The fat of the land

The impact of biofuel demand on the European market for rendered animal fats

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Acknowledgements

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Contents

1. Introduction

Globally, over 70 billion animals are slaughtered every year, with a primary purpose of providing meat as food for human consumption. As part of the process of industrialised meat production, livestock carcasses are processed to remove the saleable meat. The remnants of the carcass are then processed to provide a range of by-products, including rendered animal fats. Some animal fats are produced for human consumption, notably lard which is produced from pork fat and edible tallow from beef fat. Other fatty material of a lower quality can be rendered from mixed animal remains in high temperature processes, alongside protein meals. Traditional uses of lower quality animal fats include: soap, candle making and other oleochemicals; pet food; and combustion as boiler fuel at rendering plants.

More recently, demand has grown for animal fats as a feedstock for the production of biofuels – specifically biodiesel and renewable diesel. Biofuels can be produced from vegetable oils and animal fats in two ways. The older approach is to react them with methanol to produce "fatty acid methyl esters", commonly abbreviated as FAME, which is what is normally meant by the term biodiesel. A newer approach involves reacting them with hydrogen to produce "hydrotreated vegetable oils", commonly abbreviated as HVO[1], which is what is normally meant by the term renewable diesel. Biodiesel is chemically different from hydrocarbon diesel (in particular because the molecules contain oxygen atoms) and there is a limit to how much can be blended with fossil diesel for use in unmodified diesel engines (set at 7% in the EU Fuel Quality Directive, European Union, 2009). Renewable diesel contains the same sort of hydrocarbon molecules that are present in fossil diesel[2] and can be used up to 100% in existing diesel engines without issue.[3] As interest grows in the production of biofuel for aviation, a third option is hydrotreated jet fuel, referred to as renewable jet. This is a very similar process to renewable diesel production, and in practice hydrotreating facilities are likely to produce renewable jet and renewable diesel as co-products. In the aviation context this fuel is sometimes referred to as "hydroprocessed esters and fatty acids", abbreviated as HEFA, but this refers to essentially the same process as HVO production.

The biofuel industry in the EU is a policy-supported industry. The cost of biofuel production from animal fats exceeds the price of fossil diesel, and therefore some form of subsidy is required to make biofuel production financially viable. This could take the form of a direct subsidy, such as a discount on taxes payable on biofuel sales, or it could be an indirect subsidy such as mandating a minimum quantity of biofuel in the overall transport fuel supply. Under the EU's Renewable Energy Directive (RED II, European Union, 2018) Member States have implemented mandates requiring the use of biofuels or other forms of renewable energy in transport, which support the blending of ethanol in the petrol supply and of biodiesel and renewable diesel in the diesel supply.

The RED places a premium on the use of certain feedstocks that either require advanced technologies to process or that are considered to be wastes or residues of other processes. Since the adoption of the first RED in 2009, Member States have been allowed to count

1 The abbreviation HVO is still used by convention even when referring to hydrotreated animal fats.

2 Renewable diesel in fact contains almost 100% paraffinic molecules, while fossil diesel also contains aromatics and naphthenes. The lack of aromatic molecules in hydrotreated jet fuel (renewable jet) prevents its unblended use in the current generation of jet engines.

3 In fact renewable diesel is cleaner burning than fossil diesel, and so marginally reduces air pollution.

biofuels produced from these materials twice towards compliance with national targets for biofuel consumption. In the RED II, a list of the materials that are eligible to be double counted is provided in Annex IX. The annex is split into two parts. Part A includes feedstocks that are considered to require advanced processes for biofuel production (many of these materials are cellulosic or ligno-cellulosic in character). Part B includes two feedstocks that are widely used already for 'conventional' biofuel production. These are used cooking oil (collected from industrial food processors, restaurants and households) and animal fats that are in category 1 and 2 according to the Animal By-Products Regulation (European Union Regulation (EC) 1069/2009[4]).

1.1. Animal by-products in the EU

The Animal By-Products Regulation requires that animal by-products not intended for human consumption should be classified according to the risk that they pose to human and animal health. Three risk categories are given – Category 1 is the highest risk material (material unfit for human consumption that is associated with a specified risk of disease transmission), Category 2 is medium risk (material unfit for human consumption but not associated with any specified disease risk), and Category 3 is material that was considered fit for human consumption at the point of slaughter.

Category 1 material is often disposed of through combustion/incineration, while Category 2 material can also be used for soil improvement/fertilisation applications, composted or digested, or used to produce some other non-feed derived products. Article 13 of the Animal By-Products Regulation[5] provides that Category 1 and 2 materials can also be used in some 'technical' oleochemical applications. Both Category 1 & 2 material may be "used for the manufacture of derived products … referred to in Articles 33, 34 and 36 and placed on the market in accordance with those Articles." Article 33 in particular lists a number of oleochemical applications, including cosmetic and medical applications. These uses are restricted somewhat by Commission Regulation (EU) 142/2011, which requires that Category 1 & 2 fat derivatives[6] may not be placed on the market in feed, cosmetic or medicinal applications[7]. Previous reports that discuss this issue are inconsistent as to whether these regulations taken together have the effect of entirely preventing the use of Category 1 & 2 material in non-energy applications, but data from the European animal by-product processing industry association EFPRA suggests some use of Category 1 & 2 material in oleochemical applications in previous years (14 thousand tonnes in 2015, 4 thousand tonnes in 2016, and no significant use by 2019). There seems to be agreement that in practice any use of Category 1 & 2 material in non-energy applications is now very limited. Category 3 material has far more options for utilisation. As well as being eligible for any of the uses open to Category 1 & 2 material, Category 3 material may also be utilised for oleochemicals production, pet food and animal feed.

The Animal By-Products Regulation is focused on reducing the risk of disease transmission

4 https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:300:0001:0033:EN:PDF

5 Regulation (EC) No 1069/2009 Of the European Parliament and of the Council

6 Derivatives produced from Category 1 & 2 rendered fats by process of transesterification, saponification or hydrogenation.

7 Chapter XI of Annex XIII of the Regulation.

from animal by-products to humans and other animals. By creating a lower-risk category the Regulation aims to facilitate the productive utilisation of Category 3 animal by-products, but the priority is to ensure that no lower category material should ever be transferred to a higher category, and therefore the Regulation requires that mixtures of animal by-product material should always be placed into the lowest category (i.e. assigned the highest risk). This means that the moment that Category 3 animal fats come into contact with Category 1 or 2 animal fats they would be downgraded. In the absence of the biofuel market, there is a clear economic incentive to segregate Category 3 material with potential higher value uses from Category 1 and 2 material. The RED, however, creates a competing economic logic by placing a premium on biofuel use of the lower quality material (through the mechanism of double counting, and the associated treatment of feedstocks in Member State RED implementations). If the additional value to a biofuel producer of the double counting incentive exceeds the extra value available for Category 3 material on the market, then it would become economically rational to downgrade Category 3 material to a lower category.

Such re-categorisation of Category 3 material is not permitted under the RED. Article 30 Paragraph 3 states that, "auditing shall verify that the systems used by economic operators are accurate, reliable and protected against fraud, including verification ensuring that materials are not intentionally modified or discarded so that the consignment or part thereof could become a waste or residue," and Paragraph 7 states that voluntary biofuel certification schemes may only be approved if they provide, "adequate assurances that no materials have been intentionally modified or discarded so that the consignment or part thereof would fall under Annex IX." It would therefore not be allowable to purposefully mix Category 1 or 2 material into a batch of Category 3 material with the intention of downgrading it.[8] Under the RED, material originating as Category 3 should still be reported as Category 3 animal fat in biofuel reporting even if it has been downgraded at an intermediate point of the supply chain. A grey area would present itself in the case that a producer of animal by-products simply chooses not to invest in systems to keep material of different risk categories separated in the first place. In this report, when we talk about Category 1, 2 or 3 material we mean 'material that was in Category 1, 2 or 3 at the point of production' unless otherwise indicated.

1.2. About this study

This study reviews the use of animal fats as biofuel feedstock in the European Union and considers the implications of this use for other sectors. In particular, it focuses on the increased role of Category 3 animal fats as biofuel feedstock and discusses the risks of indirect emissions and of 'relabelling fraud', whereby Category 3 material could be purposefully downgraded to Category 1 or 2 in order to gain access to double counting incentives.

