodiesel is twice as much.

Furthermore, while there are limits in the studies undertaken, the data presented demonstrates that these first-generation biofuels struggle to meet the demands of the EU's Renewable Energy Directive (RED II) Directive – see Box 3 – i.e. a reduction in GHG emissions of 65% compared to fossil fuels, making them a less-than-ideal choice for reducing emissions.

Biofuels from these food crop feedstocks are therefore considered "high iLUC risk" biofuels. RED II has taken this into consideration in terms of phasing them out of renewable energy targets by 2030.

Box 3. EU Renewable Energy Directive 2018/2001, "RED II"

The EU's (recast) Renewable Energy Directive II sets thresholds on the carbon performance of biofuels, as well as limits and targets on how much biofuel can be blended with standard fuels.

Biofuels produced in facilities that started operation before 2015 must show a minimum 55% reduction in GHG emissions compared to fossil fuels. Those started after 2015 need to show 60% reduction, and those in operation from 1st January 2021 must show 65% savings. This only includes direct emissions, including dLUC, and doesn't include displacement / iLUC.

The use of first-generation, crop-based biofuels towards the renewable energy targets in RED II is limited to each Member State's level in 2020, or 1% higher, with a maximum of 7%. This maximum was frozen until 2023 and will then be progressively phased out by 2030, essentially ending their contribution to renewable targets.

Recognising the iLUC impacts from biofuels, RED II stipulates the progressive phase out of the highest "high iLUC risk" biofuels by 2030. However, if "high iLUC risk" crops can show they are "low risk", they can get a derogation.

RED II defines waste materials in Annex IX where it lists all the feedstock types, including UCO, that are eligible for double counting towards renewable fuel obligations. There is currently a 1.7% cap on the contribution to the EU's renewable energy targets from Annex IX Part B feedstocks, including UCO (albeit Member States can use more if they wish) in an effort to encourage the use of Part A feedstocks.

RED II mirrors the UK's Renewable Transport Fuel Obligation (RTFO), more of which below.

4. Sustainability Benefits and impacts of HVO and other Biofuel Production

Besides the climate impacts, we should also acknowledge that there are other impacts associated with LUC: the loss of biodiversity and ecosystem services, such as available water, as well as potential increases in food prices through iLUC from the competition for land space for growth[22]. These issues can open up the risk of societal and community impacts, poor labour standards and even the risk of modern slavery.

When it comes to second-generation biofuels made from waste feedstocks such as UCO, the same studies show that the equivalent impacts are generally much lower than the fossil fuel reference. This also means they meet the RED II thresholds. Hence, it is widely accepted that second-generation HVO made from UCO has up to 90% less GHG emissions (scope 1) than fossil diesel. This point is explained further in the next section on Carbon Accounting for HVO. Moreover, that UCO and other second-generation feedstocks have a low risk of iLUC.

As such, if UCO is sourced from a supply chain with robust levels of chain of custody and information transparency, high GHG savings can be made in comparison with fossil fuels. The issue is therefore whether or not the UCO feedstock is genuine – fraud is discussed later on – and the knock-on effects of displacement and iLUC – likewise discussed below.

In summary, while the intention behind first-generation biofuels is laudable, it is clear from the life cycle data and other information that there is a high risk of burden shifting from one area and supply chain to another and, indeed, possibly making matters worse. The recommendation is therefore to procure HVO made from second-generation feedstocks such as UCO.

Recommendation 1. It is recommended that only second-generation biofuels made from waste feedstocks are purchased, rather than first-generation biofuels made from virgin oil food crops. All RFAS approved HVO is certified as from waste input feedstocks: as described in the section below on Renewable Fuel Assurance Scheme – RFAS, the feedstock(s) used in the fuel's manufacture are explained in the Renewable Fuel Declaration (RFD) documentation.

Carbon Accounting for HVO

It is important to be clear about the carbon emissions from HVO when reporting and when comparing it with conventional diesel and other fuel sources.

The carbon footprint of each batch of HVO produced is provided in the Renewable Fuel Accreditation Scheme (RFAS) Renewable Fuel Declaration (RFD) documentation[25]. Albeit not verified by RFAS, this data is also provided in documents provided by the HVO manufacturer (sometimes referred to as *Biofuel Sustainability Statements*) that link to the original Proof of Sustainability from the ISCC (International Sustainability & Carbon Certification). More information is provided on these schemes below.

The values, expressed in gCO_2e per MJ[26] are calculated using a method in alignment with RED II. In the case of waste products like UCO, this is achieved in one of two ways:

01 Using the default values provided in RED II; or

02 Undertaking individual and specific calculations following the RED II methodology.

The calculations cover the life cycle of the fuel, from growth and harvesting of first-generation crops or collection of second-generation materials to processing and conversion, including transport and distribution stages. The values published for each batch will vary due to differences in the waste feedstocks used to make the HVO, and the facilities in which it was made.

Typically, these Renewable Fuel Declarations show GHG savings compared with standard fossil diesel of around 90%, as indicated above, on a well-to-wheel (WTW) basis[27].

Standard bioblend diesel available at forecourts emits 88 $kgCO_2e$ per GJ on a WTW basis[28]. HVO on the other hand emits 9 $kgCO_2e$ per GJ[29] on the basis that the direct emissions from the fuel burn are counted as zero in scope 1 – the "biogenic carbon" mentioned above. This is where the 90% life cycle carbon reduction comes from.

However, in order to have comprehensive, accurate and comparable carbon reporting, all carbon impacts of a fuel should be reported. This means reporting not just the upstream production emissions but also the direct fuel burn emissions, whether they are fossil or biogenic in origin. This is the approach taken by DESNZ, the GHG Protocol (GHGP) and the Science Based Targets Initiative (SBTi). The difference is that while fuel burn emissions for fossil diesel are reported in scope 1, biogenic emissions for HVO are reported separately from scope 1 and are categorised as 'out of scopes' in the DESNZ guidance. This is because they don't fall into either scope 1, 2 or 3. Table 2 below summarises the values.

Comparing GHG emissions for Diesel and HVO across Scopes

Fuel and Units		Scope 1	Scope 3	Total of Scope 1 and Scope 3 [ii]	Out of Scopes – biogenic carbon emissions
$kgCO_2e$ / litre	Diesel (forecourt blend)	2.51206	0.61101	3.12307	0.14
	HVO [i]	0.03558	0.27844	0.31402	2.43
$kgCO_2e$ / GJ	Diesel (forecourt blend)	70.58930	17.16948	87.75878	3.93
	HVO	1.03677	8.11314	9.14991	70.83

Table 2. Comparing lifecycle GHG emissions of diesel and HVO

i. This is only N_2O in scope 1 for HVO, as CO_2 emissions are biogenic and counted as zero in scope 1; they are reported in 'out of scopes'.

ii. This is where the statistic comes from that HVO has 90% less emissions than diesel.

4. Sustainability Benefits and Impacts of HVO and other Biofuel Production

Accurately accounting for these biogenic emissions from HVO ensures a more comprehensive understanding of an organisation's environmental impact. This distinction supports organisations in achieving transparent, responsible environmental reporting, aligning with global standards for sustainability and carbon management. To be clear, this accounting approach is about transparency in reporting, ensuring you are open about all your emissions – fossil or biogenic in source. It does not diminish the benefit of choosing sustainably sourced renewable materials, especially second-generation biofuels from wastes, as part of a carbon reduction strategy.

Recommendation 2. Carbon footprint information is available in the RFAS Renewable Fuel Declaration (RFD) that accompanies the supply of HVO and it should be used in carbon accounting, as it is specific to the batch of fuel to hand. However, other scope 1 emissions from N_2O and the 'out of scopes' information also need to be calculated and reported for comprehensive and comparable reporting that is aligned to Department for Energy and Net Zero (DESNZ), The Greenhouse Gas Protocol (GHGP) and Science Based Targets Initiative (SBTi). If the data is not available, then the recommendation is to use the default values provided by DESNZ.

Air quality

There are other impacts from biofuels, besides climate change. As with the combustion of any hydrocarbon fuel there are tailpipe emissions of nitrogen oxides (NO_x), particulates (PM), and carbon monoxide (CO).

There is a variety of test result information available publicly that state there are emissions reductions across all three pollutant gases, ascribed to the 'simpler' chemical composition of HVO[30]. Studies vary between low and variable reductions[31] in emissions of NO_x, CO and PM, to more significant levels of reduction around 10% for NOx and 30% for both CO and PM[32].

It must be appreciated though that test results are highly dependent on more factors than just the fuel itself. The Stage of the engine[33] will determine the extent of the air quality emissions – a Stage V will inherently emit less than a Stage IIIB due to after-treatment technology that removes much of any pollutants produced, thus masking whether it is due to the fuel or not. The maintenance regime of the engine also plays a key role in the engine's burn efficiency and pollutant creation, as do the ambient conditions – temperature and humidity. Lastly, the usage pattern, operator behaviour, and load on the machine will affect pollutant emissions. Therefore, while there can be some air quality benefits, they are just as reliant on other issues as the choice of fuel.

The recommendation here, therefore, is more about using the right machine for the task at hand, minimising idling and increasing operational efficiency, and maintaining it well for the cleanest burn possible.

Modern slavery

Besides the environmental impacts described above, there are additional risks of poor labour standards, and of modern slavery in particular, just as there are with any other relatively low value product.

As discussed already, a large percentage of the feedstock for HVO, UCO, comes from Southeast Asia – Malaysia, China, and Indonesia in the main. The Walk Free Foundation publishes a free-to-access, interactive map[34] that depicts the relative risk of modern slavery across the world. They describe three characteristics of modern slavery: prevalence, vulnerability, and government response.

Figure 4 from their website and Table 3 below provide their data for Malaysia, China and Indonesia, with the UK as a reference point.

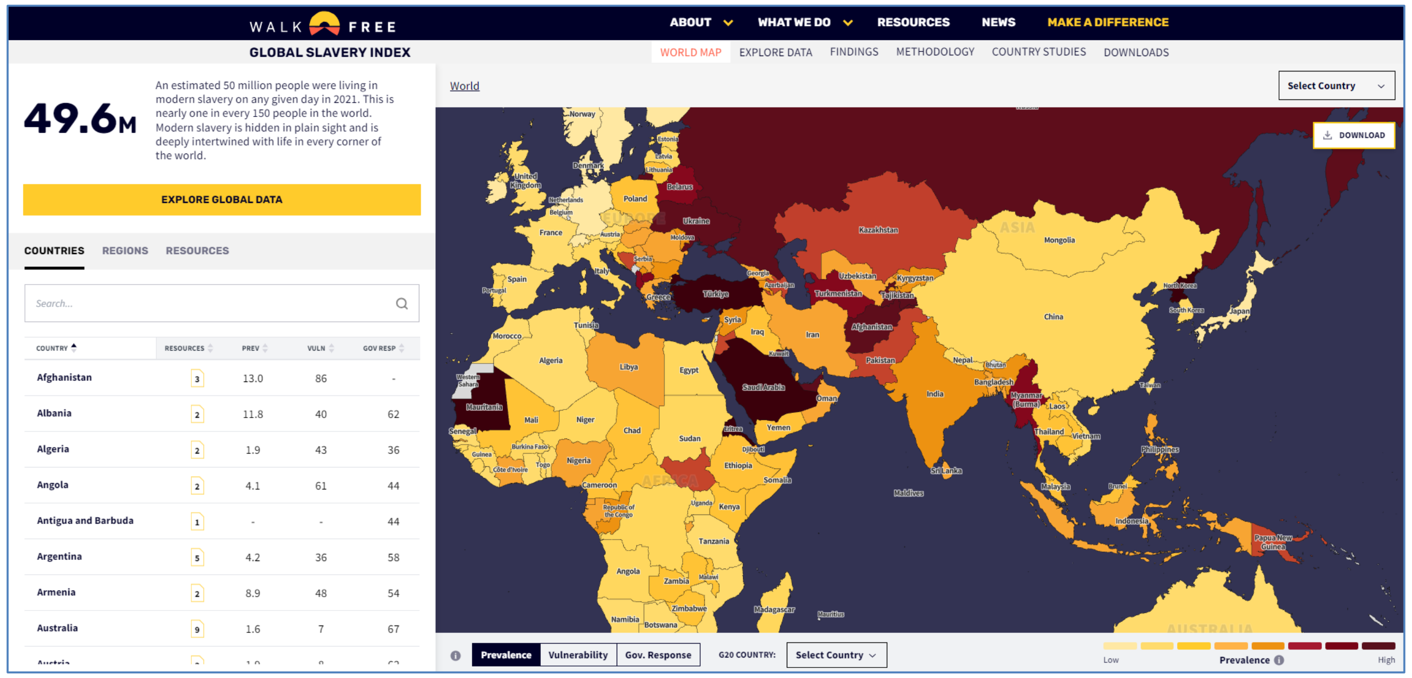


Figure 4. Risk of modern slavery by country, from the Global Slavery Index by the Walk Free Foundation

Country	Prevalence Estimated number of people per thousand living in modern slavery	Vulnerability Scored out of 100, the higher the score the greater the vulnerability to modern slavery	Government Response Scored out of 100, the higher the score the more action the Government is taking against modern slavery
Malaysia	6.3	37	45
China	4	46	40
Indonesia	6.7	49	50
UK	1.8	14	68

Table 3. Prevalence, vulnerability and government response to the risk of modern slavery from main suppliers if UCO

4. Sustainability Benefits and Impacts of HVO and other Biofuel Production

Of the estimated 49.6 million people currently living in modern slavery, 29 million of them live in Asia and the Pacific. Moreover, two-thirds of the people living in modern slavery are in 10 countries, including China and Indonesia[34].

