Sector Research: Biorefining in the UK

by 350 PPM Research Department

350PPM

Capitalist Solutions to Climate Change

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Thames Water worker Vince Minney works in the sewers, 2017
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An introduction to FOG

Discharge of fat, oil and grease (FOG) into drainage systems has become an important environmental and public health issue. This has been brought into the spotlight in the UK following frequent coverage of ‘monster fatbergs’, such as the 2017 Whitechapel Fatberg[1] which measured 250 meters in length (longer than Tower Bridge - Figure 1) and weighed an estimated 130 tonnes. Fatbergs form when FOG congeals into large clumps and hardens which can restrict the flow of wastewater systems to the point of rupture. Clearing this type of blockage from the sewer system is not only costly and time-consuming, it also presents a risk to public health and the environment. A large blockage can potentially lead to overflows of raw sewage into streets, storm drains, streams and rivers.

Commercial FOG producers fall into three main categories: Food Manufacturers, Hoteliers and Restaurants & Caterers. Such grease producers are required by UK law to fit a grease separator to kitchen drainage[2] and responsible for its continued functionality as they must also ensure they don’t dispose of anything that will damage the sewer system[3]. These FOG traps inevitably need periodic emptying by an authorised waste contractor who will collect the FOG. Depositing liquids into landfill has been illegal in the UK since 2007[4] so the grease is either taken as a feedstock for products, including bio-diesel, or incinerated for electricity generation.

Household grease capture isn’t currently mandatory so inevitably large amounts of grease makes its way into UK sewers and requires frequent mass removal by utilities firms. It is possible that the increased frequency of monster fatbergs like those publicised in London may cause a future policy shift toward FOG capture and discard in the home. Some UK councils are already trialling this approach, providing constituents with oil containers that can be emptied at designated depositories for onward recycling.

Fat: Animal fat, either from trimmings, cooking, or off the plates and flatware.

Oil: Generally cooking oil used in food preparation or off the plates and flatware.

Grease: By-products from products such as dairy, lard, etc.

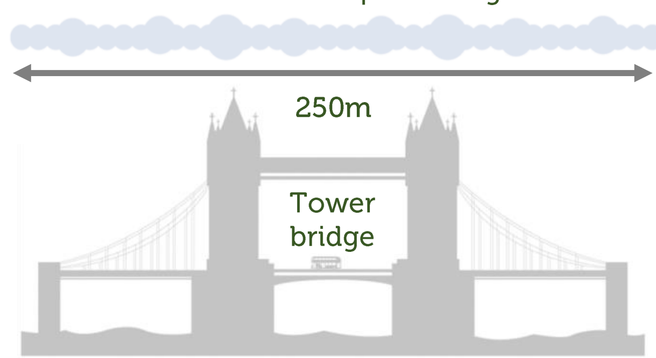


Figure 1 – Size comparison of recent monster fatberg

[1] https://www.theguardian.com/environment/2017/sep/12/total-monster-concrete-fatberg-blocks-london-sewage-system
[2] UK Building Regulations, New Part H (Drainage and Waste Disposal) 2002, Part H1, Section 2 Foul Drainage: Section 2.21
[3] The UK Water Industry Act 1991, Section 111 (1)
[4] https://www.nwl.co.uk/_assets/documents/FOG_A4_12_page.pdf

Environmental Impact

In the absence of grease traps, water treatment plants use large amounts of money and energy to remove and unblock grease using advanced filtration systems, involving heaters to make sure the grease is fluid enough to be trapped. The captured grease must then be hauled to a recycling location. By keeping FOG out of wastewater, commercial kitchen operators reduce the electricity demand at treatment plants, thereby reducing carbon dioxide emissions.

Furthermore, incinerating grease or converting it to bio-diesel means efficient burning to CO_2 with no hazardous by-products and its absence from landfill greatly reduces the amount of methane that would have otherwise been produced. Methane causes 34 times the warming of the same volume of CO_2 Compared to traditional diesel, bio-diesel virtually eliminates the emission and odour problems associated with the fossil-based fuel and has significantly lower carbon emissions per mile travelled.

Circular economy

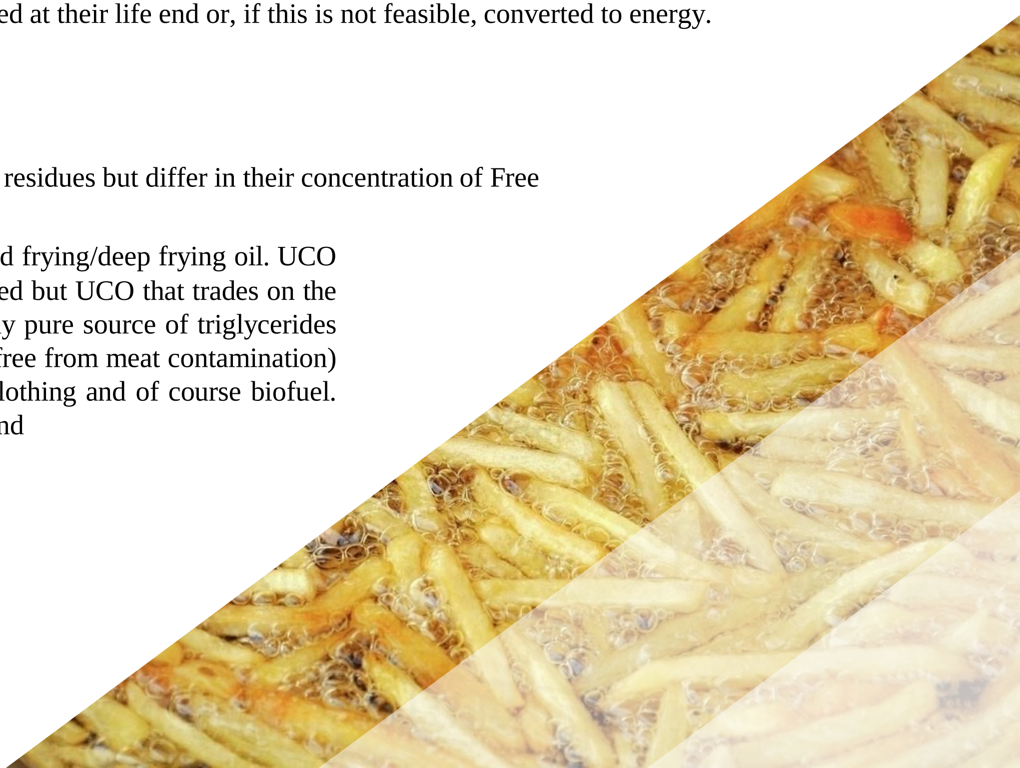
Reuse of FOG is also a quick win for UK and government funded charities such as WRAP (Waste & Resources Action Programme) who promote a transition from the linear take-make-dispose economic model to one in which resources are recycled at their life end or, if this is not feasible, converted to energy.