8 For example the ISCC scheme notes that the sustainability information on a batch of animal fats must reflect the category of those fats at the point of origin, and that for the purposes of certification a batch of Category 3 material shall continue to be identified as Category 3 even if it is downgraded for the purposes of the Animal By-Products Regulation https://www.iscc-system.org/update/17-august-2018/

2. Production and disposition of animal fats in the EU

2.1. Production

Category 1, 2 and 3 animal fats are produced primarily as a by-product of the meat industry. They are also produced in smaller quantities as a result of disposal of the carcasses of deceased non-food animals such as zoo animals and horses kept for leisure. To the best of our knowledge, there are no EU level official statistics on the production or disposition of rendered animal fats. We therefore rely on industry estimates to establish annual availability of these resources – these may be sense checked with bottom-up calculations based on the number of animals slaughtered each year.

The European Fat Processors and Renderers' Association (EFPRA) provides at its annual congresses information about the industry that is gathered by surveying its members. EFPRA is an association which is itself constituted of national associations. It represents 23 of the 27 EU Member States[9] plus Norway, Switzerland and the UK. By its own estimate EFPRA represents at least 95% of Category 1 & 2 animal fat production in all but one or two member countries, at least 80-85% of Category 3 animal fat production in all member countries and an unknown fraction of edible animal fat production.[10] It is unclear precisely how to scale from EFPRA's survey data on animal fat production and disposition to an estimate of total animal fat production and disposition in the EU. The inclusion of non-EU members will tend to inflate the estimates compared to the true EU-only value, but this is offset by the four missing Member States (though these are all relatively small) and by the partial coverage of renderers. In this study we therefore report EFPRA's data as they present it without attempting any correction to better approximate a full EU-only value. As we discuss further below, these discrepancies between the scope of the EFPRA survey and of EU-level estimates for biofuel use may account for part of the apparent inconsistencies between data reported from different sources. EFPRA does not provide an archive of its statistical overviews, and therefore this study is based on a partial set of documents from the past decade. We have referred directly to the data for the years 2015, 2016, 2019, 2020 and 2021[11], and have access to parts of the 2014 data via Chudziak & Haye (2016) and to some 2007 data via private correspondence. We refer to these sources collectively as 'EFPRA data'. Notwithstanding the limitations of this dataset it is considered to be broadly accurate by stakeholders in associated industries and is widely referred to.

According to the data for 2021 that was shared at the 2022 EFPRA congress (Dobbelaere, 2022), in 2021 EFPRA members rendered 18.6 million tonnes of animal material[12] into about 3

9 The unrepresented four are Cyprus, Estonia, Luxembourg, and Malta.

10 Private correspondence.

11 Dobbelaere (2015, 2017, 2020, 2021, 2022). We are grateful to EFPRA for sharing the most recent 2021 data on request.

12 I.e. carcasses after higher value meat and fats are removed.

million tonnes of animal fats and over 4 million tonnes of animal proteins. Of the animal fats, 2.4 million tonnes were Category 3, and 570 thousand tonnes were Category 1 & 2.

EFPRA's data since 2009 shows an increase over time in the amount of Category 3 material produced versus a relatively steady production of Category 1 & 2 material (this is discussed by Chudziak & Haye, 2016) – reported Category 3 fat production increased from about 1.3 million tonnes in 2009 to 2.4 million tonnes in 2021.

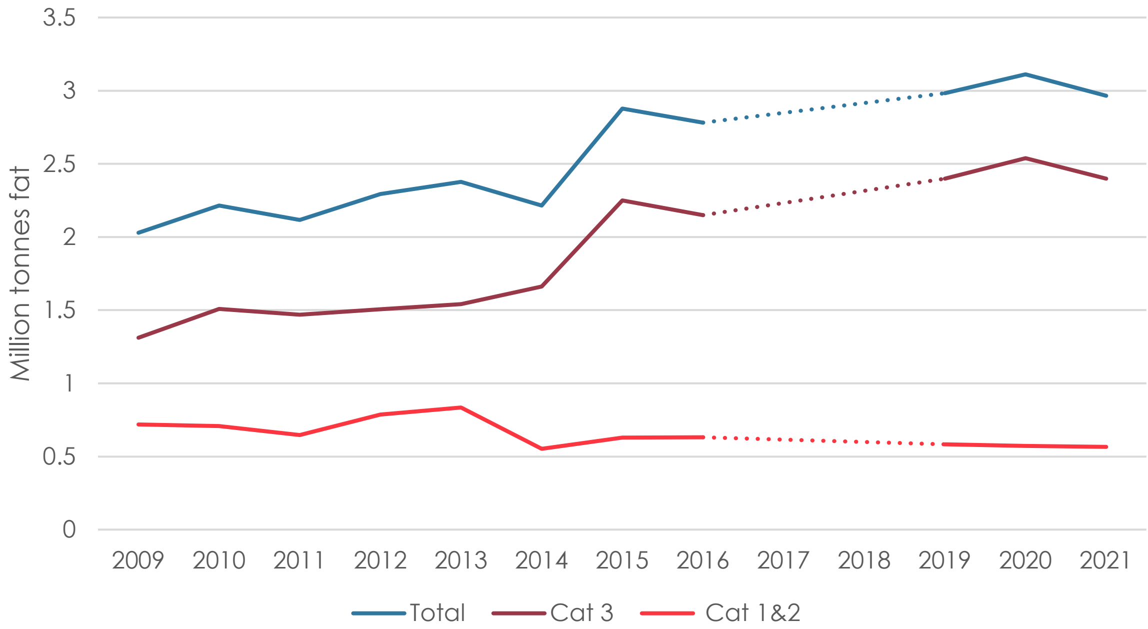

Figure 1. Animal fat production reported by EFPRA, 2009 to 2021

Source: EFPRA data.

Comparing to FAOstat data for livestock slaughter in the EU, this growth is not explained by an increase in the total number of animals being processed or mass of meat produced (total EU meat production grew by about 10% from 2009 to 2020, and bottom-up estimates of potential fat production in the EU derived by following the approach documented in Annex A are relatively steady through this period). It could in part reflect a change in Category 3 market share for EFPRA members – Chudziak & Haye (2016) reported that EFPRA covered 74% of the Category 3 market and, as noted above, we understand this is now 80-85%. It could also reflect improvements in segregation procedures for Category 3 fats or a relaxation in some Member States of categorisation protocols (Chudziak & Haye, 2016). It was suggested by stakeholders in the pet food industry that increased animal fat prices have led to material that would previously have been supplied for wet pet food being supplied for rendering instead, and that renderers may have adopted new approaches to increase fat recovery from rendered material. Both of these changes would increase Category 3 animal fat production. It is likely that the full explanation reflects a combination of these factors.

The fact that reported Category 3 animal fat production has increased over time suggests that the additional value available to Category 1 & 2 animal fats under the RED has not led renderers to relax their segregation practices with a view to increase production of Category 1 & 2 material – indeed, from the information available the opposite appears more likely to be true. Based on this, one might be cautiously optimistic that further strengthening of the market for animal fat biofuels (through REFuelEU Aviation etc.) would not lead to a transfer of material from Category 3 into the lower categories, at least not at the rendering plant. The corollary question is then whether the chain of custody systems in place are adequately robust to prevent any of this Category 3 material later being reported to Member State biofuel regulators as Category 1 & 2 in order to access double counting benefits.

The distribution of animal fat production across the EU Member States may be estimated by cross referencing data on the number of animals slaughtered in each country with estimates of the rendered animal fat produced per animal (see Annex A). The results are shown in Figure 2. It should be noted that while Category 3 fat production per animal slaughtered should be fairly consistent across time and countries, Category 1 & 2 fat production may be more influenced by exogenous factors, notably by disease outbreaks, and thus the estimates for Category 1 & 2 fat production should be considered indicative only.