While we need to appreciate that these assessments are for whole countries, rather than regions, and they aren't at the granular detail of UCO supply, together they indicate a higher risk in general of poor treatment of workers. Of particular note is the risk of modern slavery attached to the import/export of palm oil, in which China ranks highly.

As recommended already, first-generation feedstock biofuels and their co-products, such as palm, should be avoided for reasons of high life cycle GHG emissions. The information from the Global Slavery Index adds weight to this argument. It also lends weight to ensuring good supply chain visibility of the source of second-generation feedstocks such as UCO.

Just as with any other purchased product, suitable supply chain due diligence and risk assessment should be undertaken by the purchasing organisation to understand what the potential risks are and how to mitigate them. Using Standards such as *BS 25700:2022 Organizational responses to modern slavery – Guidance*[35] and *BS ISO 20400:2017 Sustainable procurement – Guidance*[36] describe how to embed sustainability into supply chain due diligence. However, any risk-based due diligence system can never be 100% watertight when it comes to identifying every risk and then enforcing compliance. This reality must be understood and accepted.

In addition, procure HVO from suppliers who have their own robust approach to modern slavery. This means they need to be able to demonstrate that they have a supply chain due diligence process to:

- Know their supply chain – supply chain mapping;
- Identify areas and supply chains at risk;
- Undertake risk-based targeted due diligence audits;
- Implement a process for managing all identified modern slavery risks;
- Set up a grievance mechanism for people in the supply chain;
- Train and build capacity for staff and suppliers;
- Develop and report publicly on measurable KPIs; and
- Collaborate and engage with all relevant stakeholders.

An organisation can never be 100% sure of having eliminated the risk of modern slavery from its supply chain – remember, the risk could be buried in the deeper tiers of your supply chain, harder to identify and engage with – but by using this approach, risks can be identified, measures put in place to manage them, and efforts made to reduce them as much as possible.

Recommendation 3. The HVO supply chain should be included in your procurement risk register with a clear action plan of what your organisation needs to undertake to identify risks and manage and reduce them. This will include using due diligence and product certifications, such as getting Renewable Fuel Declarations from your suppliers. It should also include a process for how you proceed with supplier relationships if the risk and/or reality of modern slavery is identified, depending on where in the supply chain that risk or reality is in relation to you.

5. Market Displacement Effects and Fraud

The various uses for UCO

Whenever there is a change to supply and demand in a given market, there follows a ripple through it. HVO, and biofuels more widely, are no exception.

Before the rise of biofuels, including HVO made from waste products, UCO had other outlets as a waste material. Generally speaking, UCO can be used in one of three ways:

- It can be used as animal feed, a practice that is banned in Europe[37] but occurs in South-East Asia[12, 18, 38];
- It can be bought by the oleochemical industry to make non-food products such as soaps and biodegradable polymers; and
- It can be used to illegally dilute virgin oils used in the food industry to make them go further.

This third route, known as 'gutter oil', is financially attractive to some operators as UCO can be cheaper than virgin oil destined for human consumption. Due to its negative human health impacts, it is unsurprising that it is illegal to do so in all jurisdictions. Nonetheless, it is still a common albeit illegal practice in China and Indonesia where high percentages of UCO are collected and put back into the food industry[12]. Heating oils to high temperatures in the cooking process changes their chemical characteristics, creating carcinogenic compounds – this is why cooking oil should be changed regularly. It is also the reason why testing has been developed, as described below, to test for UCO in virgin oils.

The situation now, however, is different. Over recent years UCO has been able to command a similar if not higher price and, with other incentives such as RED II and the RTFO, priorities have changed.

Figure 5 attempts to summarise the market dynamics of HVO made from UCO. Working from left to right, the image shows what can happen when there is greater demand for UCO to produce HVO. Clearly the reality is more nuanced depending on geographic location, price variability, fluctuating demand for the products, and alternatives becoming available. But it provides a sense of some of the ripple effects.

Put simply, if there is greater demand for UCO to produce HVO, it restricts the flow of UCO into other market areas. This can lead to an increased chance that the shortfall is made up from virgin oils, whether legally or not. So, despite being classified as a waste, the incentive to use UCO for biofuel production can cause displacement from other uses, leading to an increased risk of iLUC.

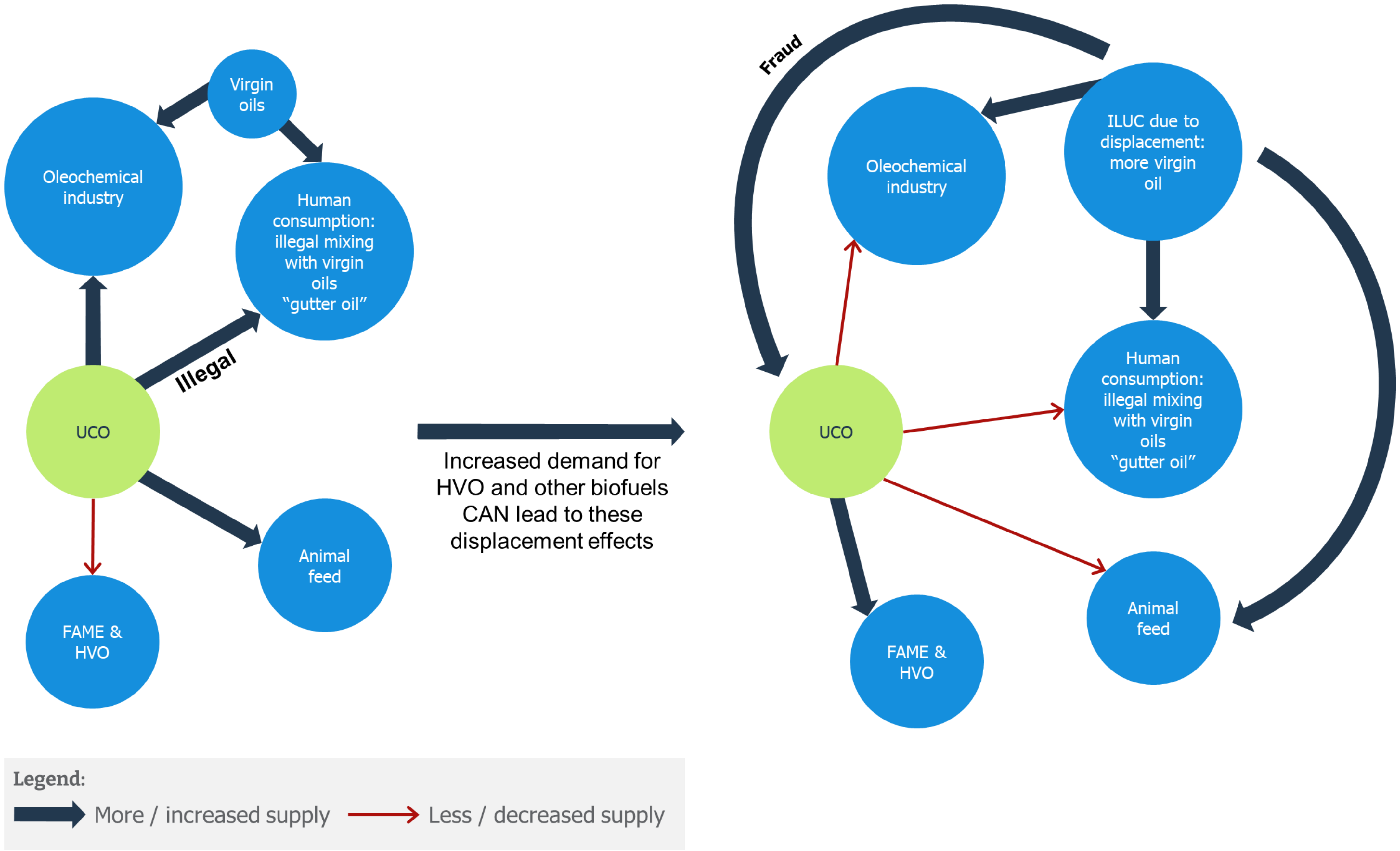


Figure 5. Potential market dynamics of HVO from UCO

5. Market Displacement Effects and Fraud

It must be stated that in two cases – reduced amounts of UCO being used to dilute virgin oil for human consumption, 'gutter oil', and likewise less UCO being added to animal feeds – is actually a good thing from a human health point of view. This is both directly in cooking oils and foods for human consumption, and indirectly from animals being reared for human consumption absorbing less harmful substances that could then be passed on to people[39].

However, the risk for additional iLUC exists not only in legal routes, such as backfilling the demand for the oleochemical sector or alternative animal feeds, but also in bypassing the route through to UCO altogether. Flipping the 'gutter oil' scenario on its head, this is where virgin oil is fraudulently used to dilute UCO due to changes in market economics where UCO is now more valuable, even to the extent of passing off 100% virgin oil as 100% UCO. And hence fraud is also a potential driver for iLUC.

There is also a wider, more global risk of displacement. If the availability of UCO feedstock in the country of origin, such as China, Malaysia or Indonesia, is reduced through exporting it to other more lucrative markets such as Europe, biofuel and HVO producers in those nations will need to replace the shortfall. This could be through using first-generation feedstocks, such as palm or soy, or by reverting to fossil fuels. The net outcome, globally, could be no change in GHG emissions, or worse still, iLUC and increased GHG emissions.

Nonetheless, while these market and iLUC impacts have been identified and discussed by many, studies have stated that the extent of the impacts is unknown as market dynamics are very complicated and modelling the 'what if?' scenarios are difficult to achieve with a degree of certainty[13]. Moreover, other studies state that UCO is considered a low risk ILUC biofuel feedstock[18]. As such, we can make the following recommendation.

Recommendation 4. Understand that legal market displacements, such as animal feed and the oleochemical industry, are an unquantified indirect land use change (iLUC) risk, albeit a low one compared to first-generation biofuels. Therefore, build that in as part of your risk assessment process, but with the knowledge that the probability of identifying and connecting HVO production directly to instances of iLUC is low.

Potential for Fraud

It is well documented that fraud can occur in the biofuel sector, as the case in the Netherlands showed[40], where investigators identified that as much as one third of the biodiesel stated as being made from UCO could actually be made from virgin oils.

With a combination of the market changes described above, the growing value of UCO for producing HVO (particularly where it has been higher than virgin oils), and the difficulty in detecting when UCO has been diluted, the temptation for fraud is apparent.

There are several possible routes to fraudulent claims of HVO being made from UCO, including[12]:

- Diluting and mixing UCO with virgin oils (the opposite of 'gutter oil');
- Using 100% virgin oil instead of UCO;
- Artificially increasing the amount of UCO by collecting it from restaurants, etc, sooner than needed;
- Issuing falsified proofs of sustainability, and adjusting the mass balance data; and
- Certifying the HVO in more than one voluntary sustainability scheme, gaining more revenue when it is placed on the market.

As explained in the analysis section below, although UCO has measurable differences in its chemical make-up when compared to virgin oil, testing regimes are not yet established at scale to test for virgin oils in UCO. Further to this, the increased demand for UCO through fraud will exacerbate the displacement impacts described above, leading to more virgin oil production and possibly also iLUC.

Tracing the source of the UCO further back beyond the shipping departure points to the first points of collection and points of origin can be difficult due to potentially large numbers of them and the inherent time and cost to do this. Therefore, to manage the risk of material being passed off as UCO, or HVO made from UCO, and the inherent sustainability risks, robust certification and supply chain tracking schemes need to be used, more of which below.

Recommendation 5. To mitigate the risk of fraudulent and falsified HVO, or the UCO that makes it, source HVO from certified suppliers that have robust supply chain certification describing the provenance and ingredients of the HVO. The predominant route in the UK is through RFAS Renewable Fuel Declarations (RFD), linked to the RTFO's approval of sustainable fuels.

6. Feedstocks for HVO besides Used Cooking Oil

Palm Fatty Acid Distillate (PFAD)

PFAD is a co-product of the palm oil refining process. CPO undergoes several stages of purification to remove water, colour, and unwanted odours and flavours before final, edible products – palm stearin and palm olein – are made. PFAD is separated out and collected from the last stage, a process called vacuum distillation, where the oil is heated to deodorise it.

Although PFAD is not the intended product of the process, it does nonetheless have applications in products as diverse as animal feed, soaps, cosmetics and other oleochemicals, as well as a feedstock for biofuels. Global production, 87% of which is in Indonesia and Malaysia, is about 2.5 million tonnes annually.

The concern with PFAD is that it is co-product of the virgin palm oil industry that can be mixed with UCO as an ingredient in making HVO. The stated issue is that if there is greater demand for HVO it could lead to higher demand for PFAD from palm oil refining, and all the displacement and iLUC issues previously mentioned. However, there are three reasons why PFAD and its potential use in biofuels is not a significant issue in this instance and is unlikely to drive additional LUC[13]:

- The reality is that PFAD is a minor by-product in palm oil refining, it accounts for about 4.5% by weight from CPO output. Moreover, the value of PFAD is about 10% less than that of the refined palm oil product. Combined, PFAD only accounts for about 4% of revenue for palm oil producers – it is not their main source of income. Therefore, any biofuel policy incentives are relatively limited in their impact, especially those that single-count PFAD, given that there are other existing routes for PFAD use.