What constitutes FOG?

FOG can be roughly categorised into two forms. Both may contain water and food residues but differ in their concentration of Free Fatty Acids (FFAs):

- **Yellow grease** – also known as Used Cooking Oil (UCO), is typically used frying/deep frying oil. UCO can have differing levels of FFAs depending on how many times its been used but UCO that trades on the international market has <5% FFAs. This means yellow grease is a relatively pure source of triglycerides and has a number of commercial uses including as feed for livestock (when free from meat contamination) but also as input in the production of soap, detergents, cosmetics, rubber, clothing and of course biofuel. Biodiesel production is by far the largest use. UCO thus has significant demand

- **Brown grease** – also called Trap Grease is a combination of the animal fat, grease and chemicals that congeal and float above the yellow grease due to their higher FFA content and therefore lower density. Brown grease has historically been less utilised as an industrial feedstock and instead burned as fuel for electricity production. However, recent scientific developments mean this is changing, please see below.



Refining biodiesel from FOG

Animal fats and vegetables oils contain triglycerides which can be turned in biodiesel through a process of transesterification. In the past in the west and at present in many developing countries, this was achieved using monocrops such as soy, palm or rapeseed. However, research suggests that repurposing land for crop based biofuels has an average of 1.8x the climate impact of fossil diesel while this number can reach as high as 3x for palm oil. In addition to the climate impact, such farming is attributed to habitat and biodiversity loss, harming local water and climate systems, reducing food security and concentrating land towards multinationals[8]. Unsurprisingly, EU regulators and member states are averse to using such crops. The UK no longer produces any biodiesel from crop based feedstocks. Demand is increasingly biased towards waste feedstocks including used oil/grease, having significantly higher carbon and environmental savings .

Used Cooking Oil (UCO)

Historically, UK biodiesel production has been almost completely achieved using UCO feedstocks that are a relatively pure source of triglycerides. They are simple to attain because large UCO producers (fast food restaurants) contain their UCO in sealed units, for regulatory/hygiene reasons, which are then easily collected by UCO aggregators or biodiesel producers.

The key chemical process for biodiesel production, transesterification, is shown in **Figure 2**. It involves synthesis of Fatty Acid Methyl Esther (FAME), otherwise know as biodiesel, from Triglyceride using methanol and an alkaline catalyst. At the end of the process, the glycerol sinks to the bottom while the biofuel rests at the top, allowing for simple extraction for the reaction products. The glycerol can also be sold to enhance revenue.

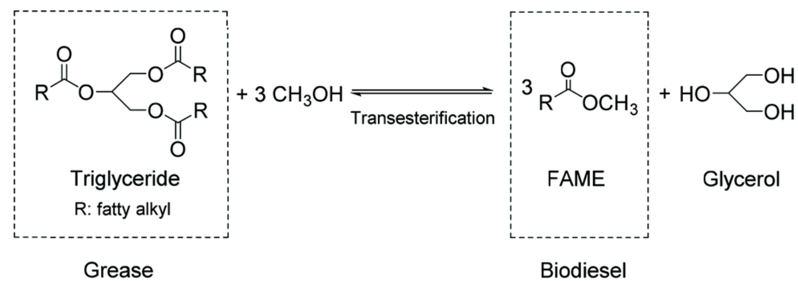


Figure 2 – Transesterification of triglyceride

UCO		Methanol		UCO - Biodiesel		Glycerol (99.7%)
1 ML	+	110 kL	≈	1 ML	+	87 t
£450,000[5]		£20,000[6]		£660,000[5]		£50,000[7]

Equation 1 – UCO to biodiesel

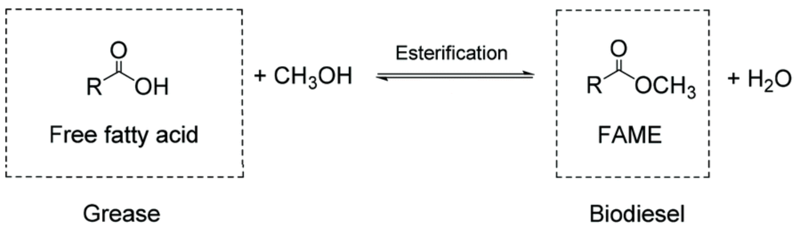
However, the relative simplicity of this process and accessibility of the feedstock means UCO demand is high meaning that large producers (discussed later) will dominate this market due to their scale and purchasing power. As per **Equation 1** , per 1 million litres of biodiesel produced, running costs would have to be less than £240,000 to break even.