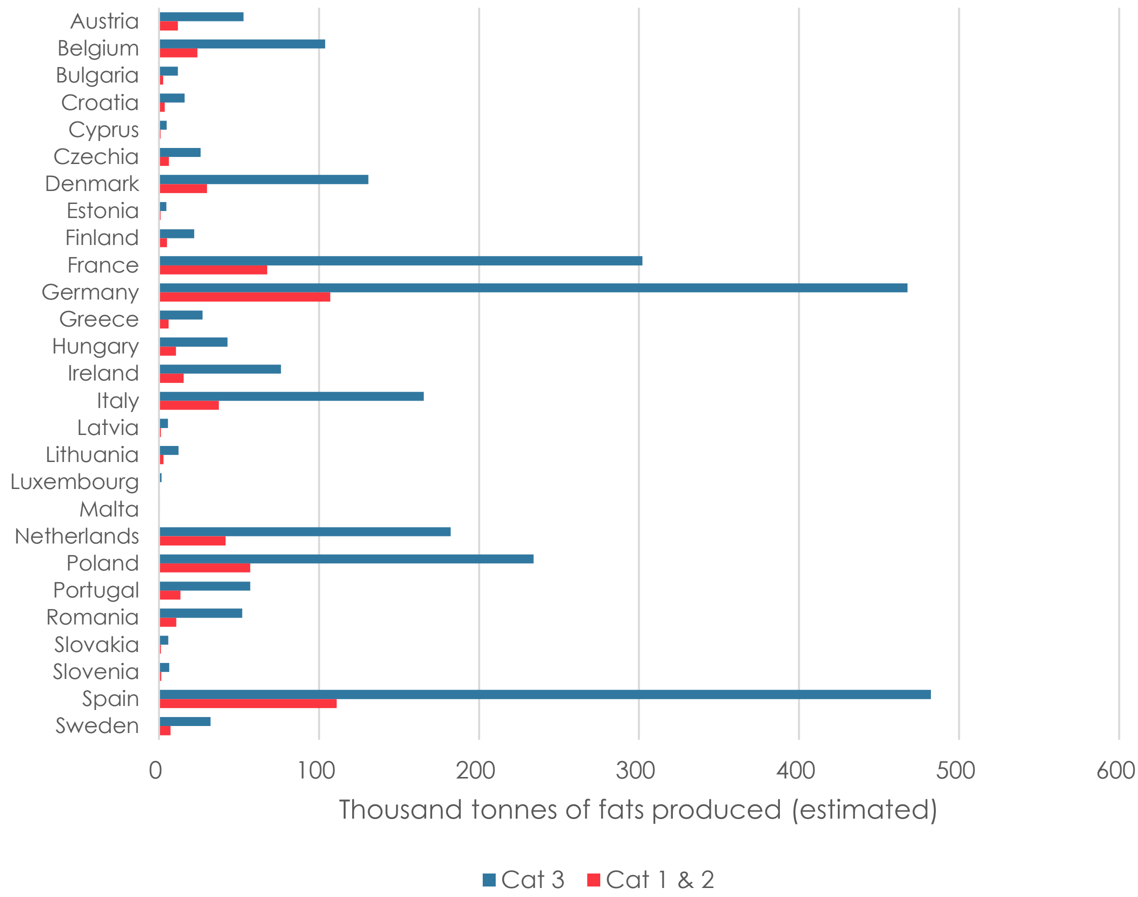

Figure 2. Indicative estimate of production of rendered animal fats by EU Member State, 2020

Source: Own calculation based on comparison of FAOstat meat production data with EFPRA animal fat yield data, see Annex A.

2.1.i) Global production, and potential for imports

Is has been noted that, "When looking at the global production and consumption of animal fats we notice a lack of reliable statistical material" (Aveno, 2020), and indeed it is difficult to find detailed data on the state of the industry globally. Saria (2008) suggested that EU rendered animal fat production represented about a fifth of the global total. If this ratio is still representative, then current global production of rendered fats would be in the region of 15 million tonnes per year. Chudziak & Haye (2016) suggest that options for the import of animal fat in Categories 1, 2 or 3 as biofuel feedstock are limited, in part because other countries do not use the same animal by-product categorisations. Based on discussion with industry experts it is our understanding that while it is possible to arrange for imports of this material, the required paperwork and the cost of transportation represent a significant practical barrier. For example, it was reported in 2021 that TEPSA Tarragona had been authorised to handle imports of animal by-products for biofuel production[13]. This shows that there is potential for such imports, but also that it is an unusual enough arrangement to be considered worth reporting on.

Eurostat trade data do show a moderate increase in total animal fat imports over the relevant period, but do not provide a basis to distinguish between categories of material or to identify end use. Since 2007 annual imports of animal fats have increased by about 150 thousand tonnes (Figure 3). This quantity of imported fats is small compared to the approximately 3 million tonnes of European production of animal fats in Categories 1, 2 and 3 reported by EFPRA, and therefore it is reasonable to conclude that consumption of animal fats for biofuel production is dominated by domestically generated resources. Haye et al. (2021) notes that imports of any animal by-products must be registered in the TRACES database[14] with information including origin and category, with the result that supply chain traceability should be better for animal fats than for many other materials.

13 https://ofimagazine.com/news/tepsa-tarragona-gets-go-ahead-to-import-animal-by-products-for-biofuels-production

14 https://food.ec.europa.eu/animals/traces_en

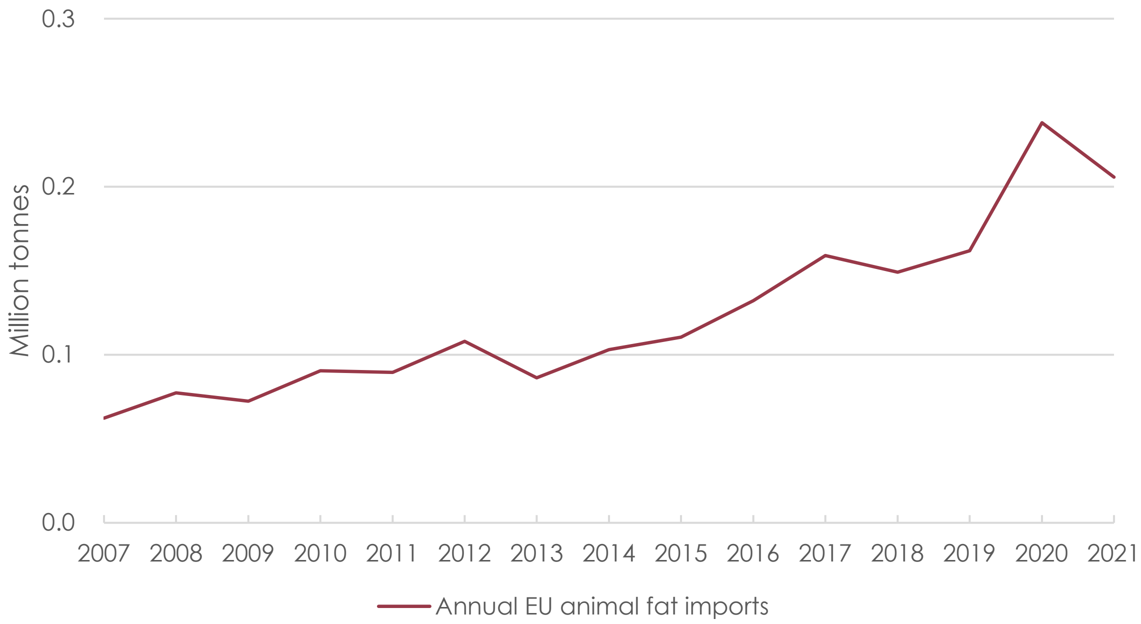

Figure 3. Imports of animal fats to the EU, excluding fish oils

Source: Eurostat.
Note: fish oils are excluded as this is a distinct market from rendered fats.

The understanding that imports of animal fats and animal fat derived biofuels are limited is supported by the lack of evidence of significant imports of animal-fat-based biofuels in available biofuel statistics. The most detailed biofuel reporting available in Europe is from the UK under the Renewable Transport Fuel Obligation (RTFO). Although the UK is no longer subject to the RED, the RTFO is still "RED-like" in its sustainability rules and offers double counting to both UCO and Category 1 animal fats. Detailed UK biofuel feedstock statistics (Department for Transport, 2022) show biofuel being produced from UCO that is sourced from countries all over the world, but show only very small quantities of animal fats sourced outside the UK, EU and EFTA (this is mostly identified as coming from Russia and Belarus, and none was reported in 2021). The UK has been one of the more attractive markets for double counted biofuels, and therefore it would be surprising if large quantities of animal fats for biofuel were being sourced outside Europe but hardly any was turning up in UK biofuel statistics.