- Second, and linked to the first point, is the fact that the UK and several other countries[41] treat PFAD as a product[42]. From DfT's RTFO website: *"PFAD has a significant economic value in relation to the main product (palm oil) and a variety of productive uses".* Hence it is a product that only single-counts when it comes to the Renewable Transport Fuel Certificates (RTFC) under the RTFO, unlike UCO which double counts, thus reducing the incentive to use it.

- A further, non-economical disincentive to use PFAD in HVO comes from life cycle assessments (LCA). LCA studies show that treating PFAD as a co-product means it shares any upstream carbon emissions with the refined palm oil product. When all the collection, transport and extraction impacts are combined with GHG emissions from iLUC, the results show that the portion of HVO derived from PFAD – when classed as a co-product – does not result in GHG emission reductions compared to fossil diesel[13].

The issue of displacement, PFAD being used in biofuels instead of the oleochemical sector, is a potential risk, but, as described above, it is one that involves complex economic modelling that has not yet been undertaken and is therefore difficult to quantify.

Having said all of this, there is still a reputational risk of procuring products, including co-products like PFAD, from the palm oil industry, even one that is fully legal and compliant with certifications of sustainability.

Recommendation 6. Although palm fatty acid distillate (PFAD) is a believed to be a low risk for iLUC, and could be coming from a sustainably verified source, it is a co-product of palm oil production according to RTFO. Therefore, if you are concerned about feedstocks coming directly from palm oil production, check with your fuel supplier to see if it is a feedstock in the HVO you are purchasing, as listed in the *Renewable Fuel Declaration* (RFD). If it is, check that it has been correctly included in carbon reduction calculations as a co-product.

Palm Oil Mill Effluent (POME)

POME is a waste product from the early stages of processing palm fresh fruit bunches (FFB) at the mill, including steam sterilisation, to create CPO. It is a watery/oily mix with very low value. It is therefore usually let out from the processing mill into settling ponds on the mill site. Here, the oily component decomposes anaerobically to produce methane, a greenhouse gas 28 times more powerful than CO_2[43].

There is therefore an incentive to capture the methane emissions from POME at palm oil mills to reduce the carbon impact of the settling ponds. The captured methane can be used as a biogas to produce electricity and heat for the mill. This is a win-win because it not only removes the methane impact, but it also reduces the energy demand, and hence GHG emissions, from fossil fuels used for heat and power to operate the mill by replacing them with renewable sources[13, 44].

In contrast to PFAD, POME is defined as a waste material by both RTFO and RED II, meaning it is double-counted and receives double the number of credits per litre against renewable fuel obligations (RTFO), in the way that UCO does.

As it has minimal value, POME is not an economic driver for CPO production and its use is unlikely to be a driver for iLUC. However, rather than encourage the removal of POME from the mill to use as a feedstock for HVO production, palm oil mills should be encouraged to install methane capture on site to produce their own power, making themselves as self-sufficient for energy as possible, and reducing their direct GHG emissions. Indeed, this is happening to some extent already[44].

Furthermore, even with the information above about POME being a low value waste, there remains the reputational issues of a by-product from the virgin palm oil industry, even if it is being used in a low impact fashion.

Recommendation 7. Palm oil mill effluent (POME) is a waste product from palm oil production with low economic value, classified as such by the RTFO and, like PFAD, is believed to be a low risk for iLUC. However, if you are concerned about feedstocks coming directly from palm oil production, check with your fuel supplier to see if it is a feedstock in the HVO you are purchasing, as listed in the *Renewable Fuel Declaration (RFD)*

7. Analysing HVO

Analysis techniques are often used as part of the audit process on products to test the ingredients, their purity and their source. This section looks at a selection of them and their benefits.

^{14}C analysis

One such technique used in products with biological content is ^{14}C analysis, known as "carbon 14 analysis".

^{14}C analysis enables the user to differentiate between ingredients in a biofuel blend from a fossil source as opposed to those from a renewable, biomass source, allowing you to determine their relative proportions. It does this by using the different radioactive properties of carbon's two main isotopes and how that characteristic differs between the two fuels sources.

In short, fuels made from renewable sources contain a known amount of ^{14}C, the radioactive isotope of carbon, whereas fossil fuels contain zero ^{14}C. There is further explanation in Box 4. Due to this property, ^{14}C analysis can be used to test the ratio of fossil fuel to biomass in biofuel blends – very useful if you want to check that the right amount of biomass content is actually in the fuel and that it hasn't been diluted.

Box 4. ^{14}C Analysis

Otherwise known as radiocarbon dating, this is a well-established technique for measuring the age of materials of biological origin.

^{14}C is a radioactive form of carbon constantly being formed from nitrogen and high energy sun rays in the upper atmosphere. It gets absorbed through weather cycles and photosynthesis into plants and ultimately all living things. This means that all living matter contains a known and consistent amount of ^{14}C.

Once a living organism dies it can no longer replenish its ^{14}C and the clock starts ticking on the radioactive decay. ^{14}C has a half-life of 5,730 years, decaying to back to nitrogen. After about 50,000 years, there is no ^{14}C left. This is why it is used by archaeologists to determine the age of the materials they uncover. Importantly, it also means that fossil fuels contain no ^{14}C.

In Europe, the standard EN 16640 is used to measure the biobased carbon content as a fraction of the total carbon content and is applicable to all biobased products.

Since October 2021 the Dutch Emissions Authority requires ^{14}C testing of HVO, in order to check and validate the biogenic content of any HVO, and any other biofuels, coming into the country[45].

It can't be used, however, to differentiate between biomass ingredients from different sources, such as virgin vegetable oil compared to UCO. Other techniques are needed for that.

Virgin oil vs UCO

UCO and virgin oils are relatively similar at a chemical level. This is why there is a risk of the fraudulent mixing of (cheaper) virgin oils with (higher value) UCO in order to make the UCO 'go further'. This is amplified by the incentives in RED II, even to the point of passing off 100% virgin oil as 100% UCO in manufacturing FAME or HVO biodiesel. There is more in earlier sections on the risk of fraud.

Nonetheless, due to the chemical changes that virgin oils undergo during the cooking process, caused by the high temperatures, presence of water in food and more, it means that the resulting UCO does have recognisable differences to virgin oil that can be tested[40]. Methods including gas chromatography/mass spectrometry (GCMS) have been shown to differentiate between virgin oils and UCO, for reasons of identifying 'gutter oil' contamination in virgin oils for human consumption. Whilst this is promising the issue is, however, one of cost, speed, ease, and reliability of these tests that means they are not currently widely used.

8. Mitigating the Risks - Traceability and Sustainability

There are many certification and standards schemes that provide levels of assurance about the provenance and sustainability credentials of products that come from a biomass feedstock. The predominant one in the UK is the Renewable Fuel Assurance Scheme (RFAS), linked to the Renewable Transport Fuels Obligation (RTFO). These are explained below.

The Renewable Transport Fuels Obligation – RTFO

The Renewable Transport Fuels Obligation (RTFO) is a robust UK policy mechanism managed by the DfT to reduce GHG emissions from road transport and non-road mobile machinery (NRMM) and ensure that the supply is sustainable.

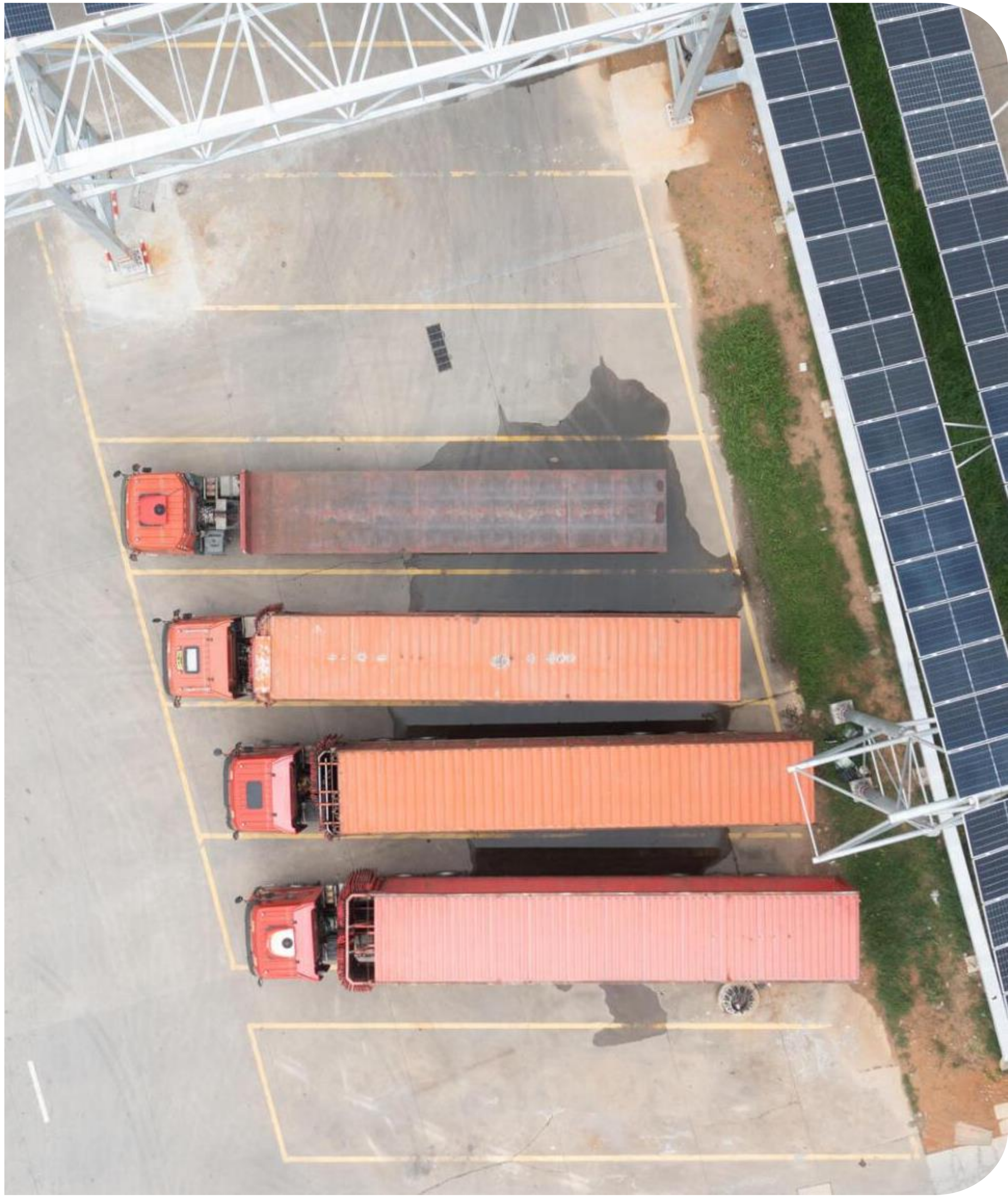
Under the RTFO, large suppliers of fuels must meet an annual obligation to submit a number of tradeable Renewable Transport Fuel Certificates (RTFC), which are distributed to demonstrate the supply of renewable fuels. Suppliers can achieve this either by supplying renewable fuels and gaining RTFCs directly, or by buying RTFCs from the tradeable market, or by paying a fixed sum determined by DfT to buy themselves out of their obligation. Clearly, the intention is to encourage suppliers of fossil fuels to supply renewable fuels or blend their products with a percentage of renewable biofuels. The obligation limit is currently 7% for road-going fuel (so-called B7) which will gradually increase to 14% by 2032.

The RTFO has four strict sustainability criteria[46] and calculation methods that need to be met with evidence to gain a RTFC and thereby ensure the sustainability of the fuels. These include that GHG savings must be 65% lower than the fossil fuel reference[47] (the same as in RED II) and they need to preserve land with high biodiversity value or carbon stock, ensuring only legal forestry. Evidence for this is provided in Proofs of Sustainability from traceability schemes such as ISCC – more of which below.

Biomass feedstock materials that are described as ‘products’ count single under the RTFO - each litre or kg of biofuel put on the market gains one RTFC[48]. These products include virgin oils such as palm, soy, rape, and sunflower, but also co-products like PFAD. However, there is a cap by volume on the number of RTFCs that can be claimed for crop-derived biofuels, rather than the full 7%. It is 3.33% in 2024, decreasing year by year to 2% in 2032, a policy to incentivise the move away from virgin oils to waste and other secondary feedstocks[49].

Most waste and residue biomass materials such as UCO can claim double the number of certificates, i.e. two certificates per litre or kg. As just explained, this is a deliberate policy incentive to encourage suppliers who place biofuels on the market to use waste and residue feedstocks to support their annual obligation. The list of products and wastes in the RTFO mirrors Annex IX in RED II. In line with RED II, high iLUC risk biofuels from first-generation feedstocks are being phased out by 2030.