[5] https://www.greenea.com/en/market-analysis/
[6] https://www.methanex.com/our-business/pricing
[7] http://www.hbint.com/datas/media/590204fd077a6e381ef1a252/sample-quarterly-glycerine.pdf
[8] https://euractiv.eu/wp-content/uploads/sites/2/2017/12/Brandstofbrief-Letter-Biofuels-1-12-final.pdf

Other feedstocks and products

With constant competitive pressure affecting UCO availability and price, academics and existing biodiesel producers are constantly researching new waste to be used as feedstocks:

Figure 3 – Transesterification of triglyceride



Tallow

Another significant, though diminishing, feedstock is tallow. Tallow is meat fat, processed from suet. This market is much smaller than the UCO market and the majority of tallow used for UK biodiesel production originates from Europe. Due to its high saturate levels, biodiesel from tallow tends to crystallise at higher temperatures than biodiesel from plant oils. In cold climates this makes tallow biodiesel unsuitable for winter use apart from blending at low rates into conventional diesel[9]. Per 1 million litres of biodiesel produced, running costs would have to be less than £370,000 to break even.

Food waste

Though not a focus of this report, a large growing feedstock with increasing research comes from 'rendering' food waste via lipid extraction to extract up to 30% of its weight in FFAs to esterify (Figure 3) into biodiesel. The residuals can also be processed in anaerobic digestion (AD) plants.

Brown grease/trap grease

High FFA content hinders the transesterification of brown grease to FAMEs due to soap forming with the alkaline catalysts. However, increased efficiency of esterification of FFAs in the grease, as detailed in Figure 3, is broadening the range of potential feedstocks for biodiesel production including those that are currently cheaper than UCO. Converting FFAs also increases the overall conversion rate of the feedstock. Titration of FOG after pre-treatment specifies the exact FFA content which allows the correct amount of catalyst and methanol to be added. This maximises the FAME produced and minimises the FFAs left to affect the transesterification stage. The feedstock cost/sale price margin is significantly higher than UCO.

Brown grease		Methanol		Biodiesel		Glycerol (99.7%)
1 ML	+	110 kL	≈	1 ML	+	87 t
£270,000[10]		£20,000[6]		£660,000[5]		£50,000[7]

Equation 2 – Brown grease to biodiesel

Tallow		Methanol		Tallow-Biodiesel		Glycerol (99.7%)
1 ML	+	110 kL	≈	1 ML	+	87 t
£325,000[5]		£20,000[6]		£665,000[5]		£50,000[7]

Equation 3 – Tallow to biodiesel

[9] http://www.global-greenhouse-warming.com/biodiesel-from-tallow.html
[10] Call with EM Oils – oil and fat collector - **Estimate**

Renewable Transport Fuel Obligations and biodiesel demand

About 23% of total greenhouse gas (GHG) emissions in the UK originates from the transport sector, making it a huge target for the EU when prioritising climate change measures. Biodiesel, though varying between feedstocks, offers huge GHG reductions when compared to the fossil fuel equivalent. For example burning yellow and brown grease derived biodiesel gives a GHG saving of an amazing 90%. However, B100 (100% biodiesel) is rarely used as a standalone fuel, predominantly because feedstock impurities increase its Cold Filter Plugging Point (CFPP) - the lowest temperature at which the fuel still passes through a standardized filtration device without crystallising. A fuel cannot be used under its CFPP. This means current biodiesels need to be blended with standard diesel to ensure efficient engine use. Even blended biodiesel can face issues in the extreme climates of Canada or Northern Europe in winter so usage and prices tend to increase in warmer months.

The government's main policy tool to reduce GHGs from transport is the Renewable Transport Fuel Obligation (RTFO). The RTFO obligates fuel suppliers to provide a specified volume of sustainable, renewable fuel (such as biodiesel) in their overall supply. Suppliers redeem a (tradable) certificate or buy-out their obligation per litre of fuel, though buy-outs virtually never occur in the UK. Certain waste feedstocks, including UCO/tallow/trap grease, are worth double their percentage volume. This can be positive and negative for demand. Suppliers will strive to use the feedstock to gain the higher contribution though less volume is required to achieve the defined threshold.

Furthermore, an update of the European Renewable Energy Directive (RED) mandates a transition to a more renewable transport sector by 2030 and the required ratio of biodiesel to fossil based fuel is increasing dramatically. Pre 2018 the UK RTFO had been a stable 4.75% but from Apr 2018 the RTFO increased to 7.5% and will step to >10% by 2022. The detailed planned increases until 2022 are shown in Figure 4.[12]