2.2. Disposition

EFPRA also provides a characterisation of the way that animal fat resources are used. Figure 4 shows the reported disposition of Category 1, 2 and 3 fats[15] for those years where data was available, between 2006 and 2021. The most significant changes over this period are the growth of utilisation for biodiesel and a corresponding reduction in the amount of material combusted for heat and/or power.

15 Note that there is an inconsistency in the EFPRA data presentation relating to edible fats. The reported total production of Category 3 fats in EFPRA's statistical overview matches the sum of the total disposition of fats reported as "Category 3 and edible".

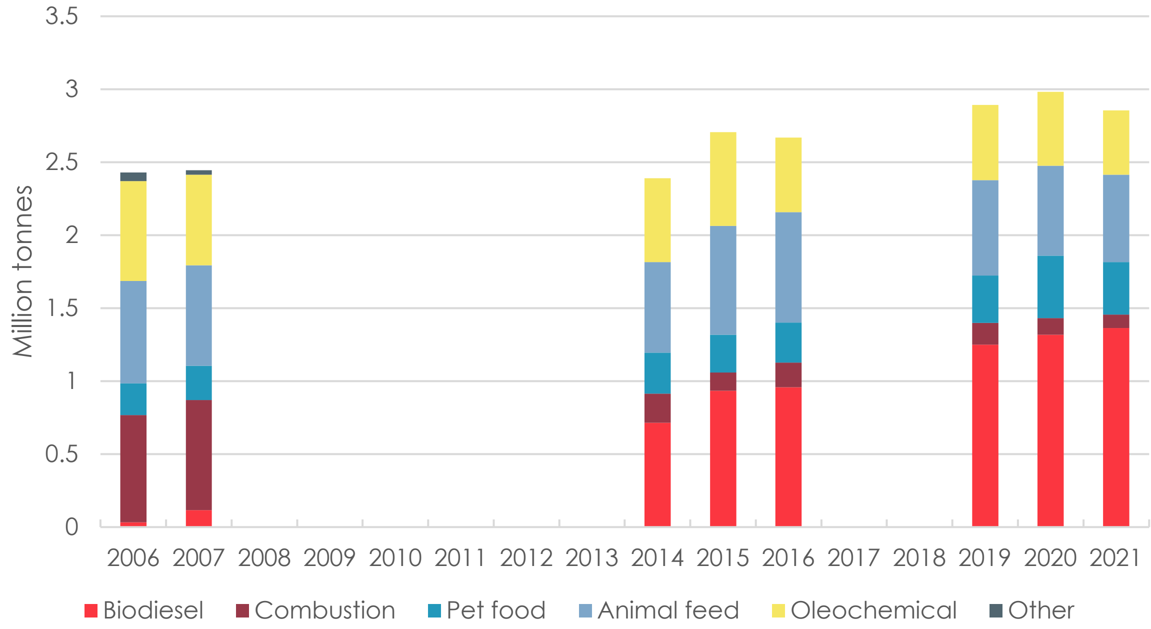

Figure 4. Disposition of rendered Category 1, 2, 3 and edible fats in the EU for years where EFPRA data was available

Source: EFPRA data.

Notes: data for 2006/07 were presented for the EU-18; EFPRA does not distinguish between use for biodiesel and use for renewable diesel.

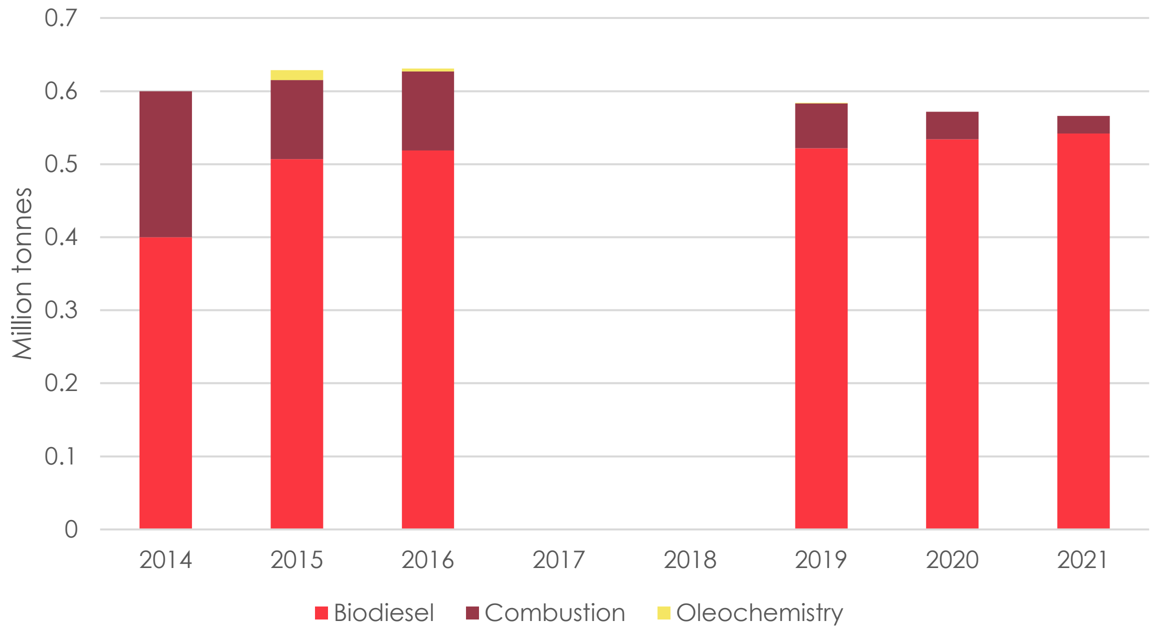

Figure 5. Reported disposition of Category 1 & 2 animal fats in Europe

Source: EFPRA data; data for 2017/18 was not available.

Since 2006, the reported consumption of animal fats for biodiesel production has grown from 30 thousand tonnes per year to 1.4 million tonnes a year in 2021. This includes processing almost the entire Category 1 & 2 resource (540 thousand tonnes, see Figure 5) plus a further 820 thousand tonnes of Category 3 fats. Use by the biofuel industry is discussed in more detail in the next section.

For Category 3 animal fats, other uses remain important despite the growth in consumption for biofuel. The other main uses are in pet food, as feed for other animals and in the oleochemicals industry (Figure 6). We note again that because the EFPRA data is survey based the coverage of the dataset may vary between years and thus a degree of caution should be exercised in interpreting changes. That said, the EFPRA data show that since 2014 the use of Category 3 fats for biodiesel has increased by 160%. The second largest use is in animal feed (not including pet food) which has declined by 4%, reaching 600 thousand tonnes in 2021. Oleochemical use has declined by about a quarter to 440 thousand tonnes in 2021, while use in pet food is reported to have increased by 30% to 360 thousand tonnes despite the competition from biodiesel. Overall use in non-biodiesel applications has declined by just 5% since 2014 according to this data.

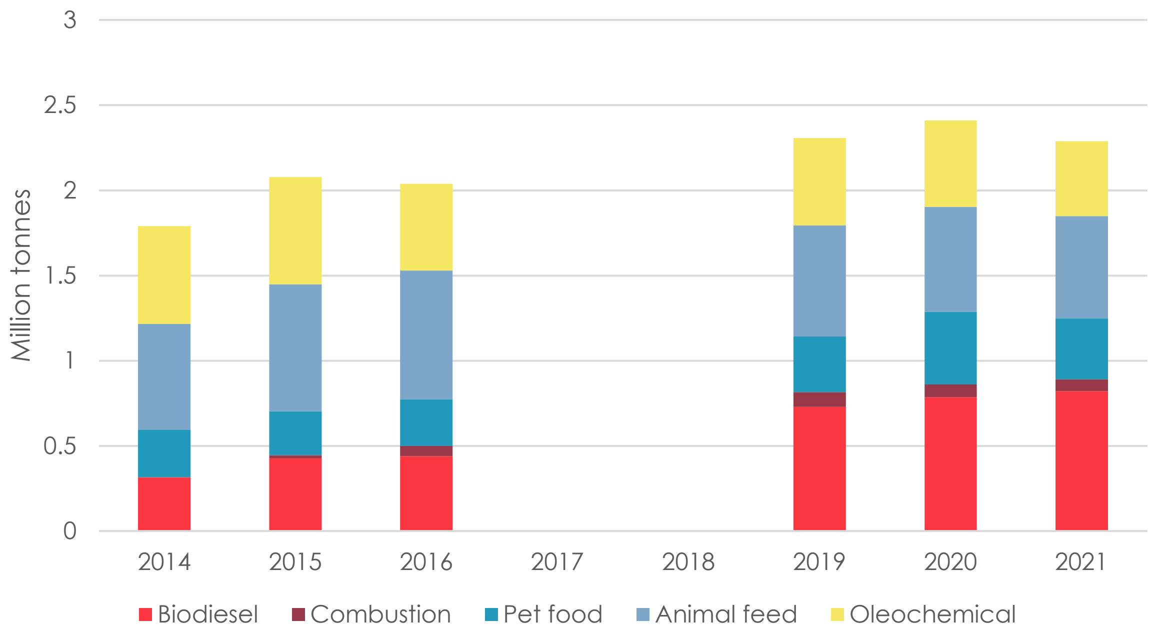

Figure 6. Reported disposition of Category 3 animal fats in Europe

Source: EFPRA data; data for 2017/18 was not available.