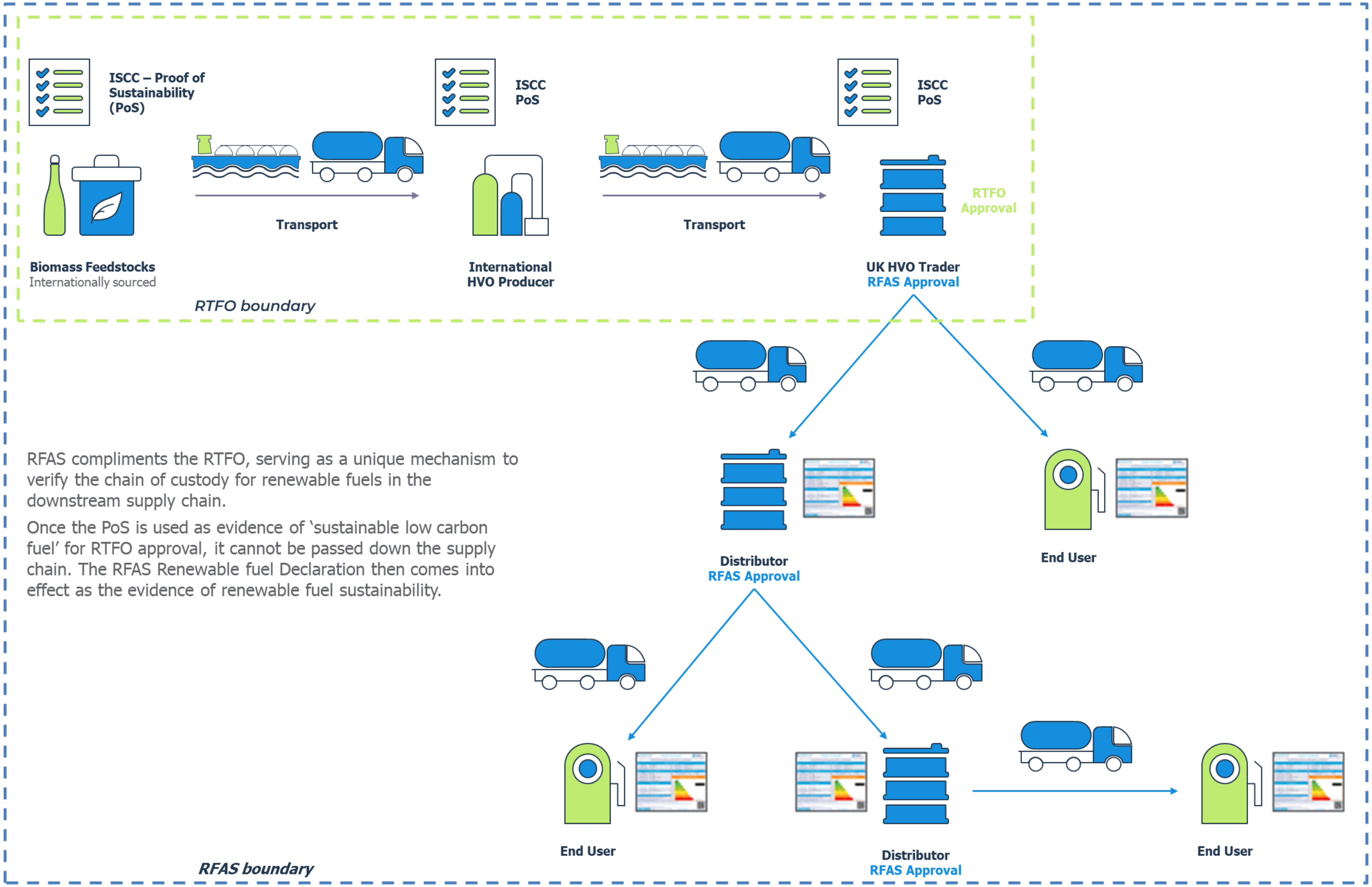
To fulfil their obligation to the RTFO in terms of sustainable feedstocks and reduced GHG emissions, traders of HVO provide evidence to the DfT – Proofs of Sustainability – based on the sustainability certifications they have gained from bodies such as ISCC. Once approved on by the RTFO, the duty (tax) is paid, and the supplier is given the requisite number of RTFCs. The Proof of Sustainability cannot however be used any further by downstream distributors. This is where the Renewable Fuel Assurance Scheme (RFAS) then provides chain of custody assurance down the supply chain, building on from the robust approvals process that RTFO places on suppliers of HVO.



8. Mitigating the Risks - Traceability and Sustainability

Renewable Fuel Assurance Scheme – RFAS

The UK's Renewable Fuel Assurance Scheme – RFAS[25] – is a voluntary scheme run by the Zemo Partnership, working with and following on from the RTFO. As described above, the RTFO process goes up to the point of duty, i.e. where the tax is paid to HMRC on any fuel. As the Proofs of Sustainability used for RTFO approval cannot be handed down the supply chain, RFAS picks up from here and provides the continuation of the information and evidence through the supply chain on the fuel being distributed. This is achieved through the use of Renewable Fuel Declarations (RFDs), which are described below, while Figure 6 depicts the relationship between the RTFO and the use of Proofs of Sustainability, and RFAS and its Renewable Fuel Declarations.



RFAS compliments the RTFO, serving as a unique mechanism to verify the chain of custody for renewable fuels in the downstream supply chain.

Once the PoS is used as evidence of 'sustainable low carbon fuel' for RTFO approval, it cannot be passed down the supply chain. The RFAS Renewable fuel Declaration then comes into effect as the evidence of renewable fuel sustainability.

Figure 6. Relationship between RTFO and RFAS

The RFAS scheme verifies the life cycle GHG emissions savings of biofuels placed on the UK market by approved suppliers, compared to fossil fuels, and that the feedstock comes from a sustainable source with assurance on the chain of custody. It applies to HVO and FAME, and equally applies to road-going fleet and NRMM.

As with RED II and RTFO, biofuels must demonstrate life cycle GHG emissions savings of 65% or more compared to the fossil fuel reference[47]. Similarly, the criteria for demonstrating sustainability of feedstocks include the protection of land and biodiversity, the use of biomass wastes and residues (aligning with RTFO feedstock lists) and the traceability of renewable fuels across their supply chain through a chain of custody.

8. Mitigating the Risks - Traceability and Sustainability

The scheme therefore provides a high level of assurance that fuels being supplied to customers are from renewable sources, with quantified emissions savings, allowing them to use biofuels as one part of the decarbonisation strategies.

Customers of biofuels from RFAS-approved suppliers get sustainability information in the form of Renewable Fuel Declarations (RFD) for each batch they buy, an example of which can be seen on the website, including:

- The type of fuel and any blending involved by %, as well as the volume and/or mass;
- Where the fuel was manufactured;
- The feedstock(s) used in the fuel's manufacture;
- Where those feedstocks came from;
- Traceability evidence, such as ISCC and other schemes approved by RTFO;
- The GHG intensity (gCO_2e/MJ) and the savings compared to fossil fuels; and
- The supply chain model used, such as mass balance.

Importantly, unlike RTFCs, RFDs are not tradeable or transferable – they can only be provided with the fuel being sold to the customer.

This point on GHG intensity balance needs further explanation. Data published in RFDs on carbon emissions savings data is based on scope 3 carbon emissions on a well-to-wheel basis, where scope 1 emissions of CO_2 are treated as zero due to being biogenic in origin. However, it does not include other scope 1 GHG emissions, namely N_2O, nor does it include 'out of scopes' emissions.

As discussed in the section on Carbon Accounting, comprehensive and transparent carbon emissions reporting in accordance with DESNZ, the GHG Protocol, and SBTi also requires that 'out of scopes' carbon data (the biogenic carbon emissions) are considered and reported alongside scope 1 direct emissions. Indeed, RFAS now provide a tool for calculating GHG emissions in accordance with the GHG Protocol.

This does not detract from the benefit of using renewable materials in preference to conventional fossil fuels, wastes in particular, as part of a broader strategy to reduce net global emissions, as long as there is no inadvertent burden shifting. It is simply a more holistic and transparent way of explaining an organisation's emissions.

Recommendation 8. When procuring HVO, ensure that it is from an RFAS-approved supplier registered on their website, and that supporting evidence documentation – the Renewable Fuel Declaration – is requested from the supplier. Also, evaluate and include the 'out-of-scopes' (biogenic) carbon emissions in your carbon reporting.

As with any certification scheme, certified products and their suppliers come and go. RFAS keeps an up-to-date list of certified suppliers on its website – there are currently 20 registered for HVO – who they audit every year. This, and the subsequent links to ISCC Proofs of Sustainability (including suppliers' own documents, sometimes called *Biofuel Sustainability Statements* based on the ISCC Proofs of Sustainability), should be reviewed by customers looking to buy HVO who want a deeper level of knowledge and assurance that all the correct certificates and supporting evidence are in place for each supplier being considered.

Traceability Schemes – ISCC

There are several schemes that provide sustainability and traceability assurance on materials from biological sources, many of which are approved for use as evidence by RTFO, and hence the underlying basis for the onward evidence that RFAS provides in its RFDs. The most prevalent in terms of biofuels and HVO in the UK is the International Sustainability & Carbon Certification (ISCC). According to statistics from the DfT 97% of the biofuels in the UK in 2022 were certified to the ISCC[50].

The scheme is an independent organisation that certifies biomass feedstocks, first-generation crops and second-generation wastes that:

- Protect land with high biodiversity value and high carbon stock,
- Protect soil, water and air;
- Provide safe working conditions;
- Comply with the human, labour, and land rights as set out in the ILO[51];
- Ensure traceability throughout supply chains from the Point of Origin; and
- Reduce GHG emissions

8. Mitigating the Risks - Traceability and Sustainability

ISCC Proofs of Sustainability (or those from other suitable schemes) are needed in the UK to meet the demands of the RTFO and to obtain Renewable Transport Fuel Certificates. While Proofs of Sustainability cannot be passed down the supply chain, they are the basis on which RTFO compliance is given at which point onward evidence in the RFAS is provided through the Renewable Fuel Declarations described above. Indeed, the ISCC is explicitly recognised in the UK as a mechanism for compliance with the RTFO, similarly with RED II in the EU.

Process

To achieve certification of sustainability, all economic operators within a value chain are audited against the ISCC's criteria by independent ISCC-certified auditors working on behalf of independent Certification Bodies. After registering with the ISCC, the economic operators become 'System Users'.

Audits are done retrospectively, generally for the preceding twelve-month period, through which the Certification Body must be able to ascertain at least a "limited assurance level". Once compliance with ISCC criteria has been established, ISCC certificates are issued by the Certification Body to the specific site of the economic operator. Certificates are valid for twelve months. As such, for a site to maintain its certification, an audit must be done at least every twelve months.

All tiers of the supply chain must be certified for handling sustainable materials. Developed from the guidance on the ISCC website[52], Figure 7 below depicts the stages for certifying feedstocks and production of HVO. It shows that certification goes back to the *Point of Origin (PoO)* where the supply of UCO starts, such as restaurants. For completeness, we have also shown the equivalent stages for first-generation feedstocks from food crops and animal feed.

Mandatory *individual* certification of locations starts at the *Collecting Point* and then also applies to *Processing Units* and subsequent *Traders/Suppliers*. Prior to that however, PoO are treated differently. While they are usually covered under the certification of their *Collecting Point*, they can also get individual or grouped certification on a voluntary basis. Importantly, all PoO that are not individually certified must provide a self-declaration to their *Collecting Point* (the same applies to first-generation farms and plantations)[53].

ISCC-certified auditors will investigate all tiers of the value chain. At the PoO level, they will audit the *Collection Point* certification and self-declarations. This includes assessing the quality management documentation provided by the *Collecting Points*, conducting site visits, and verifying the traceability evidence and sustainability declarations of the UCO. The aim is to ensure that all UCO used in biofuel production under the ISCC scheme is sustainably sourced, and the self-declarations are truthful and reliable.

Nonetheless, there are so many economic operators, PoO in particular, that any auditing programme must have a risk-based sampling approach. This situation inherently opens up the potential for fraud in the ways described above, particularly with self-declarations from small-scale operators reliant on extra income. Because of this, the ISCC is continuously putting measures in place to identify and reduce these risks. In particular, further checks – surveillance audits – can be undertaken on existing certified suppliers to make sure they are adhering to the scheme's criteria. This can be done where there is a concern of non-compliance with ISCC criteria requirements or if there is evidence and allegations of fraudulent behaviour that need investigating.