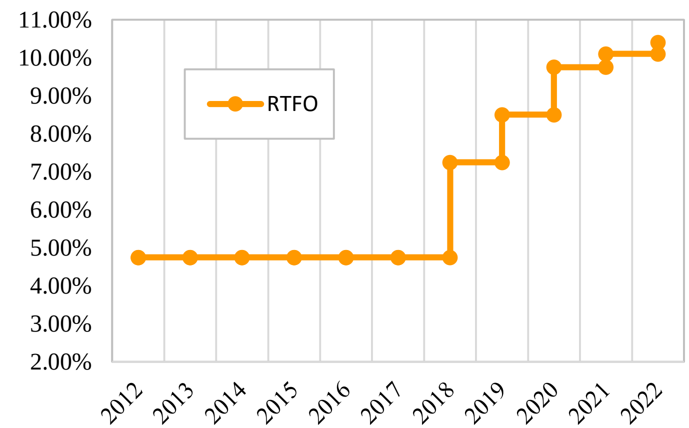
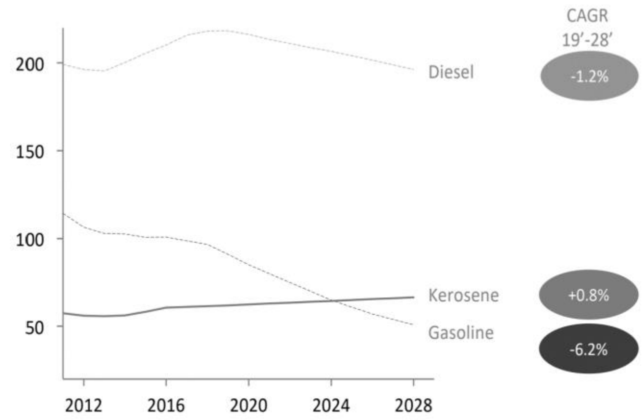


Figure 4 – Volume of renewable fuel in supply[11]

[11] 2014 UK greenhouse gas emissions, provisional figures, Department of Energy and Climate Change, 2015.
[12] RTFO guidance part 1: process guidance year 2019

Figure 5a – EU transportation fuel consumption



Why does biodiesel have more than one price?

Biodiesel is not a homogeneous commodity. The price you pay for a litre is dependent on a number of factors, most importantly the feedstock used in its production. This is because the large array of potential feedstocks affect the properties of the end fuel and, as mentioned above, biodiesel from certain feedstocks have different RFTO contributions. Furthermore, within each group of feedstock there can be variation, i.e. UCO with differing FFA or Iodine content which will affect its CFPP. The double counting of waste oil feedstock fuels means oil companies have an incentive to blend UCO-Methyl Esther (UCOME) only if its price stands below double that of FAME (standard vegetable derived biodiesel).

What does a flat diesel market mean for biodiesel?

Diesel consumption across the EU is expected to decline slightly over the next decade as per Figure 5a then continue its decent into the mid century (Figure 5b). This reflects governments' focus on reducing the ratio of diesel vehicles over concerns around air pollution caused by diesel engines' NO_x and other emissions. The trend of increasing fuel efficiency of all road vehicles also means that even as new cars hit the road, the marginal impact to fuel demand is diminishing. We can expect the UK diesel consumption to follow the same trend. Renewable fuel quotas are calculated as a percentage of the total fuel consumed so theoretically less diesel supplied would mean less biodiesel too. However, as required UK law, the volume of biodiesel to be added to the fossil based fuel is more than doubling in the three years from 2018, due to RTFO increases so the net effect will be an increase in demand for biodiesel, especially from waste-oils.

In Figure 6 on the next page you can see real UK biodiesel consumption up to the beginning of 2019 as well as the forecast considering the net affect the RTFO increases will have on UK biodiesel consumption over the next few years.

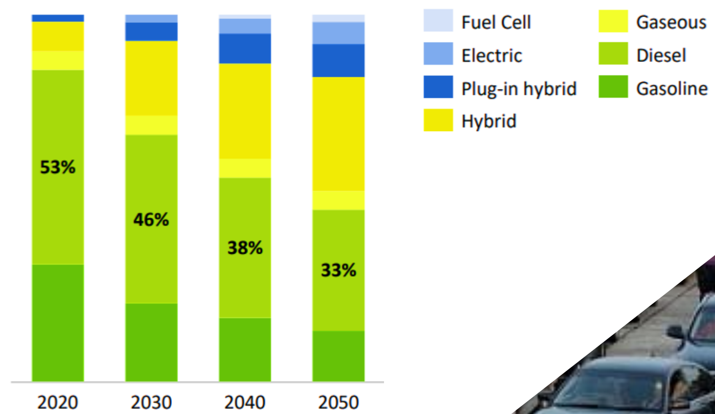


Figure 5b – EU fuel consumption [13]