Information is also available for the German industry specifically. Fehrenbach et al. (2019) reports (based on data from local industry associations) that in 2016 the vast majority (96%) of Category 1 material was used for biodiesel, with 3% going to technical use, while all Category 2 material went to biodiesel. In Category 3, 20% was used for animal feed or pet food, 47% for technical uses and 33% to biodiesel. Given the past lack of support for animal-fat-based biodiesel under the German scheme it may be assumed that these fuels were destined for export to other EU countries.

2.2.i) Use as biofuel feedstock

As is demonstrated by EFPRAs statistics on the disposition of rendered animal fats, the ability to contribute towards national biofuel targets has made biofuel production an appealing market for renderers. National biofuel mandates imposed in order to comply with the requirements of the RED create a form of subsidy for biofuel producers which enables them to pay more for feedstocks and thus gain advantage compared to other industry players. For example, in the Dutch market biodiesel and renewable diesel from animal fats are eligible to generate "HBE-O" certificates[16] that can be used to show compliance with the Dutch mandate for renewable energy in transport. For Category 3 animal fats, one certificate is issued for every gigajoule of fuel supplied. For double counted Category 1 & 2 animal fats two certificates are issued for every gigajoule of energy supplied. One recent market report[17] puts the price of HBE-O certificates at around €12.50 per gigajoule. This translates to about €420 of subsidy value for every tonne of Category 3 animal fats converted, but double that (about €840) for every tonne of Category 1 & 2 animal fats converted.

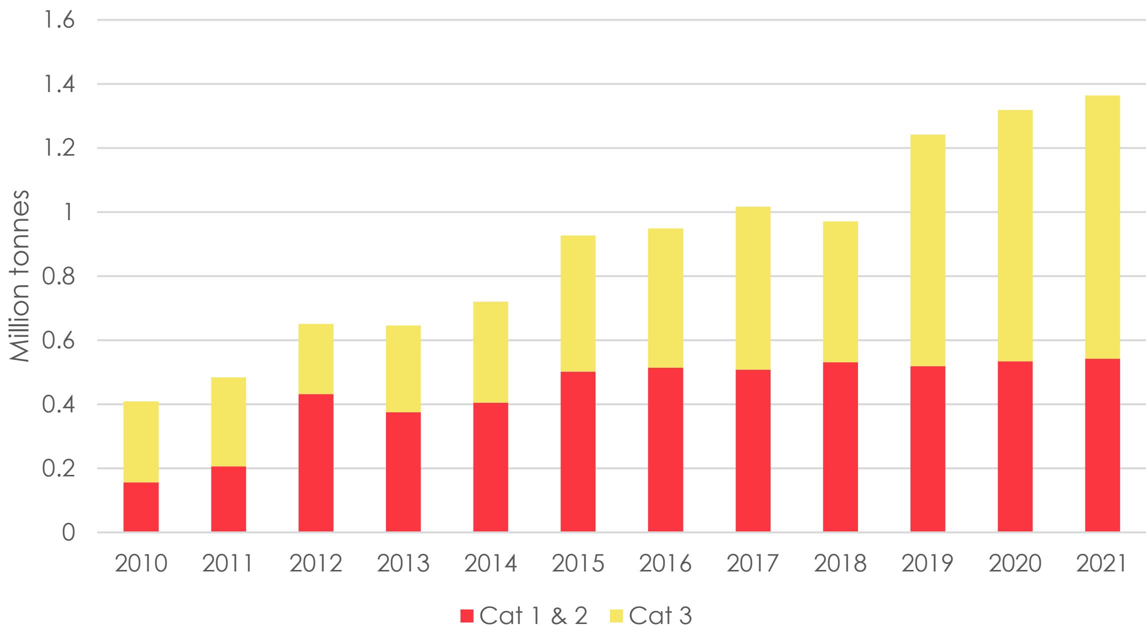

Figure 7. Animal fat use for biodiesel production by category

Source: EFPRA data.

Figure 7 shows EFPRA estimates of the quantity of animal fats used for biodiesel production every year since 2010, divided between Category 1 & 2 fats and Category 3 fats. It is noteworthy that according to the EFPRA data the use of Category 3 fats in biodiesel production developed in parallel with the use of Category 1 & 2 fats despite the potentially higher value of Category 3 material in other markets. The data suggests a shift towards the use of Category 1 & 2 fats in 2012 – this could relate to the publication in that year of the

16 Hernieuwbare brandstofeenheden – overig.

17 https://www.fastmarkets.com/insights/hbe-multiplier-for-dutch-marine-biofuel-reduced

proposed ILUC Directive (European Commission, 2012), which was the first EU legislation to explicitly suggest differentiating the level of support given to different categories of animal fats. Under the original RED, member states were permitted to double count any feedstocks identified as wastes or residues, and it was therefore left to the Member States to determine whether this would apply to Category 3 animal fats. The ILUC Directive (eventually adopted in 2015) introduced Annex IX to the RED and specified only Category 1 and 2 material, thereby excluding Category 3 fats from this treatment. The uptick in the use of Category 1 & 2 material for biodiesel in 2012 could be evidence of early action by some Member States to restrict incentives to Category 3, or evidence of biodiesel producers pre-emptively adjusting their supply chains to prioritise Category 1 & 2 resources.

The use of Category 1 & 2 material for biodiesel has now been more or less maxed out – 96% of Category 1 & 2 fats are identified as going to biodiesel in 2021 – and so the only way to increase use of EU-generated animal fats is now to further increase consumption of Category 3 material. As can be seen in Figure 7, in the longer term the restriction of double counting to Category 1 and 2 fats only has not prevented an increasing diversion of Category 3 resources to fuel use.

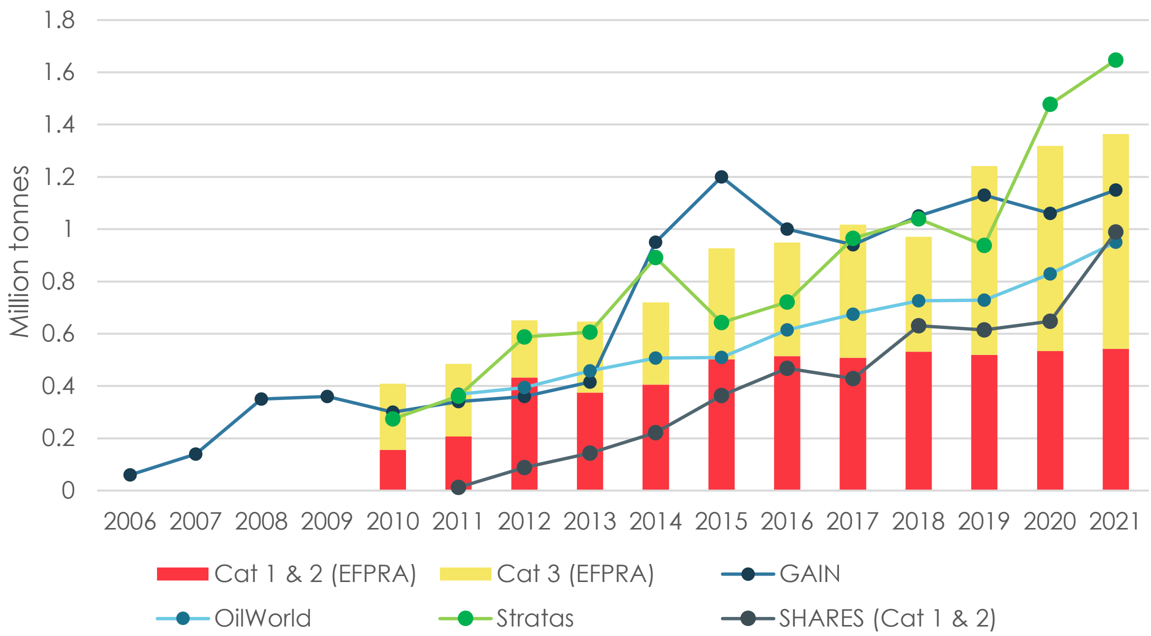

Figure 8. Estimated animal fat consumption for EU biofuels based on statistics from EFPRA and from the US Department of Agriculture Global Agricultural Intelligence Network