8. Mitigating the Risks - Traceability and Sustainability

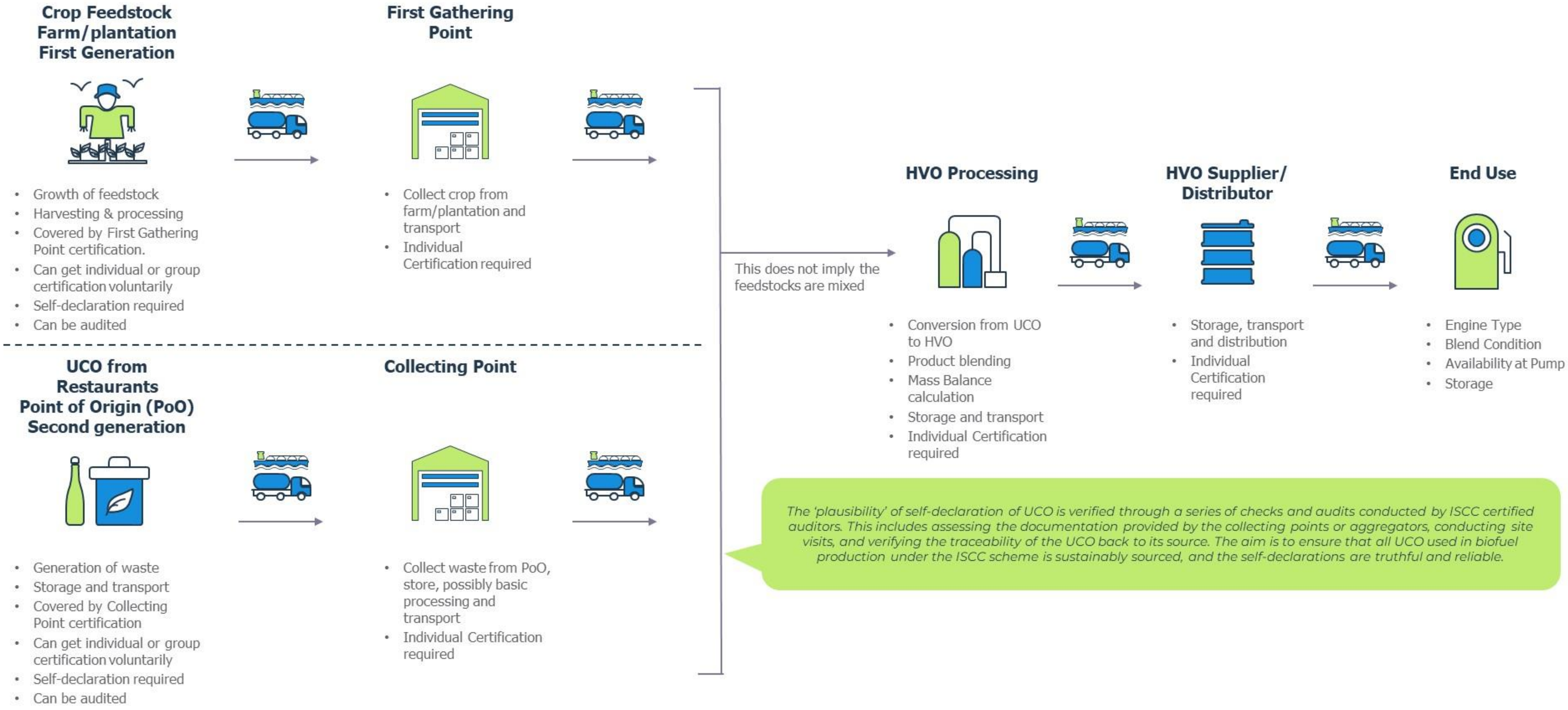


Figure 7. Stages of certification for feedstocks and fuels

By way of example, between 5th January 2023 and 10th May 2024, a total of 35 organisations had their ISCC certificates withdrawn. Nine organisations (including one in the UK) had their certificates excluded. This means they cannot claim any ISCC sustainability credentials. Certificates were terminated or withdrawn from producers following an ISCC Integrity Audit[54]. However, the reasons why certificates are withdrawn or cancelled is not published. One organisation, PT. Vita Bren Indonesia, had their ISCC certificate withdrawn and then excluded on 6th January 2024 and will not be able to reapply to ISCC until 5th January 2028. A list of all ISCC certificates audit reports, including those that have been suspended and withdrawn or are fake, can be found in the ISCC website's certificate database[55].

8. Mitigating the Risks - Traceability and Sustainability

Ultimately, economic operators who have had their certification withdrawn can be excluded from ISCC certification for up to 5 years. During this time, they cannot claim that the material they handle is sustainable in accordance with ISCC. Information on operators in this situation is held in the ISCC database and made available for viewing.

To help interested parties understand the changing landscape of certification, the ISCC runs an *Email Notification Service*[56] that alerts stakeholders about any suspended or withdrawn certificates.

If a producer has had a certificate terminated, their *disqualification* will also appear on the Union Database[57], a platform developed and managed by the European Commission. This aims to ensure the reliability of transport fuels claiming eligibility for being counted towards the share of renewable energy in the transport sector in any EU member state.

Certificate information and mass balance

An ISCC supplier certificate describes the following information:

- The economic operator and which specific location has received the certificate;
- The Certification Body that provided the certificate;
- A unique certificate number;
- The dates of the 12-month validity; and
- The input materials and products;

One aspect mentioned in previous sections – mass balance – requires more explanation.

Claims about the sustainability of products are based on the ability to trace the feedstocks and materials used to make them through the value chain. Traceability in HVO value chains can be tracked through one of two different models, shown in Figure 8, albeit mass balance tends to be the most prevalent choice[58].

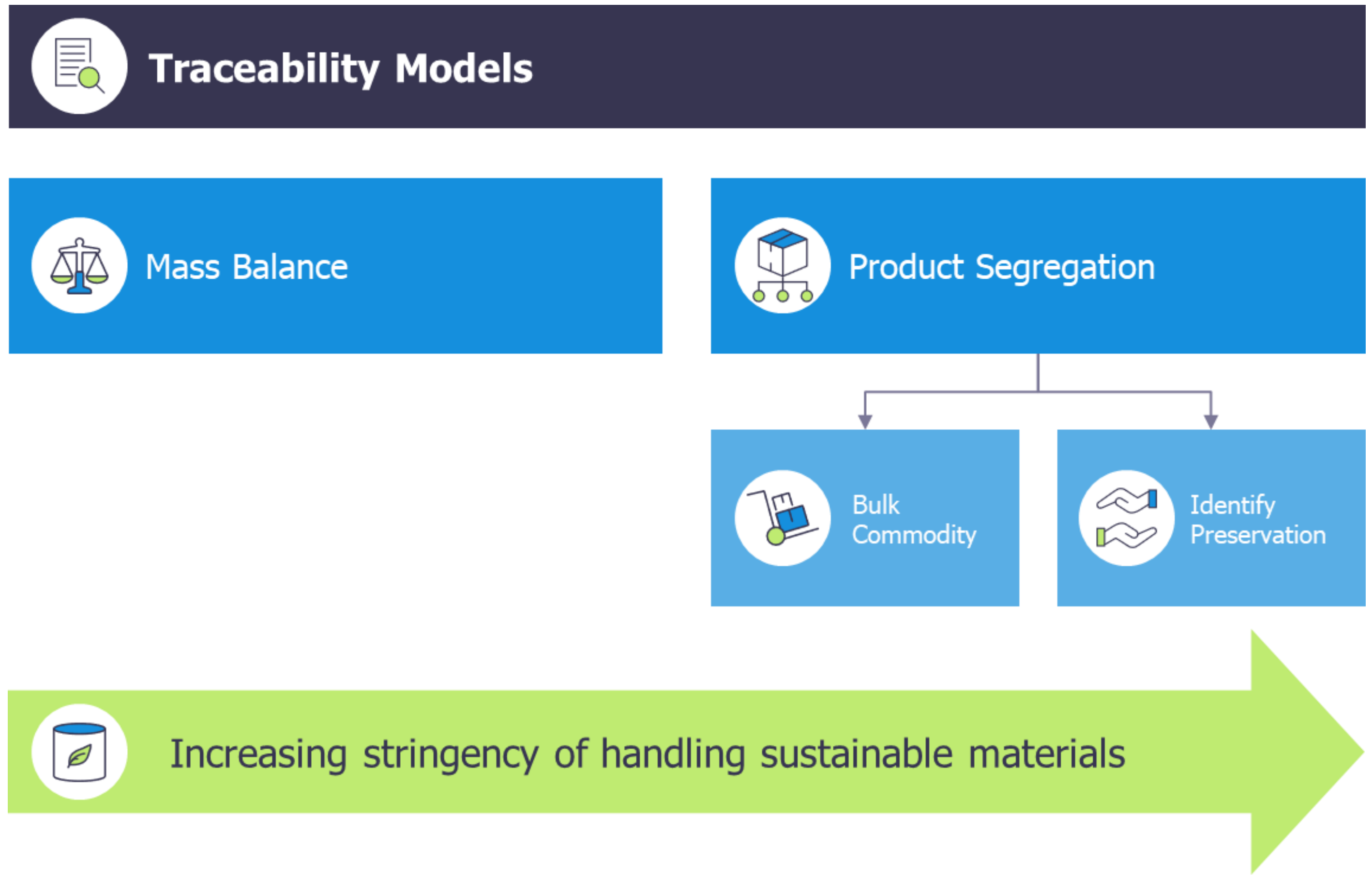
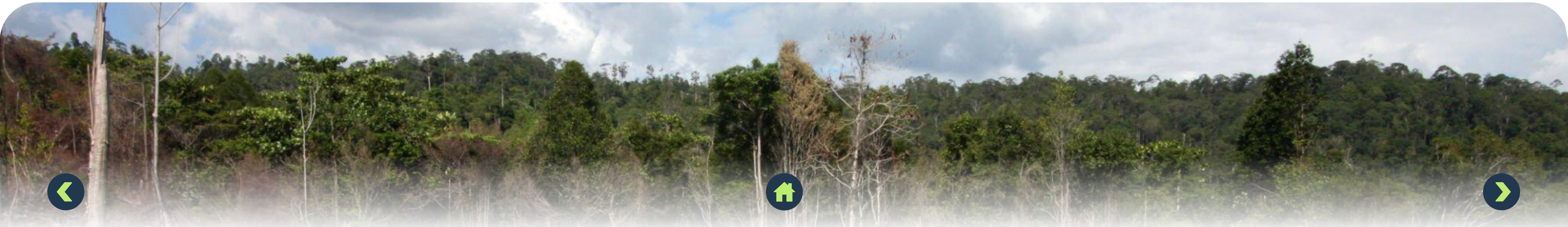


Figure 8. Traceability models used for HVO

Production Segregation is where sustainable materials have to be physically separated from non-sustainable materials and traceability is followed with certification through the value chain. There are two sub-categories. **Identity Preservation** is where sustainable materials from one source (a plantation, farm, or point of origin) are also kept physically separate from sustainable materials from other sources, thus allowing traceability right back to the origin. **Bulk Commodity** allows mixing of sustainable materials from different sources, but still keeping non-sustainable materials separate. The relevant certification assures the end consumer that 100% of the product they are buying is sustainable.



8. Mitigating the Risks - Traceability and Sustainability

Mass Balance allows the mixing of certified and non-certified materials at some stage of the value chain, in collection, processing or production. However, the amount of certified material entering the value chain must be known and controlled so that the same amount leaves the value chain. Traceability of the certified portion is followed through the value chain, segregated in the bookkeeping from the uncertified portion. This can also be described as 'book and claim'[59]. This paper trail enables a purchaser to claim that they are buying the certified portion of the material even though it can be blended with other, uncertified materials, meaning that what you actually get could be between 0 and 100% of the certified portion. This is a common approach when segregation is difficult due to blending and aggregation processes and hence is the main approach taken in supply of HVO. Figure 9 below shows how this works.

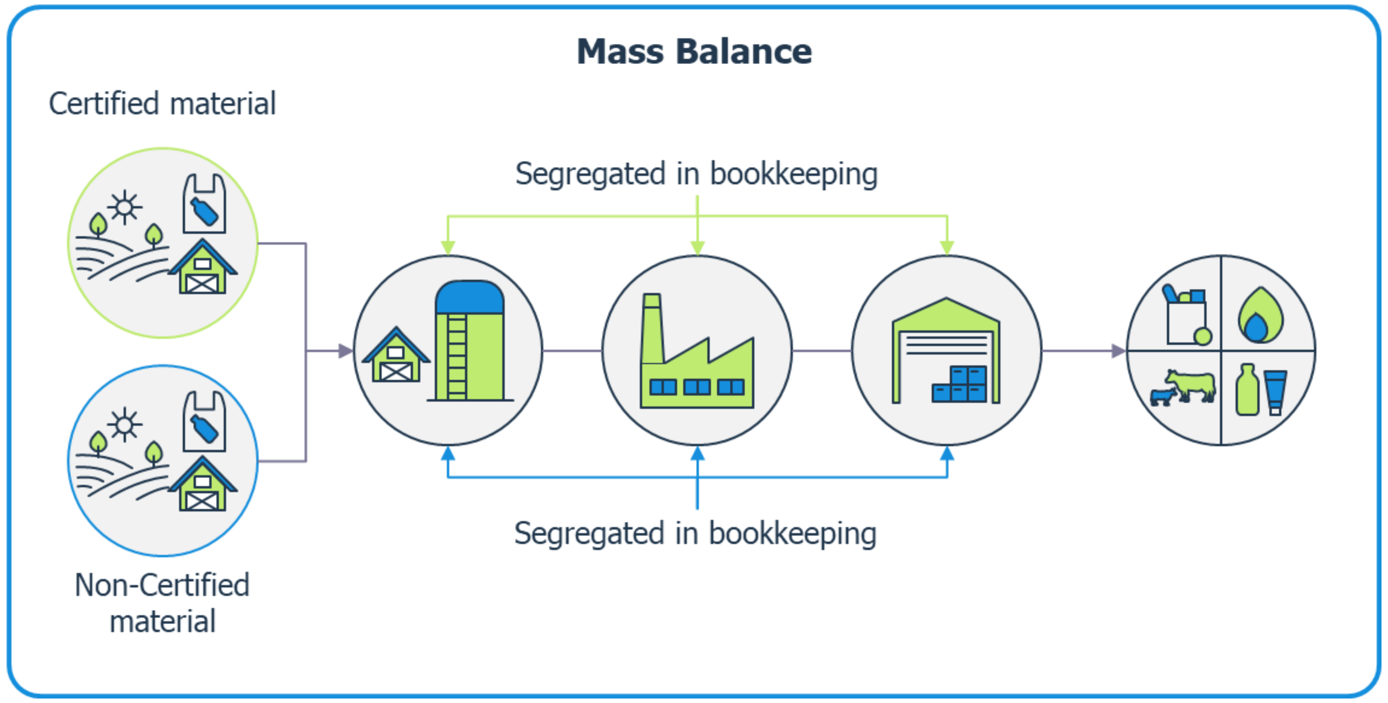


Figure 9. Mass balance

The inherent risk in mass balance is that even with supply chain traceability, fraudulent activity could occur with the non-sustainable portion of a batch, such as fake proofs of sustainability, hidden in the paperwork provided for certification. This was discussed previously in the section on market displacement, fraud and risk of iLUC[12].