[13] EU Commission

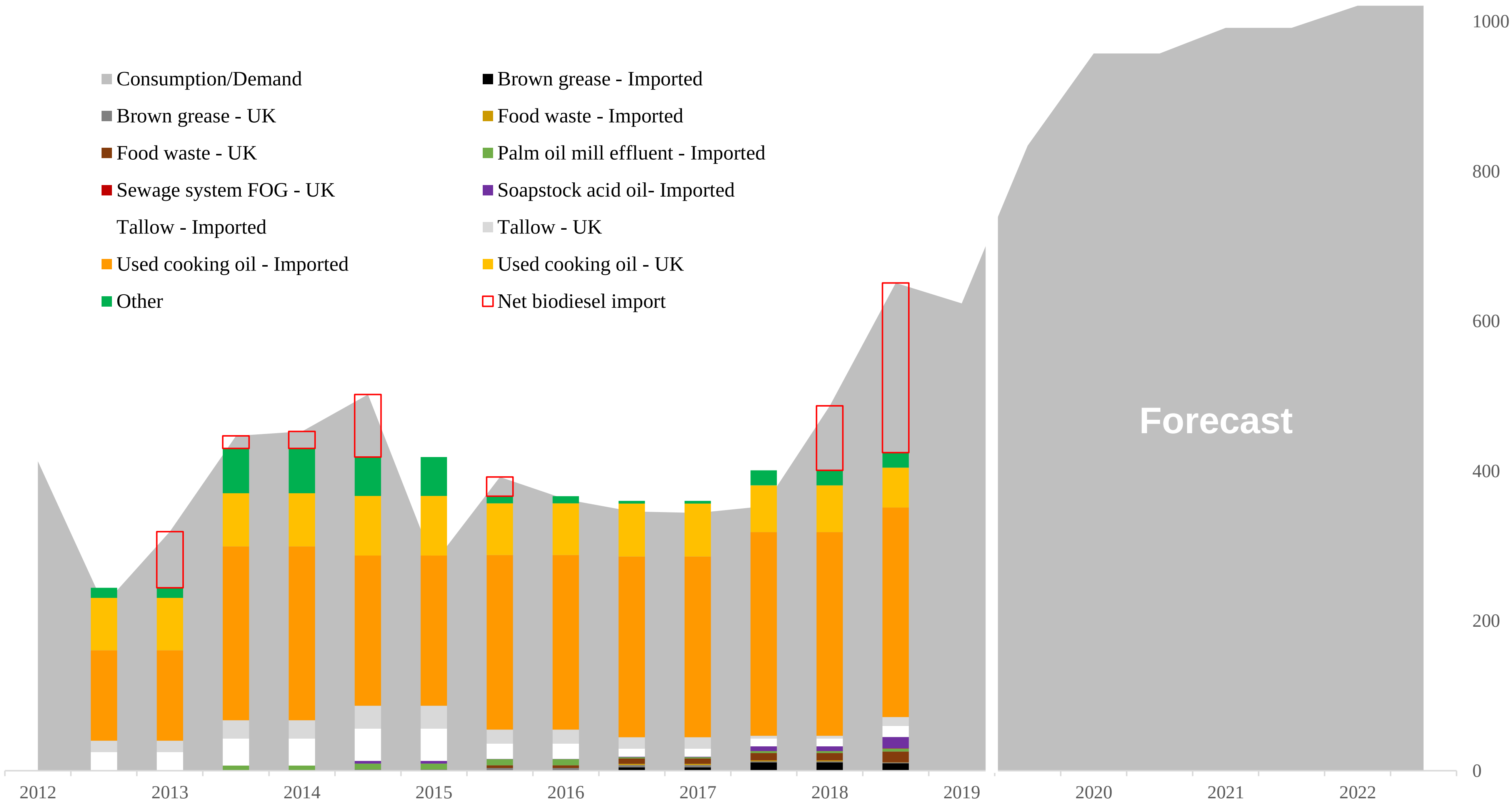


Figure 6 – Biodiesel production and consumption (million liters / year)[14]

[14] https://www.gov.uk/government/collections/biofuels-statistics

Running on UCOME

In addition to UK biodiesel consumption, Figure 6 above shows a bar chart of UK production on the same scale. The data highlights that, before the recent renewable fuel requirement increase, the UK was largely meeting its biodiesel obligations through domestic production. In fact, in 2017, 88% of biodiesel produced in the UK was supplied to the UK road transport market, with 12% being exported[15]. The data also shows a clear preference for UCO as a biodiesel feedstock and within UCO there is a clear preference towards imported feedstocks. Furthermore, both of these trends are exaggerating over time. In the most recent, 2018, data UCO Methyl Esther made up 78% of total UK biodiesel produced. Of that, 84% was imported in the ratios shown in Figure 7.

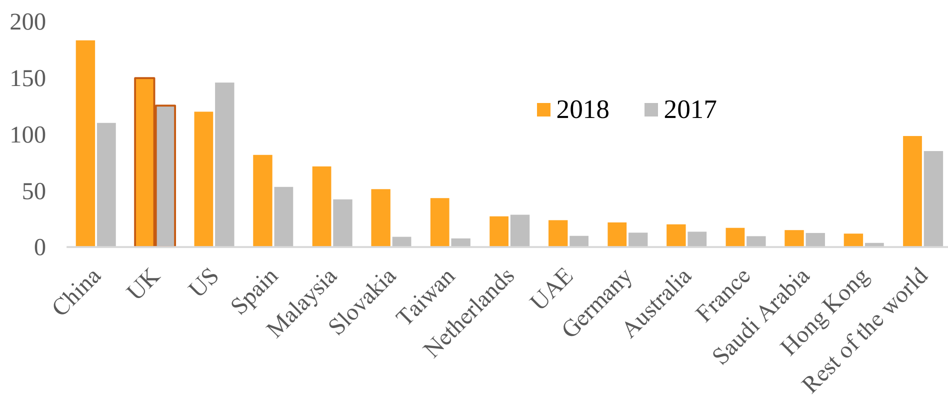


Figure 7 – UCO refined into UCOME (million liters Apr – Dec 2018)[14]

Imports bridging the gap

However, when the RTFO increased in 2018 UK biodiesel production did not increase anywhere close to the required amount to ensure domestic demand was met with domestic supply. This means that the UK transitioned from being a net exporter to needing imports to fill the gap. This also came at a time when the EU was forced to remove anti-dumping duties imposed on Argentinian and Indonesian Soy oil Methyl Esthers (SMEs) and Palm Oil Methyl Esthers (PMEs) respectively which flooded the market with cheap biodiesel. In Feb 19 the UK/EU reinstated duties of between 25-35% on these countries' major producers which will reduce the attractiveness of imports, at least to an extent[16].

[15] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/775243/nonfood-statsnotice2017-31jan19i.pdf
[16] https://www.gov.uk/government/publications/imports-of-certain-biodiesel-originating-in-argentina-anti-dumping-duty-2316/imports-of-certain-bio-diesel-originating-in-argentina-anti-dumping-duty-2316

Increase UK production or import?