Sources: EFPRA data; GAIN data from Flach et al., 2016 (2022); Stratas and OilWorld data provided by Transport and Environment; SHARES data from Eurostat[18].

Notes: SHARES data reflects reported biofuel consumption from Category 1 & 2 animal fats, rather than production; where data was given as quantity of biofuel we have converted to feedstock demand based on standard yields from Biograce for biodiesel and renewable diesel production and on the biodiesel/renewable diesel split reported by Stratas.

18 https://ec.europa.eu/eurostat/web/energy/data/shares

While it is generally agreed that the overall use of animal fats for biofuel feedstock has increased fairly continuously since the introduction of the RED, there is some disagreement (or at least inconsistency) between different sources in relation to the exact level of supply of animal-fat-based fuels to the EU market. Figure 8 again shows the EFPRA estimates of EU consumption of animal fats for biofuel production, and compares it to data from the market analysts OilWorld and Stratas Advisors, from USDA's GAIN reports[19], and from the EU SHARES renewable energy monitoring tool. As is immediately apparent in the figure, the estimates show significant deviations from each other.

The easiest deviation to explain is perhaps the low reported quantities in the SHARES data prior to 2015. It is clear from the dataset that reporting of this information was inconsistent between Member States in earlier years. For example, Spain's reporting on biofuel consumption in the SHARES dataset only starts in 2016, and Finland's in 2013. The SHARES data therefore systematically understates total quantities produced and consumed in the EU in these earlier years.

The reporting basis for the SHARES data is the consumption of biofuels from feedstocks on Annex IX, which means that this data should be limited to only Category 1 & 2 animal fats. It is therefore interesting that for 2021 (the last year of reporting available) SHARES data for biofuel consumption implies just under a million tonnes of feedstock consumption – this is nearly double the amount reported by EFPRA for Category 1 & 2 fuels. **This datapoint strongly suggests that biofuels from material that originates as Category 3 are incorrectly being reported as produced from Category 1 & 2 material** and presumably double counted. This SHARES data is the strongest evidence we have found that this type of misreporting may be occurring systematically.

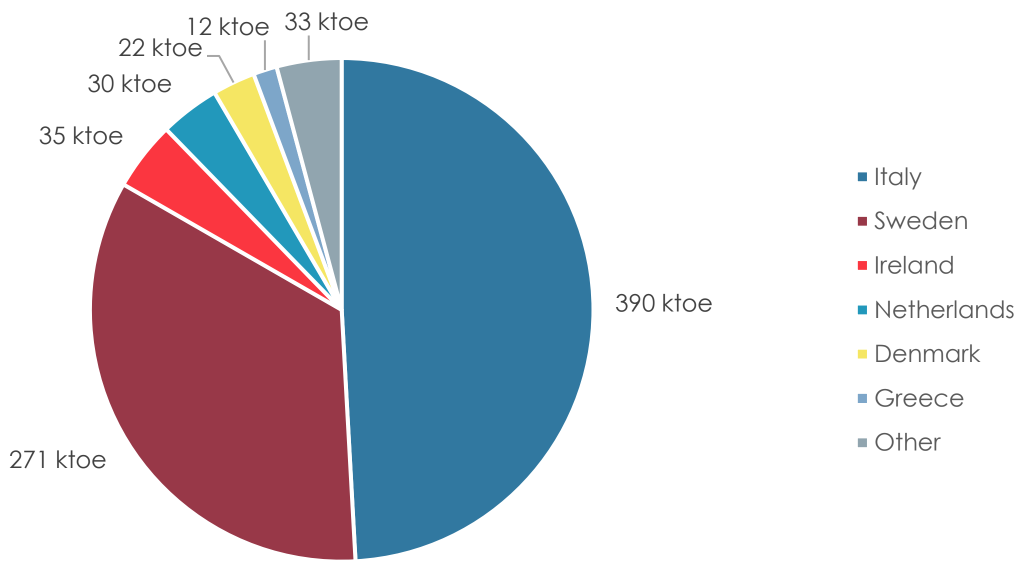

Figure 9. Consumption of biofuels from Category 1 & 2 animal fats by country in 2021

Source: SHARES.

19 The USA Global Agricultural Intelligence Network publishes annual reports on EU biofuels which include estimates of the EU feedstock mix.

The SHARES data also provides an indication of which countries are the major consumers of biofuels from animal fats. As shown in Figure 9, Italy and Sweden appear to be the most important consumers in 2021. Given that the sum of animal-fat-based biofuel consumption in these countries alone is greater than the quantity of Category 1 & 2 fats believed to be available for biofuel production in Europe, if this data is accurately reported it implies that Category 3 material has been misreported in 2021 in at least one of these two countries. The Swedish data for 2020 and 2021 are somewhat suggestive in this regard – the reported supply of Category 1 & 2 based biofuels increased year on year by more than 200 thousand tonnes of oil equivalent, and the quantity of biofuel reported as "other compliant biofuel" (which should include category 3 animal fats) simultaneously fell by a similar amount. It is not possible, however, to draw any firm conclusion from this limited evidence.

Production of biofuels from animal fats is less concentrated, but according to data from Oilworld is led by the Netherlands, Finland, Spain and France (Figure 10). This shows that biofuels from animal fats are routinely being transported from the country of origin to countries that presumably offer a more favourable value proposition.

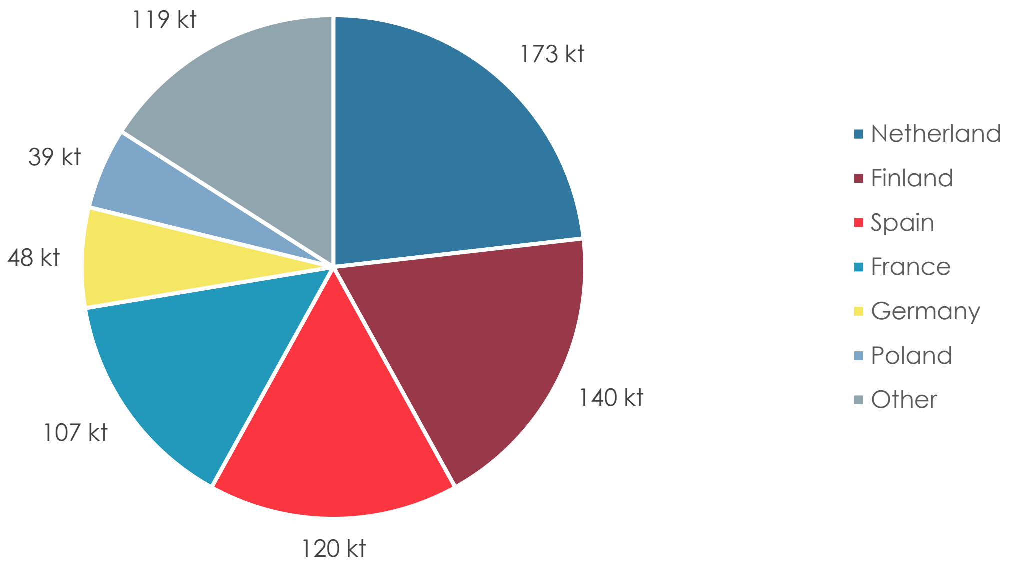

Figure 10. Production of biofuels from animal fats by country in 2021

Source: OilWorld data provided by Transport and Environment.