Practical issues

There is a more administrative and practical point of certification and providing evidence of sustainability. As with any process there are steps to be taken, checks and verifications to be made, which add time to the system. Once a fuel supplier has obtained ISCC Proof of Sustainability, they can then apply for their RTFCs, a process that can take up to an additional 30 days. This presents some challenges as the HVO might already be on the market or even been consumed by the time Proofs of Sustainability are issued. This could impact on traceability and whether or not a supplier's certificate has been withdrawn. This system, while designed to support decarbonisation, highlights the need for efficient, timely and transparent certification processes to maintain the integrity and trust in sustainable fuel sources.

Recommendation 9. When procuring HVO, ensure that it is from a supplier who can provide RFAS-approved HVO, in the form of Renewable Fuel Declarations. This is backed by the RTFO process that checks supply chain evidence in the form of Proofs of Sustainability from schemes such as ISCC (other accreditations are available, but ISCC accounts for 97% of all RTFO-accredited renewable fuels by volume). If further due diligence is required, check the ISCC website that the certificates of suppliers further up the supply chain haven't been suspended (a temporarily invalid certificate), expired (validity has run out and a new audit is required), withdrawn (prematurely cancelled by the Certification Body due to a non-compliance) or excluded. Note that although the website is updated daily, as with any system there can be a time lag between certificates being added or withdrawn. Any interested parties, i.e. purchasers, should sign up to the ISCC Email Notification Service about suspended or withdrawn certificates.

9. Procuring HVO

Business case

Whilst prices of HVO, fossil diesel and other biofuels may vary considerably, there is usually a price premium to pay for HVO and supplies can be intermittent. The decision on whether to purchase HVO and how to purchase it will be dependent on the procurement method and risk factors described in this section.

If a buying organisation has an appetite to purchase HVO, the following factors can be considered in a business case:

- **Client demand.** For example, HS2 has an ambition to increase the number of "diesel free sites" as the project develops, and the Construction Leadership Council has set out its target to reduce diesel use on construction sites by 78% by 2035 through its *Zero diesel sites route map*[1]. HVO can be an interim solution as other technologies develop.
- **Investor demand**. Businesses relying on investment, via PLC, AIM or private equity should consult with their investors to understand the demand for Net Zero Carbon.
- **Government policy and regulation.** Public sector and highly regulated private organisations such as utility businesses should pay attention to policy and forthcoming legislation.

Procurement options

There are various ways to procure HVO depending on the business circumstances:

Ad-hoc purchase at pumps. This is the least favoured option due to the site-based nature of construction sites and is more appropriate for haulage businesses. In this sense it is appropriate for HGV lorries delivering plant to site. While it looks like HVO is generally available at HGV filling stations[60] the reality is that it is nowhere near as widespread as fossil fuels – there are around 40 sites and a few forecourts that sell HVO. Moreover, there is usually a price premium. HVO on public sale is available either as pure, 100% HVO, or in some cases blended with conventional diesel. It will be necessary to record this information for accurate reporting.

Spot buy and storage. Where it is possible to store fuel, spot buying from one of a range of suppliers to achieve the best balance between price and security of supply. It is possible to assure secondary feedstock but decisions around availability and price may make this difficult to achieve. Fuel purchased with RFAS certification – in the form of Renewable Fuel Declarations – provides evidence of the feedstock source, as well as information on GHG reductions compared to diesel. There are around 20 RFAS-accredited suppliers of HVO. Whereas most customers used to purchase HVO from Neste, being the dominant supplier, there is now more choice in the market with suppliers from the USA and South-East Asia.

Long term agreement. For purchasers with significant and relatively consistent demand, longer term agreements can be beneficial with a single supplier, or a small group of suppliers. This enables purchasers and suppliers to work together on demand planning, due diligence, assurance and reporting to ensure the most accurate picture possible of HVO supply.

Hire company provides fuel. This can be a potential solution for organisations with limited leverage in the market. Hire companies may be better placed to procure HVO from reliable sources that come from waste feedstocks.

Risk

There are three potential risks from procuring HVO:

- **Reputation risk** related to feedstock from sources using forced labour or supporting environmental damage, e.g. deforestation.
- **Risk of false carbon accounting** if the HVO purchased is inaccurately or fraudulently claimed to be sourced from sustainable feedstock.
- **Security of supply -** Demand for HVO, particularly sourced from UCO is rising and availability is limited, giving rise to supply interruptions on construction sites.

9. Procuring HVO

Reputation risk

Whilst there are certification schemes available, it is difficult to trace back to the ultimate source of the UCO (rather than HVO), such as restaurants and food production facilities. Campaigning NGOs are active in this space and could expose perceived abuses of human rights and/or environmental damage. Purchasers need to carefully consider the probability and consequence of such a risk, as described in Figure 10. RFAS RFDs provide a high level of assurance, but it is hard to provide 100% traceability back to the original UCO feedstock source. Applying the precautionary principle, organisations vulnerable to NGO intervention should also consider alternative low carbon solutions.

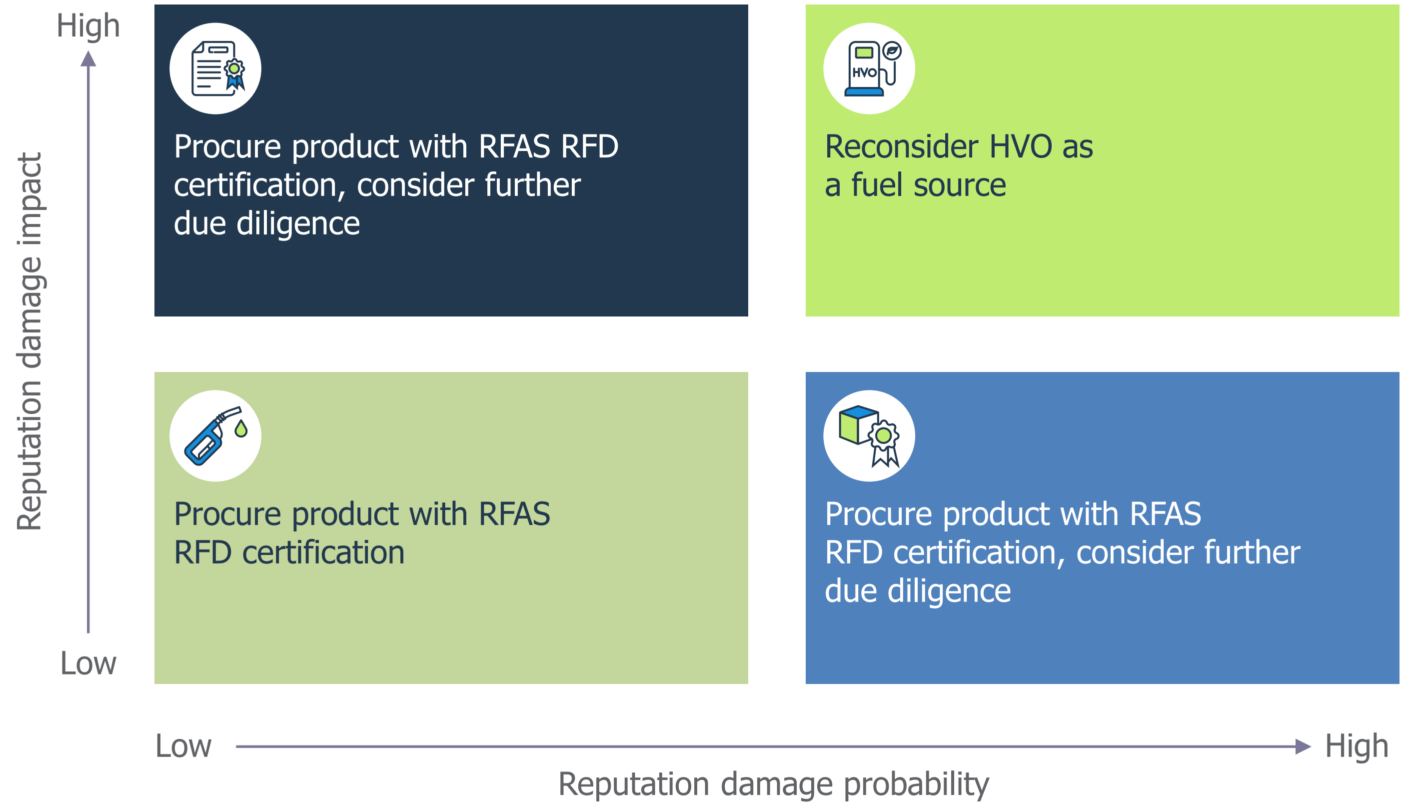


Figure 10. Reputational impact

- **Low probability/low impact –** Given that reputation damage is minimal, purchase of product with RFAS RFD, certified to EN 15940, either as a bulk purchase or at the pump. RFAS RFD certification should be available for pump purchase on request.

- **High probability/low impact -** The fuel should have RFAS RFD certification and should meet the standard EN 15940. Depending on your risk register profiling, consider further due diligence with your supplier and their supply chain.

- **Low probability/high impact –** The fuel should have RFAS RFD certification and should meet the standard EN 15940. Depending on your risk register profiling, consider further due diligence with your supplier and their supply chain. Purchasers should prepare a statement for their press office to describe what due diligence has been done. This can be used as a first response in the event of media attention.

- **High probability/high impact –** If reputation risk is significant, it may be necessary to reconsider purchasing HVO and focus on longer term technical solutions such as electric and hydrogen technology to reduce carbon. If it is necessary to purchase HVO, the guidance for low probability/high impact should be followed.

9. Procuring HVO

Carbon accounting

The level of accuracy needed for carbon accounting purposes will depend on the materiality of fuel supply to the organisation's overall carbon footprint and the drivers to reduce carbon (e.g. requirements from clients or investors in the private sector, policy or political drivers in the public sector). Suppliers in the UK will be able to provide a Renewable Fuel Declaration for each batch they provide. If this is not available, due to the route you purchase your HVO, then use the data that DESNZ publishes on a generic carbon footprint for HVO. The risk model is further explained in Figure 11.