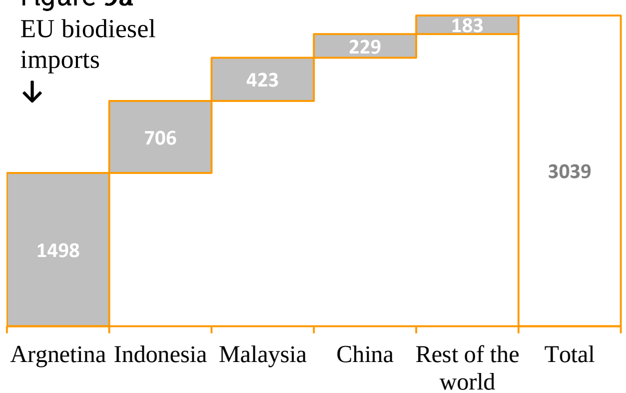
The UK's domestic supply is currently not meeting consumption demands which are set to increase further. The key question then is:

can the UK's increased demand be filled by upping domestic output or are imports better suited to bridge the gap?

In 2018 the shortfall was covered by imports. However, with increasing duties on Argentina and Indonesia, imports will be dampened. Another factor to consider is the global trend towards renewable energy. Transport biofuel consumption needs to triple by 2030 to be on track with the Sustainable Development Scenario (SDS). This equates to 10% of global transport fuel demand, compared with the current level of around 3%[17]. Achieving these targets will greatly inflate global demand for biofuels.

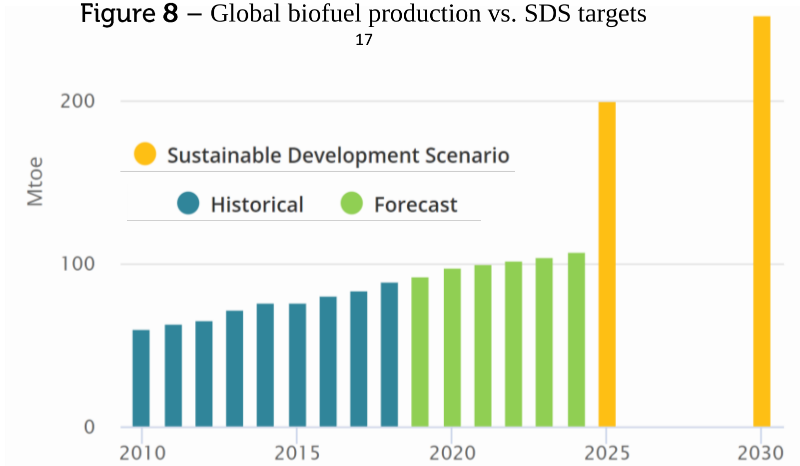
Figure 9b – Exporter domestic obligations →

Figure 9a – EU biodiesel imports ↓



[17]https://www.iea.org/tcep/transport/biofuels/

Figure 8 – Global biofuel production vs. SDS targets [17]



Global pressures

This means the world's biodiesel exporters are on track to become significant biodiesel consumers with less to sell. For example, the three largest exporters to the EU, Argentina, Indonesia and Malaysia (Figure 9a), are already significantly increasing their own biofuel thresholds as per Figure 9b.

Pressures on imports, means that at least some of the UK ~2,000 million litres/year 2022 requirement (Figure 6) will come from increased domestic production. However, detailed later in this report's analysis of current biodiesel producers, the UK's current biodiesel capacity is estimated to be less than 1,000 million litres/year. This means that even if all UK biodiesel producers were at maximum output, the demand from 2020 onwards won't be fillable by domestic producers' current plants.

Assuming that UK biodiesel production capacity will indeed increase, the supply of feedstock then becomes the restricting factor.