Based on correspondence with OilWorld it is understood that their data may have only partial coverage of Category 3 animal fat use, which would be consistent with this data being similar to the SHARES numbers. OilWorld and USDA are more or less in agreement from 2010 to 2013 but diverge in 2014; Stratas data suggests that this coincides with a ramp up in renewable diesel production from animal fats, suggesting that OilWorld may also be missing (or at least have been missing) some consumption of animal fats for renewable diesel. A final datapoint comes from the EU's 2020 Renewable Energy Progress Report (European Commission, 2020), which included a value of 693 thousand tonnes oil equivalent of biofuel from animal fats used in the EU in 2018, consistent with about 860 thousand tonnes of animal fats used as feedstock[20].

20 Using Biograce data on conversion yield and using the Stratas estimate of biodiesel/renewable

Taking the available data as a whole we can conclude with a degree of confidence that animal fat consumption for biofuels in the EU is now running well above a million tonnes a year, probably between 1.1 and 1.5 million tonnes, of which something around 550 thousand tonnes is produced from Category 1 & 2 material, and the rest from Category 3.

Note that there has been some variation in the treatment even of Category 1 & 2 animal fats in national biofuel support schemes. For example, in the past Germany did not allow animal fat based biofuels to count towards its GHG quota at all (IFEU, 2020), although this was amended for 2022 and onwards with the transposition of the RED II.[21] The UK (which still has an RED-like biofuel support scheme even after Brexit) offers double counting to Category 1 material but not to Category 2 material (UK Department for Transport, 2021). In Germany, support for animal fat based biodiesel was previously ruled out to avoid "the competition for use that would be created by the promotion of [tallow methyl ester] compared to other sectors that already use animal fats as raw materials" (IFEU, 2020)[22]. We note that German biofuel reporting (Bundesanstalt für Landwirtschaft und Ernährung, 2021) includes an 'other' category alongside UCO under the heading of biofuel from Annex IX Part B feedstocks. It is unclear to us what is included under 'other' Annex IX Part B feedstock if not animal fats, but the German SHARES reporting shows no biofuels from Category 1 & 2 animal fats being used in Germany in previous years.

2.2.ii) Risk of misclassification of material

In the previous section we noted that under the Dutch biofuel mandate the use of double counted Category 1 & 2 fats allows a biofuel producer to receive double the implied subsidy value that is available to a producer using Category 3 fats (which is about €420 per tonne of material processed). The Dutch biofuel statistics (Dutch Emissions Authority, 2022) show that this hierarchy of incentives is currently working – in 2021, about 83 thousand tonnes of Category 1 & 2 animal fats were consumed as biofuel, while no more than 11 thousand tonnes of Category 3 animal fats were used.[23]

While the Dutch statistics show a much greater use of lower quality material, the EFPRA data suggests that across the EU as a whole **biofuel-led demand for Category 3 fats has outgrown demand for Category 1 & 2 fats**. It is not entirely surprising that Category 3 fats should be in demand even without double counting. The main alternative to Category 3 fats in the single counting market is the use of virgin vegetable oils, and in the context of sustainability concerns that are most strongly associated with first generation food-based biofuels the appeal of a non-food feedstock is obvious. If more Category 3 fats are being used than Category 1 & 2 facts, this implies that there are some countries in which most biofuels from animal fats are single counted. This seems to have been the case in Sweden, for example, where national biofuel statistics (Swedish Energy Agency, 2022) show significant consumption

diesel split in that year. ¶

21 https://www.argusmedia.com/en/news/2217327-germanys-parliament-passes-biofuels-law

22 "Die Nutzungskonkurrenz, die gegen-über anderen Branchen, die bereits tierische Fette als Rohstoff verwenden durch eine För-derung von TME geschaffen würde."

23 Category 3 animal fats are listed in an 'other' category so it is not possible to precisely identify the consumed volume.

of animal-fat-based HVO from 2012 onwards, but SHARES data shows no reporting of the use of Category 1 and 2 animal fats in Sweden until 2018.

As noted above, 2021 data for the EU as a whole from SHARES suggests that more biofuel is being reported to Member States as derived from Category 1 & 2 material than is consistent with the available supply of that material. This concern is echoed in conversations with stakeholders in other industries that use Category 3 animal fats. While we were not able to find demonstrated and documented examples, there is a firm belief in the industry that some material that is identified as Category 3 at the rendering plant is being either downgraded in the supply chain and reported with a downgraded category, or is simply being mislabelled in biofuel reporting. Under the Animal By-Product Regulations, any Category 3 material contaminated with lower grade material must be recategorised to that lower category. However (as noted above) it is not allowed under the RED to purposefully reclassify Category 3 material into Category 1 or 2 in order to benefit from double counting rules, and downgraded material should be reported with its original category for the purpose of biofuel reporting. Reporting animal fats that were produced as Category 3 in a lower category would therefore be a form of fraud.

While purposeful reclassification is not permitted, the incentive to do so is clear. In our example above from the Dutch biofuel support scheme, the act of relabelling a tonne of Category 3 fat as Category 1 or 2 fat would immediately increase the value of certificates from turning that fat into biofuel by €420. Fraudulently accessing that extra value would significantly distort the competition for Category 3 resources between biofuel producers and other users.

The EFPRA data on production of the three categories of animal fats shows that Category 3 production has actually increased despite the presence of double counting incentives, which suggests that renderers have not relaxed the stringency of their segregation systems at the rendering plant in response to the RED incentives. While material produced as Category 3 may be getting reclassified elsewhere in the supply chain, we are not aware of any examples of this being actively detected, either by national biofuel policy administrators or by anyone else. A review of documented biofuel fraud cases presented in Haye et al. (2021) does not identify any such cases, and argues that the strong systems already in place for tracking animal by-products reduce the risk of this sort of fraud. Given, however, that those systems are conceived on the assumption that operators will generally want to avoid having their material downgraded rather than seek to have it downgraded, it is unclear whether they are robust to these new market conditions. Certification schemes have introduced rules to make it clear that only the initial status of animal fats is relevant to their regulatory treatment, and therefore the auditors for voluntary certifications should understand that mixing material of different Categories after the point of origin is not an acceptable basis to become eligible for double counting.

It is possible that the forthcoming Union biofuel database (Alberici et al., 2020) will allow for improved governance of material sourcing by tracking material from the point of production to the point of biofuel supply. The effectiveness of the database in reducing fraud risk will be determined by the final design and implementation. To the best of our knowledge the Commission has not yet released a detailed documentary specification for the database, however a "Communication for Launch Planning" document that has been published by the Nederlandse Emissieautoriteit (European Commission, 2022a) states that the database will include a "Reporting obligation from collection point or gathering point" and anticipates full system launch in the fourth quarter of 2023.

3. Implications of increasing demand for animal fats for biofuel production

At the time of writing, the Renewable Energy Directive is being renegotiated for the second time in five years, as part of the EU's Fit for 55 climate policy package. These negotiations are intended to increase the ambition of the EU's climate goals, including for renewable energy in transport. While the EU has signalled that it does not intend to deliver long term growth in the market for food-crop-based biofuels, the situation is different for the biofuels listed in Annex IX of the RED. 'Advanced' biofuels listed in Part A of Annex IX will receive strong support through sub-targets for 2030, and strong growth is therefore expected in this part of the market (including cellulosic biofuel production).

Biofuels in Part B of Annex IX are in a more complicated position. While Part B biofuels will still be eligible to be double counted in the amended regime, there is no sub-target for Part B fuels and their contribution to RED targets is capped (currently to 1.7% of regulated transport energy, although Member States have some scope to adjust this limit upwards). Without a sub-target, Annex IX Part B fuels must compete for space under the RED with other forms of transport renewable energy such as renewable electricity supplied to electric vehicles, recycled carbon fuels, and food-based biofuels (delivered under their own cap).

The Fit for 55 process is expected to expand this market opportunity – fuels supplied to maritime and aviation applications will be brought fully within the RED so that the 1.7% cap applies to a larger total fuel pool, while the proposals would make Annex IX feedstocks eligible to be used to meet new complementary targets for aviation and maritime fuels under REFuelEU Aviation (European Commission, 2021b) and FuelEUMaritime (European Commission, 2021c).