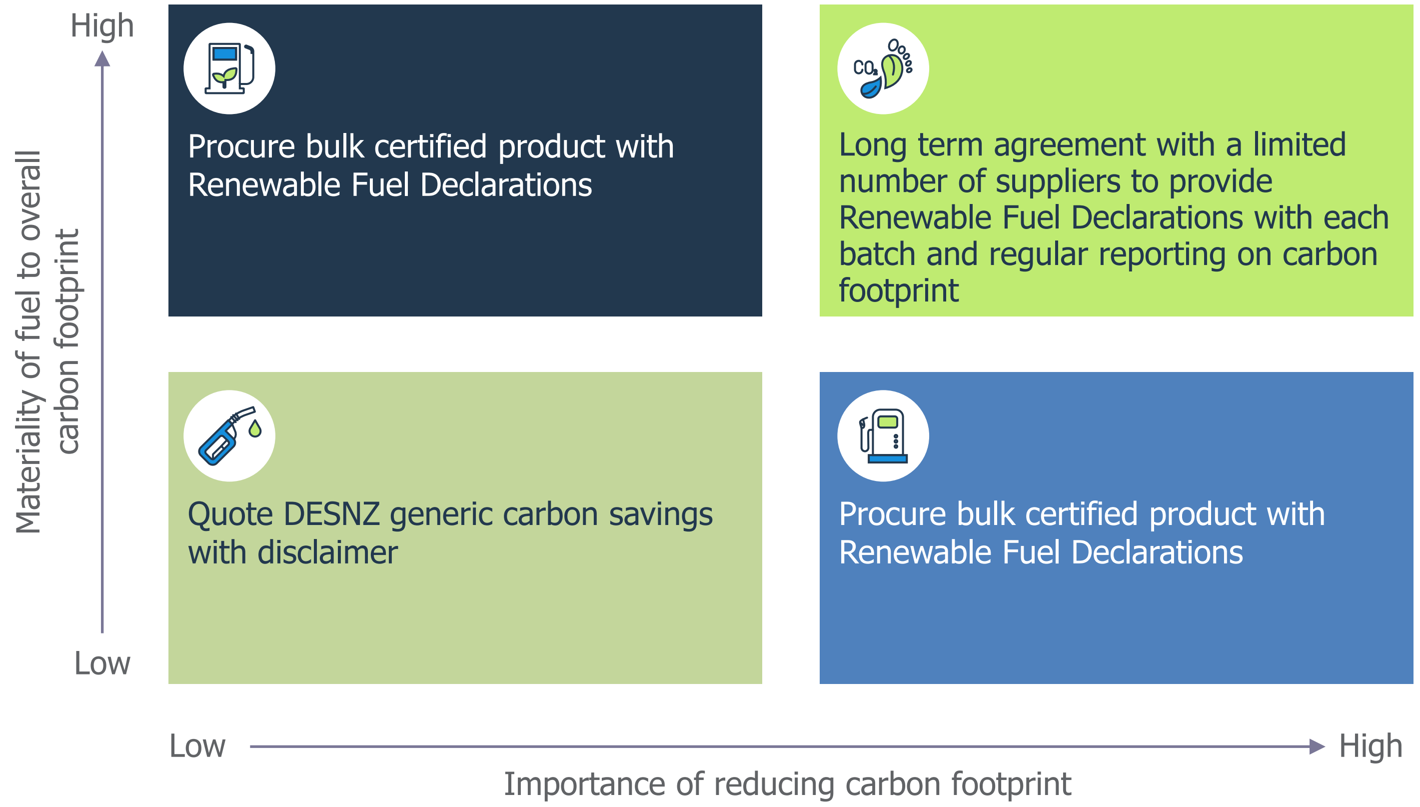


Figure 11. Carbon impact

- **Low importance/low materiality –** By purchasing fuel certified to EN 15940 it is possible to use a generic carbon saving number published by DESNZ[61]. It should be noted this is an average number based on all HVO supplied in the UK and it is recommended that this is stated in all claims of carbon reduction.

- **High importance/low materiality –** Bulk purchase should be from a reliable supplier who can provide Renewable Fuel Declarations (RFDs). These provide carbon reduction figures, but not 'out of scopes'; DESNZ conversion factors can be used with confidence for this part.

- **Low importance/high materiality –** Bulk purchase should be from a reliable supplier who can provide Renewable Fuel Declarations (RFDs). These provide carbon reduction figures, but not 'out of scopes'; DESNZ conversion factors can be used with confidence for this part.

- **High importance/high materiality –** In this case it will be important to establish a long-term relationship with a preferred supplier, or a small number of preferred suppliers. They should set up a performance reporting process to track and trace fuel supplied with appropriate RFDs and Proofs of Sustainability. This will help to ensure long term, consistent carbon reporting.

9. Procuring HVO

Security of supply

The supply of HVO is directly linked to the availability of feedstocks such as vegetable oils or animal fats. Despite the European market for used cooking oils growing rapidly, the supply is not currently meeting demand and is not expected to do so until 2030. Supply is mostly from Asian countries such as China, Indonesia and Malaysia, but with growing imports from the USA. Risk mitigation will depend on the criticality of fuel supply to the operation, and the importance of securing supply of HVO. This is shown in Figure 12.

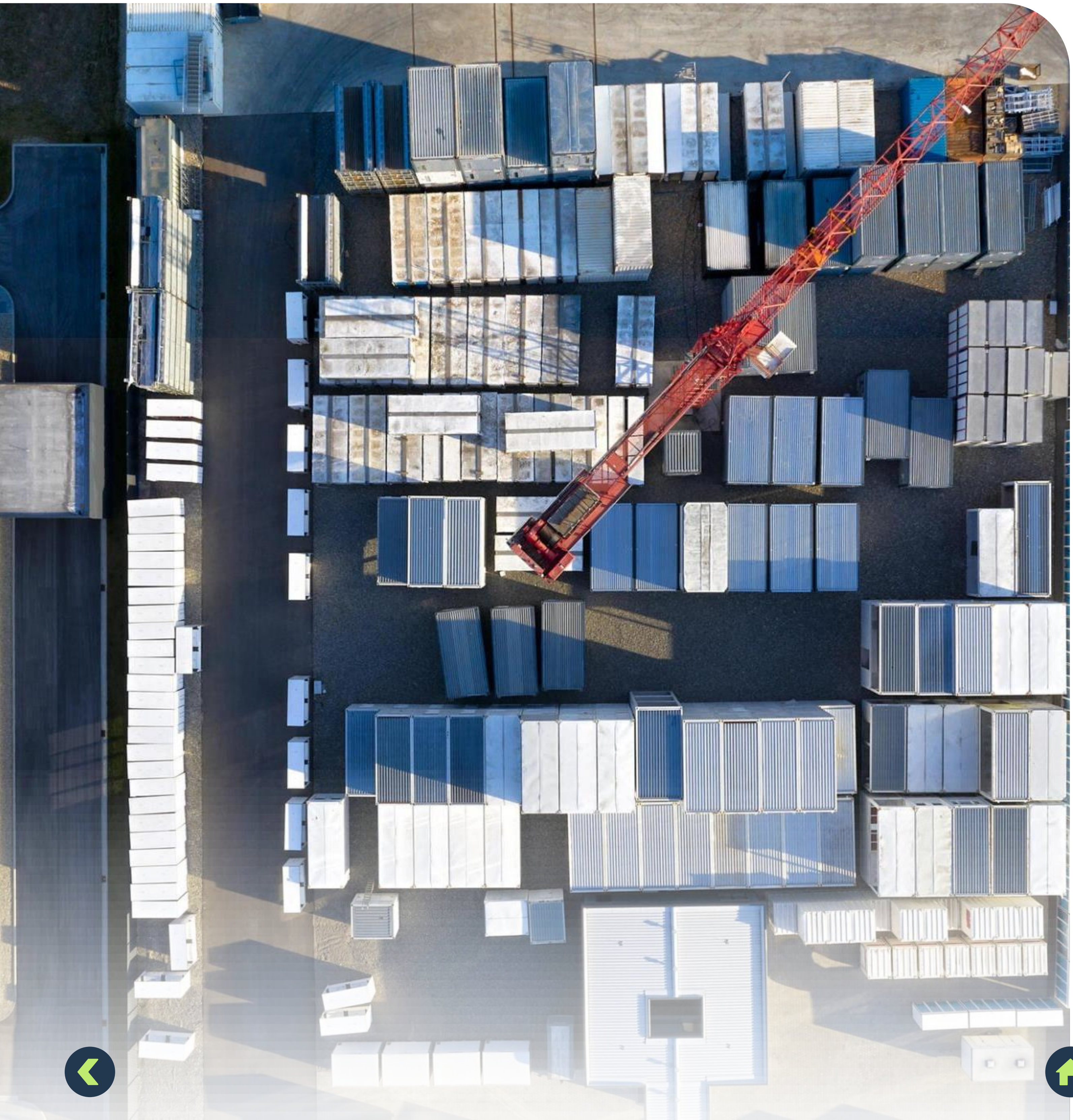


Figure 12. Security of supply

- **Low importance/low criticality –** In this case, spot buying may be the best strategy. Purchase HVO when it is available and has a low price premium but use conventional fuel as the primary source of supply.

- **High importance/low criticality –** In this case, HVO should be procured as the main source of supply. The risk of supply interruption can be mitigated by a programme of storage and demand planning and purchase of conventional fuel as a last resort.

- **Low importance/high criticality –** In this case, HVO should be purchased where possible but alternative sources should be considered as a back-up. Storage and demand planning will help to mitigate the risk of supply interruptions.

- **High importance/high criticality -** In this case it will be important to establish a long-term relationship with a preferred supplier or a small number of preferred suppliers. They should set up a supply/demand process to track and trace fuel supplied to ensure long term, consistent supply.

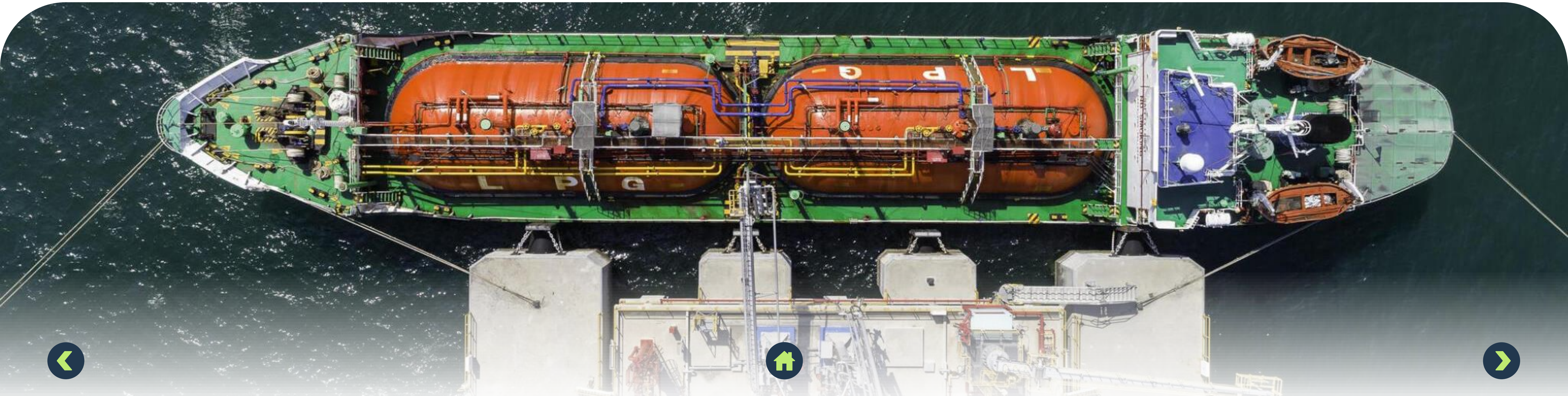
9. Procuring HVO

Summary of risks and procurement options

The summary of balancing risks against procurement methods is shown in Table 4 below:

	Reputation risk mitigation	Accuracy of carbon accounting	Security of supply
Buy at pumps	Low – Harder to identify feedstock.	Low/Med – Need to know % blend and use DEFRA factors.	Med/Low – HVO not availability at pumps is not widespread.
Spot buy and store	Med/Low – Can ask for RFD to provide some assurance.	Med – Can use figures from RFD where available. DEFRA factor for balance.	Med/High – Using a variety of suppliers helps to secure spot buys.
Long term partnership	Med/High – Difficult to trace to original UCO feedstock source but reporting/audit provides the best possible solution.	High – Supplier can provide regular reports from RFDs.	Med/High – Long term relationship with supplier should ensure priority if supply interruptions are experienced.
Supply through hire company	Med/High - Need to ensure hire company has adequate due diligence processes.	Med – Need to understand hire company's certification requirements.	Med/High – Hire company should have greater procurement leverage and offer storage capacity.

Table 4. Balancing risks in procurement



SUPPLY CHAIN SUSTAINABILITY SCHOOL

10. Appendices

Appendix 1. Glossary

Term	Short Description	Longer Description
ASTM D975	Diesel Fuel Standard	American Standard that diesel fuels must meet to be placed on the market.
AQ	Air Quality	The degree to which the air in a particular place is pollution-free. Linked mainly to NO_x and PM emissions, see below.
Bioethanol	Biofuel	Bioethanol is primarily produced from crops such as corn and sugarcane.
Cetane Number	Cetane	Number used to indicate the combustion speed of fuels and compression needed for ignition. A higher cetane number indicates a shorter ignition delay and a better performance of the fuel. It is the equivalent of the octane number to gasoline.
CO_2	Carbon Dioxide	A naturally occurring greenhouse gas, but produced in greater volumes since the Industrial Revolution, significant for its role in climate change.
CO_2e	Carbon Dioxide Equivalent	A metric to compare the emissions from various greenhouse gases based on their global warming potential (GWP) relative to CO_2.
dLUC	Direct Land Use Change	Primary forest or savannah cleared to make space growing crops, either for food (for humans or animals) or for fuel, giving rise to GHG emissions.
EN 590	Diesel Fuel Standard	European Standard, used in the UK, that diesel fuels must meet to be placed on the market.
EN 15940	HVO Fuel Standard	Paraffinic fuel specification that governs a new generation of cleaner transport fuel for use in road vehicles. HVO is included under this Standard
FAME	Fatty Acid Methyl Esters	FAME is a type of biodiesel produced from vegetable oils, animal fats, or recycled greases, made through transesterification.
GHG	Greenhouse Gases	Refers to the gases that trap heat in the atmosphere, contributing to global warming. Common examples include CO_2, methane, and nitrous oxide.
GTL	Gas-to-Liquid	A refinery process that converts natural gas or other gaseous hydrocarbons into longer-chain hydrocarbons, such as petrol or diesel fuel.
HVO	Hydrotreated Vegetable Oil	HVO is the main name within the industry, as well as in the fuel standards and European regulations. Can also be referred to as 'green diesel', 'renewable diesel', 'second generation diesel', 'bio-hydrogenated diesel', 'hydrogenated esters and fatty acids (HEFA)', 'hydrogenated vegetable oil'.
IEA	International Energy Agency	An autonomous intergovernmental organisation that provides data, analysis, and policy advice on energy issues. The IEA is a key source of information on energy markets, energy efficiency, and renewable energy technologies like HVO.
iLUC	Indirect Land Use Change	Existing farmland for food and animal feed crops is displaced by crops for fuel production. The need for food crops is then met by clearing *additional* primary forest and thus the demand for fuel crops *indirectly* leads to a change of land use and the associated carbon and other sustainability impacts. iLUC can also be caused by displacement effects where an agricultural product is diverted to a new use, but the previous need still has to be met. This demand could be met by more land use change and hence the risk of iLUC.
ISCC	International Sustainability and Carbon Certification	A global certification system for sustainability and greenhouse gas emissions, covering all sustainable feedstocks, including agricultural and forestry biomass, biogenic wastes and residues. It's widely used in verifying the sustainability of bioenergy and bio-based products.
LCA	Life Cycle Assessment	A technique to assess environmental impacts associated with all the stages of a product's life, from raw material extraction to disposal.