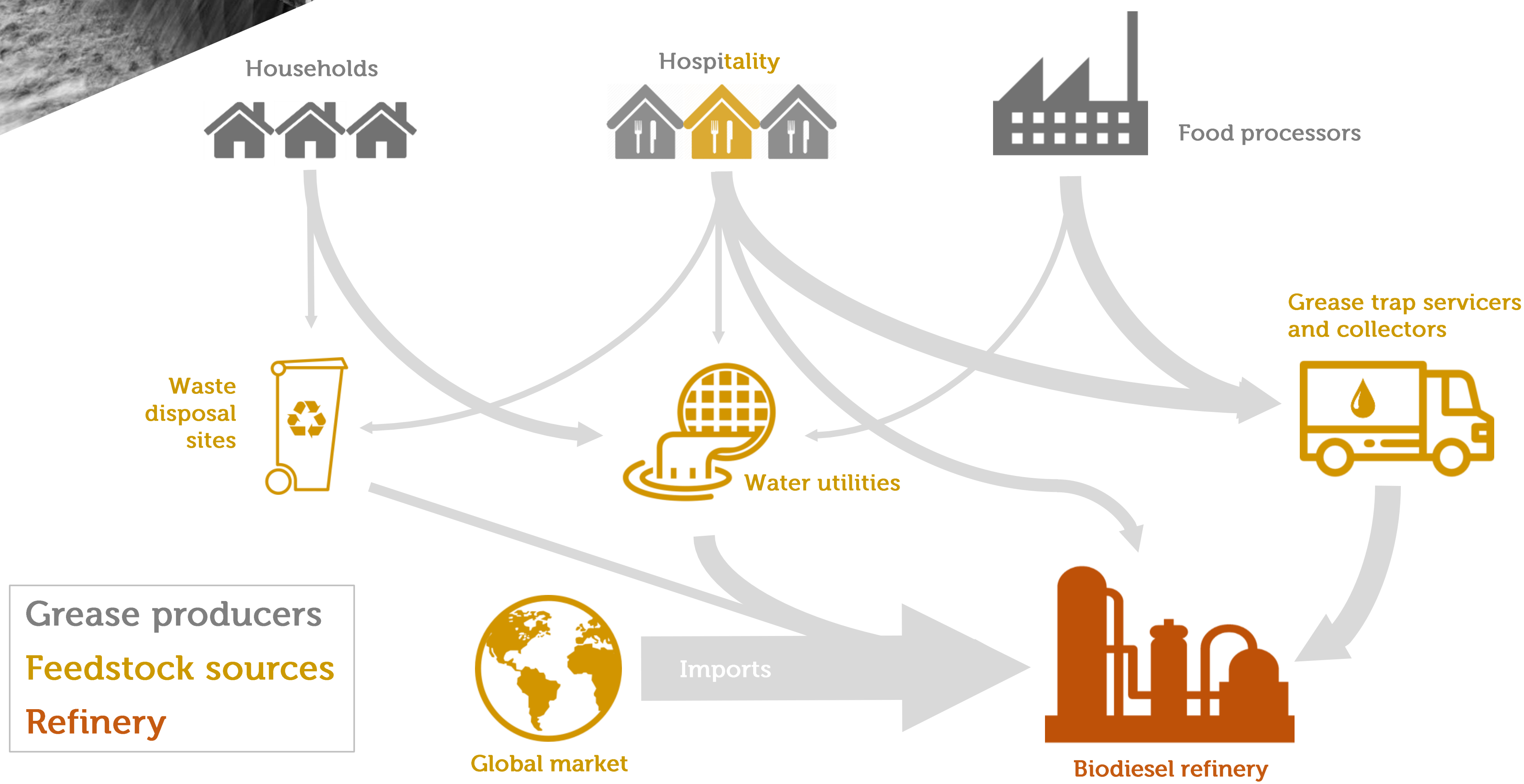


Figure 10 – Grease producers and suppliers ecosystem

Getting to the grease

The main feedstock for UK biodiesel production is imported UCO. However, the large scale UCO market is fully developed and has very fine margins. UCO imports and relationships with suppliers are concentrated with established, large producers. Given the ratio of imported UCO it's clear that incremental domestic biodiesel production needs to come from emerging feedstocks such as brown grease.

As shown in figure 10, the key existing and potential sources of brown grease feedstock are:

1. **Imports –** 83% of brown grease refined in 2018 was imported from the US. Most of which was refined by Argent Energy in the UK which made up 40% of their total production[14].
2. **Grease collectors –** Grease trap providers normally sell their products on a maintenance/service basis and collect, or organise the collection of, the brown grease. Through interviews with grease collectors it was determined that they tend to give the grease to an Anaerobic Digestion plant or Waste to Energy plant. Such grease collectors would be an ideal source of feedstock if the grease quality is high enough to refine as it would be inexpensive. More research is required on the possible size of this source.

Grease aggregators

- EM Oils
- Booker Recycling
- Proper Oils
- Baker commodities
- Business Waste LTD
- Arrow Oils Ltd
- We Buy Waste Oil
- Keenan Recycling
- Waste Vegetable Oils
- Colbeck Recycling
- T. Quality
- etc...

Grease trap providers and collectors

3. **Water utilities** - Thames Water alone has 56,104 drains and sewer blockages occur annually, of which over 50% are caused by fats, oils and greases. The associated annual cost of unblocking is around £12m[18]. These blockages are mainly caused by fats and grease that congeal with wet wipes and other solids, some of which then attach to the sewer wall. It is sometimes possible to collect the removed grease with a large vacuum extractor. The FOG can then be filtered and refined.

   However, the quality of this feedstock is low. The lipid fraction of the sewer grease was primarily in the form of FFA, at 20.7% which will be too impure for most refineries' technology[19]. However, Argent Energy is know to be capable of processing this material and even refined the FOG portion of the Whitechapel Fatberg. The price of the feedstock itself will be negligible to nothing. The cost associated with removal maybe be significant but water companies are likely to be interested in any contribution to their huge problem and cost.

4. **Waste disposal sites** – UCO volumes still to capture in the EU are mainly from households but volumes will be limited. A growing number of local authorities are working with local producers and private waste companies in setting up waste oil collection facilities and household waste recycling centres across the UK. It is early days for this feedstock source given the small number of councils making setting up these facilities but money wasted on blockages, increased awareness of the problems caused by incorrectly disposing of FOG and heightened demand for biodiesel and feedstocks may mean we see and a continuation of this trend.

5. **Restaurants** – Some fast food restaurants are large enough to have their own relationship with a biorefinery to purchase their FOG.

[18] http://crescoplumbinganddrainage.co.uk/london-sewers-saved-15-tonne-ball-grease/
[19] https://www.sciencedirect.com/science/article/pii/S0956053X16302495

Biodiesel refineries

Biodiesel producer	Brown grease capability	Feedstocks (2017 %)	Biodiesel plants and capacity (million liters / year)		2017 Profit Margin	Facts
Greenergy	✕	92% UCO 7% Food waste 1% Other	Immingham Teesside	220 284	0.39%	• UK's largest supplier of road fuels • Biodiesel output 26% higher 2017-2016. • Europe's largest manufacturer of biofuel from waste
Argent Energy	✔	40% Brown grease (US), 9% UCO, 4% Food waste, 9% Tallow, 8% Palm oil mill effluent, soap oil	Stanlow (£75m) Motherwell	75 60	0.58%	• 8.9 million litres UCO processed a year • Only plant in the UK to utilise distillation to produce EN14214 biofuel.
olleco	✕	47% UCO 53% Food waste	Bootle Aylesbury	16 20	?	• Granted a Royal Warrant by The Queen for efforts towards building a circular economy.
BROCKLESBY A BLEND FOR SUCCESS	✕	UCO/Food waste	North Cave	?	Negative	• **For closure[20]** • **JV with Greenergy**
Total biodiesel specialists				675	VERY LOW	
PRAX, MABANAFT, Esso, Valero, PHILLIPS 66, BP, Shell	✕	Mainly UCO	Part of existing refineries and partnerships with the above	?	?	• These large petrochemical producers need biodiesel to reach RTFO requirements for the fossil based fuels they sell in the UK. • Very little/no information about their own biodiesel plants so possible they partner with the above specialists.
Large petro-diesel producers						
Apple oils, Bio UK Fuels, East Yorkshire Biofuels, Pure Fuels, Uptown Biodiesel, World Fuel Services, Puma Energy	✕	100% UCO	Multiple	~200	N/A	• Collection of smaller UCO only producers. • Volumes not comparable to the above companies
Total				<1,000		

Figure 11 – Biodiesel producers and plants

[20] https://www.hulldailymail.co.uk/news/business/biofuel-project-set-end-greenergy-2893173

Big players, low margins

The margins for manufacturing biodiesel depend on the spread between the biofuel feedstock (normally UCO) and the finished product prices (normally UCOME) as well as between biodiesel and its fossil equivalent. However, the prices for traded feedstocks like UCO are predominantly driven by demand for biodiesel meaning margins are invariably extremely tight. This is evident when considering the reported profit margin of some of the UK's largest and most successful biorefineries (Figure 11). Forward purchase of feedstocks means margins can be locked in when the opportunities exists to reduce risk though it will minimise upside.

In part due to thin margins, in recent years, the industry has seen a number of plant closures and/or consolidations into the top three players who can utilise their scale to widen margins when purchasing domestic or imported feedstock (UCO). The remaining small scale UCO refineries maintain strong local business relationships to achieve a low price for the feedstock which enables their model.

Opportunities

Any opportunities, then, must come from alternative feedstock sources like brown grease/sewer FOG. With few parties (potentially only Argent Energy) possessing the correct refining technology, the demand for and price to obtain it is considerably lower. Further analysis to secure a reliable, sustainable and inexpensive large source for FOG would be necessary before beginning a project. This is currently not achieved, by the one current brown grease refiner who imports it from the US, though it is theoretically possible.

The market for biofuels and specifically biodiesel in the UK in the short to medium term (1-10 years) looks promising as domestic demand has and is increasing dramatically while, as things stand, domestic capacity isn't currently large enough. Beyond this point, trends away from even blended fossil fuels to electric means the volume biofuels required, though at a high level today, will gradually start to drop off.

Future UK policy

Brexit

Given the probability of regulatory alignment and continued commitment to the environment in any Brexit arrangement, it's not expected that the UK's ambitious RTFO will be impacted by an EU-Exit, even though the UK implements EU renewable fuel requirements. The UK has its own Climate Change Act setting binding carbon emission reductions and RTFO policy is considered the best way of delivering these reductions in the road transport sector.

Fraud

The arduous nature of the new RTFO policy, may have already pushed some actors to rig the system and/or reporting. Greenergy, Europe's largest waste refiner, and various third parties are currently (May 2019) under joint investigation by the UK's Serious Fraud Office (SFO) and the Dutch authorities. The SFO has carried out searches at five sites in Britain, with further searches being conducted across Europe to investigate "certain aspects of biodiesel trading".[22]

Biofuels global future

The long term future for global biofuels looks to be similar to that of the UK. Biofuel production needs to increase greatly in order to meet global sustainability goals aiming to cap global heating at 1.5°C from pre-industrial levels. As per Figure 11 and similar to the UK, most of the world is considerably behind on meeting their biofuel production requirements except ASEAN, though they produce most of their fuel from palm which has a negative environmental affect[17]. However, developing countries are likely to have a longer transition to electric while the warmer climates of most developing countries mean they can blend higher amounts of biofuel.

Next generation feedstocks

Under the Renewable Energy Directive (RED) discussed on slide 7, by 2030, 3.5% of transport fuel's volume must be made up of biofuels from 'next generation' or 'advanced' feedstocks that offer even higher GHG savings. These may change as new technologies develop but are currently listed in Appendix IX of the RED.[23] They include:

- Algae
- Straw
- Animal manure
- Sewage sludge
- Palm effluent
- Tall oil pitch
- Crude glycerine
- Bagasse
- Grape marcs
- Nut shells
- Husks
- Cobs

Country/region	Forecast annual production growth (2019-24)	Annual growth needed to meet SDS (2019-30)
United States	1%	6%
European Union	0.5%	8%
Brazil	3.5%	6%
India	11%	22%
China	16%	17%
ASEAN	9%	8%

Figure 11 – Global biofuel production actual vs required [17]

[21] Greenergy Annual Report 2017
[22] https://www.ft.com/content/c416064a-77c2-11e9-bbad-7c18c0ea0201
[23] https://data.consilium.europa.eu/doc/document/ST-10308-2018-INIT/en/pdf

350PPM

Capitalist Solutions to Climate Change

Tel: 0203 151 1350
Fax: 0203 151 9350
nickd@350ppm.co.uk
Level 1, Devonshire House,
One Mayfair Place,
London, W1J 8AJ.

www.350ppm.co.uk