10. Appendices

Appendix 1. Glossary

Term	Short Description	Longer Description
Lipid	Greasy substance	Organic compounds that are insoluble in water. They include many natural oils, waxes, and steroids.
NO_x	Nitrogen Oxides	Refers to gases composed of nitrogen and oxygen: NO and NO_2. NO_x emissions are produced in the combustion process, such as in vehicles and industrial plant. They are a concern due to their harmful effects on air quality and human health. N_2O, a potent greenhouse gas, is sometimes included in with the other nitrogen oxides.
NRMM	Non-Road Mobile Machinery	NRMM, or Non-Road Mobile Machinery, refers to mobile machines and vehicles that are not licensed for use on the UK's roads.
OEM	Original Equipment Manufacturer	An organisation that makes equipment from component parts brought from other organisations.
PFAD	Palm Fatty Acid Distillate	A co-product of the refining process of virgin palm oil used in non-food sectors.
POME	Palm Oil Mill Effluent	A waste from palm processing at mills.
PM_{10}	Particulate matter with diameters that are 10 micrometres and smaller	A mixture of solid particles and liquid droplets found in the air that lead to respiratory illnesses.
$PM_{2.5}$	Particulate matter with diameters that are 2.5 micrometres and smaller	A mixture of solid particles and liquid droplets found in the air that lead to respiratory illnesses.
RED	Renewable Energy Directive	An EU Directive that sets targets for the overall share of energy from renewable sources in the EU. It includes stipulations for renewable transport fuels.
RFAS	Renewable Fuels Assurance Scheme	A UK scheme that assures the sustainability and greenhouse gas savings of renewable fuels used under the RTFO. It provides transparency and traceability in the supply chain of renewable fuels.
RSB	Roundtable on Sustainable Biomaterials	A global, multi-stakeholder initiative that develops and implements guidelines and standards to ensure the sustainability of biomaterials, including biofuels. The RSB certification is widely recognized and aims to minimise the environmental and social impacts of biomaterial production while promoting economic development in the biofuel sector.
RTFO	Renewable Transport Fuel Obligation	The UK Renewable Transport Fuel Obligation requires companies that supply transport fuels in the UK to ensure a specific percentage comes from renewable sources. This is to reduce carbon emissions from vehicles, encouraging the use of biofuels and other sustainable alternatives to traditional petrol and diesel, thereby supporting climate goals.
UCO	Used Cooking Oil	A waste product from the food hospitality and processing sectors that can be used as a feedstock for biodiesels.
UCOME	Used Cooking Oil Methyl Ester	UCOME is another name for FAME; a type of biodiesel produced by processing used cooking oil (UCO) through transesterification into FAME biodiesel.

10. Appendices

Appendix 2. References and Interviewees

References

This guide has been informed by desktop research of over 60 resources, interviews with various international organisations and experts in HVO manufacture, procurement and supply, and a dedicated project steering group.

Interviewees

We want to thank the many organisations, who kindly donated their time to be interviewed by the project team. Your knowledge and experience have helped shape the development of this guide.

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2. Environmental sustainability of biofuels: a review, Jeswani et al. Proceedings of the Royal Society A, 2020, https://royalsocietypublishing.org/doi/10.1098/rspa.2020.0351. Third generation biofuels also exist, made from oils gathered from growing microalgae, but they are not considered in this report.
3. Strictly speaking, all biofuels could be called 'renewable'. However, the term 'renewable diesel' has come to be associated with HVO to distinguish it from FAME.
4. https://assets.publishing.service.gov.uk/media/618bf34ae90e070446653aca/renewable-fuel-statistics-2020-final-report.pdf
5. Low carbon fuels strategy, Call for Ideas, DfT, February 2022, https://www.gov.uk/government/consultations/low-carbon-fuel-strategy-call-for-ideas.
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7. It is often thought that the removal of the 'red' diesel rebate for construction NRMM on 1st April 2022 was also a driver for the increased use in demand for HVO, but this is not the case. The rebate, at 46.81 pence per litre, applied to both fossil diesel and biofuels including HVO, and it was removed equally from both on that date. There was therefore the same financial impact of moving from 'red' diesel to 'white' diesel, as from 'red' HVO to 'white' HVO.
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12. Used Cooking Oil (UCO) as biofuel feedstock in the EU, van Grinsven et al., CE Delft, December 2020, https://cedelft.eu/publications/used-cooking-oil-uco-as-biofuel-feedstock-in-the-eu/
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16. 10 years of EU fuels policy increased EU's reliance on unsustainable biofuels, Transport & Environment, 2021, https://www.transportenvironment.org/articles/10-years-of-eu-fuels-policy-increased-eus-reliance-on-unsustainable-biofuels
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21. https://thejacobsen.com/2024/04/19/cwg-yg-higher-on-week-uco-dco-down-again/
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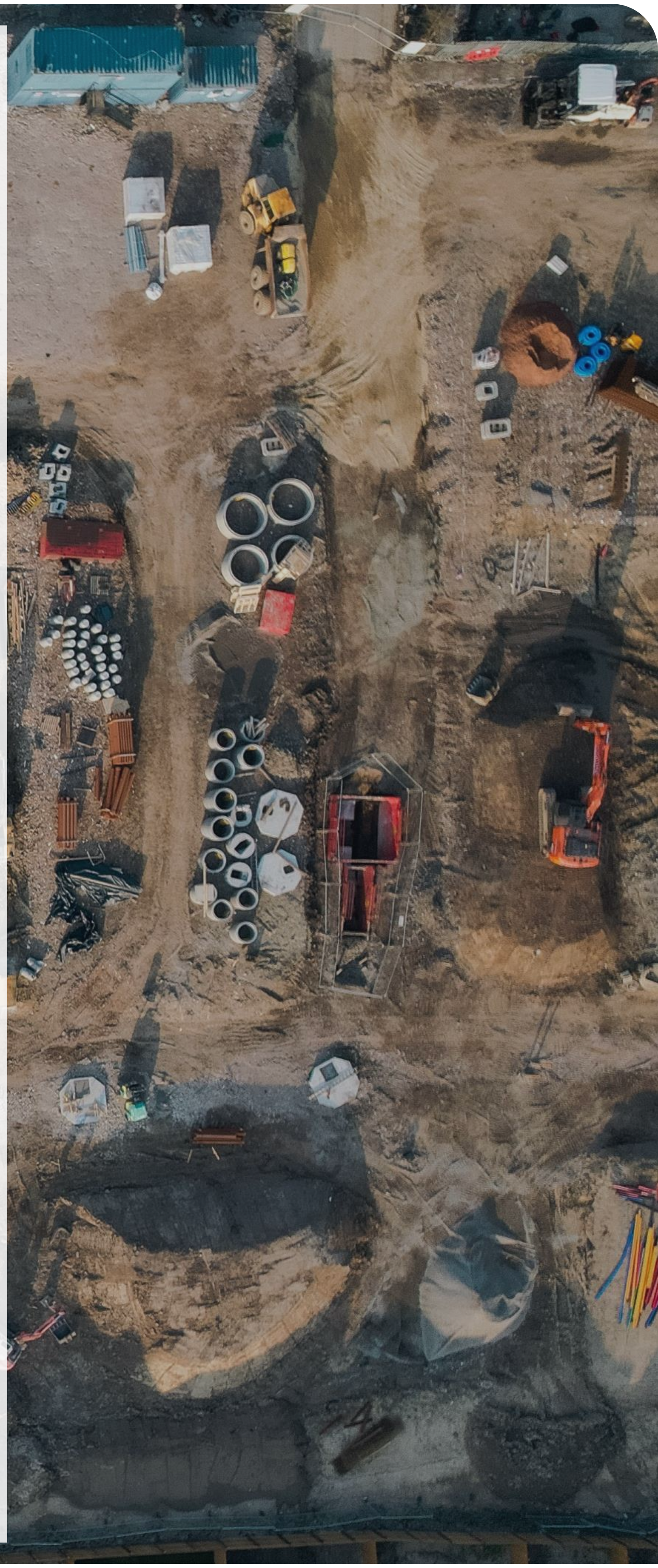
23. The land use change impact of biofuels consumed in the EU: Quantification of area and greenhouse gas impacts, Ecofys, IIASA, & E4tech, 2015, https://energy.ec.europa.eu/publications/land-use-change-impact-biofuels-consumed-eu_en
24. It is worth noting more widely that land use change is one of the planetary boundaries we have already exceeded, along with GHG emissions and freshwater impacts https://www.stockholmresilience.org/research/planetary-boundaries.html
25. https://www.zemo.org.uk/work-with-us/fuels/the-renewable-fuels-assurance-scheme.htm
26. Grammes of CO_2e per megajoule of energy. gCO_2e per MJ is equivalent to kgCO_2e per GJ.



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27. "Well-to-wheel" emissions ("WTW") cover both the direct scope 1 emissions from burning the fuel (this is the "tank-to-wheel" portion, and what is mostly usually reported) as well as all the upstream scope 3 emissions from the extraction, processing and transporting the fuel (the "well-to-tank" portion). It is a more comprehensive and accurate description of a fuel's impacts.
28. This is equivalent to 3.123 kgCO_2e per litre, using DESNZ 2023 conversion factors
29. This is equivalent to 0.314 kgCO_2e per litre, using DESNZ 2023 conversion factors
30. Due to the feedstock source and its hydrotreatment, there is a greater degree of homogeneity in the aliphatic chains, with fewer aromatic compounds as well as less oxygen and sulphur content. This leads to what is described as a 'cleaner burn'.
31. HS2 BBV alternative fuel trial, Centre for Low Emission Construction, Imperial College London, 2021, https://assets.publishing.service.gov.uk/media/6152d9df8fa8f5611126927a/Imperial_College_London_-_HS2_Alternative_Fuel_Trial__BBV_.pdf.
32. Fuels for Efficiency, IEA-AMF, October 2017, https://www.iea-amf.org/content/publ202ications/project_reports/
33. "Engine Stages" describe European emissions standards for vehicles. They are applied separately, but in the same manner, to road-going vehicles and NRMM. The higher the Stage number, the lower the emissions of harmful air pollutants including nitrogen oxides, particulate matter, and carbon monoxide. Stage V is currently the highest for NRMM. More information for NRMM at https://dieselnet.com/standards/eu/nonroad.php
34. https://www.walkfree.org/global-slavery-index/map/ and https://www.walkfree.org/global-slavery-index/map/#mode=data
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39. So-called 'bioaccumulation'
40. Used Cooking Oil (UCO) as biofuel feedstock in the EU, van Grinsven et al., CE Delft, December 2020. More at https://www.reuters.com/business/energy/germany-triggers-eu-investigation-into-chinese-biofuels-sources-2023-06-07/
41. While the DfT names PFAD explicitly in the RTFO as a product, Annex IX of RED II does not name it specifically. Nonetheless, the Netherlands, Norway, Germany and Sweden classify PFAD as a co-product similar to the UK. On the other hand, Finland, home to Neste, classifies PFAD as a residue.
42. Sometimes listed as co-product.
43. https://www.gov.uk/government/publications/renewable-transport-fuel-obligation-rtfo-feedstock-materials-used-for-creating-renewable-fuels/rtfo-list-of-feedstocks-including-wastes-and-residues
44. ISCC Impact Report, 2022 https://www.iscc-system.org/about/impact-2/impact-report/
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46. The Renewable Transport Fuel Obligation – an essential guide https://assets.publishing.service.gov.uk/media/65a8113db2f3c60013e5d4ce/rtfo-essential-guide-2024.pdf
47. Biofuels must have at least 50% lower emissions than their fossil fuel alternatives if they're from installations that were in operation before October 2015; they must be 60% lower if from installations started between October 2015 and December 2021; and 65% lower if from installations that started operation after 1st January 2021.
48. RTFO list of feedstocks https://www.gov.uk/government/publications/renewable-transport-fuel-obligation-rtfo-feedstock-materials-used-for-creating-renewable-fuels/rtfo-list-of-feedstocks-including-wastes-and-residues
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50. https://www.gov.uk/government/statistics/renewable-fuel-statistics-2022-final-report/renewable-fuel-statistics-2022-final-report Figure 22. Other certification schemes include the Roundtable on Sustainable Biomaterials (RSB), and the Biomass Biofuel Sustainability voluntary scheme (2BSVS).
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