3.1. Up in the air or all at sea?

While the European Commission has clearly identified that used cooking oil and animal fats can only play a minor long-term role in replacing petroleum for aviation, and that advanced biofuels and e-fuels have much better scalability, lipid hydrotreating to produce renewable jet fuel is the most mature technology available for alternative aviation fuel production. Lipid hydrotreating allows animal fats and vegetable oils to be transformed into hydrocarbon fuels that can be used in existing road vehicles (as renewable diesel), or in jet engines after appropriate upgrading (renewable jet fuel). There is therefore considerable pressure to accelerate the first phase of deployment of alternative fuels in aviation by using HEFA before the more scalable and sustainable alternatives are ready.

The impact assessment on REFuelEU Aviation anticipates about a million tonnes of lipids being used as aviation fuel feedstock by 2030, growing to about 3 million tonnes by 2050. The FuelEUMaritime proposal states that "sustainable maritime fuels produced from feedstock listed in Part B of Annex IX of Directive (EU) 2018/2001 are essential" and anticipates 800 thousand tonnes of demand for Annex IX Part B lipids by 2030. The impact assessments on both REFuelEU Aviation and FuelEUMaritime anticipate that lipids will be rapidly overtaken as biofuel feedstock by cellulosic biomass resources, but neither proposal includes a mechanism that would guarantee this outcome. In the event that cellulosic biofuel development and the development of e-fuels lag the pace foreseen by the European Commission in Fit for 55, there will be enormous pressure to use UCO and animal fats to comply with the aviation and maritime targets. Category 3 animal fats are included as eligible feedstocks in the FuelEUMaritime proposal, and while they were excluded from the Commission's original REFuelEU Aviation proposal we understand that this is likely to be amended during the trilogue, in which case Category 3 fats could be in high demand for non-road transport. An increasingly valuable compliance market is likely to draw yet more material away from existing users.

Looking beyond the EU, the world is in the middle of a boom in lipid hydrotreating capacity development with billions of litres of capacity announced for deployment in the next few years (Malins & Sandford, 2022). If all announced projects were to be successfully completed by 2024 and operated at full nameplate capacity it would create 17 million tonnes of additional oil and fat demand globally. Animal fats are firmly on the agenda as a potential feedstock for these facilities, but it is unclear at this point just how much animal fat will be consumed in hydrotreating plants in the coming years – most announced facilities state that they will run on some combination of waste oils, animal fats and vegetable oils. Even if the market for biofuels from Category 3 animal fats is constrained in Europe, these resources (and biofuels produced from them) will be in demand in other markets – for example the potentially lucrative Low Carbon Fuel Standard market in California does not make any distinction between categories of animal fats.

There is little scope to increase the supply of animal fats in the EU to help meet this demand, and any further measures taken to extract residual additional fat from animal protein at EU rendering plants will affect the quality and availability of animal protein resources currently used in pet food and animal feed. While there is more potential to increase used cooking oil collection (Greenea, 2016) these are resources that could readily be used by the existing biodiesel industry to supply on-road biofuels. Creating incentives to pull this material into aviation is likely to simply move these resources from one part of the renewable economy to another with no net climate benefit (Malins, 2021) and with potentially dire consequences for the existing waste-based biodiesel industry as biodiesel producers lose their feedstock supply to renewable diesel producers (EWABA, 2022).

The reality of the EU's 2030 alternative fuel mix, and the contribution of animal fats and used cooking oil to that mix, will in the end be dependent on the interaction of the finalised policies themselves, the way that Member States implement those policies, and the relative speed of development of key technologies such as electric drive vehicles, advanced biofuels and e-fuels. For now, double counting remains a strong incentive for the use of Annex IX Part B resources, and though the Fit for 55 package proposes to remove the double counting incentive this will likely be offset by increased ambition for total biofuel supply and the introduction of the new aviation and maritime policies.

3.2. Displacement of animal fats from existing use

Animal fats are a 'rigid' resource, i.e. a resource that is available in a set quantity that is largely independent of demand. The quantity of animal fats available on the market is primarily determined by meat consumption and by mortality rates among animals kept for non-food purposes (e.g. zoo animals, horses) rather than by demand for fats. Resources with rigid supply may be contrasted to resources with an elastic supply, for which we expect an increase in demand to lead directly to an increase in production, which include primary agricultural outputs.

Animal fats are also a resource that has traditionally been 100% utilised, being sold for various uses or combusted for energy in on-site boilers at rendering plants in the absence of higher value options. There may be some scope to increase the production of rendered fats in less mature markets outside Europe, and there is a degree to which renderers can adopt additional fat removal processes such as solvent extraction to maximise fat yields from processed carcasses, but the main consequence of increasing animal fat consumption in one sector (in this case biofuels) is to reduce use in other sectors. If consumers in those other sectors are forced to move to alternative inputs, this will generally have emissions consequences. Identifying these emissions consequences requires identifying the replacement materials that are likely to be used when availability of animal fats is reduced. In some cases, one by-product might be replaced in a market by another by-product. To give a relatively trivial example, a reduced availability of beef tallow for pet food use might result in a given pet food manufacturer increasing its purchases of pork lard. While such substitutions certainly happen, considering the replacement of one resource with rigid supply by another resource with rigid supply tells us nothing about the net production increase to compensate for net reduction in by-product availability. Displacement and indirect emissions studies therefore focus on options to replace animal fats that are diverted to biofuel production with resources with an elastic supply, such as vegetable oils.

EFPRA's data identifies four significant ongoing uses of animal fats outside of the biofuel industry:

1. Combustion for heat and power;
2. Oleochemicals;
3. Livestock feed;
4. Pet food.

Where animal fats would otherwise be combusted for on-site energy fuel oil is generally identified as the most likely substitute fuel. This is because boilers set up to run on animal fats will generally be simple to transition to fuel oil use. In the longer term it would be possible to refit the boilers to run on natural gas (for lower emissions) or even coal (to reduce costs), but these outcomes have been considered less likely.

In oleochemical uses, palm oil has been identified as the most likely substitute. Palm oil is identified as a potential substitute firstly because it has somewhat similar properties to animal fats, in particular in terms of being solid at room temperature. Secondly, palm oil is generally the cheapest virgin vegetable oil available on the market, and therefore cost can be minimised by using palm oil instead of other alternative vegetable oils.

For livestock feed, there has been some question as to whether a reduction in supply of animal fats is likely to lead to replacement with vegetable oils or with other potential feed ingredients. Animal fats have been seen as a relatively low-cost feed additive, but fats are still more expensive per unit of digestible energy delivered than other 'energy feeds' such as maize or wheat. If farmers were only trying to minimise the cost incurred per unit of digestible energy delivered to their livestock, we would therefore not expect them to use animal fats at all. In fact, when fats are used in animal feed they play a specific role in the dietary ration that could not be readily replaced by an alternative carbohydrate-based energy feed, including supplying dietarily important fatty acids. Woodgate & van der Veen (2004) states that:

> *"The fatty acid composition and the melting point of fat for feed applications are important features for the production of a high quality feed pellet and a good consistency of meat. The alternative use of vegetable fats with lower melting point results into the so-called "weak" meat, which is not acceptable for consumers. For animal fats the good nutritional aspects (e.g. linoleic acid), digestibility and high energy density are playing an important part to draw up a feed composition. Feeding animal fats have especially a positive influence on the meat quality and taste. Feed producers prefer animal fats on account of the positive effect on the crystallisation characteristics for calfmilk replacers and the formation of a firm pellet for compound feeds. A firm pellet leads to higher production capacities (up to 15%) and a higher feed performance. Better economics are also relevant in the case of feeding animal fats, i.e. lower feed costs, higher feed performance and higher return on animal by-products. The fatty acid composition of the fat used for feeding monogastric animals is of direct influence on the composition of the fat stored by the animal."*

In practice if animal fats are removed from pet and livestock feed it is likely that they will be replaced to a large extent with vegetable oils (probably primarily palm oil in the EU), though it is possible that to some extent reductions could be compensated by a shift to lower cost energy feeds such as feed wheat or maize, perhaps with accompanying reductions in animal growth efficiency (Malins, 2017b).

Animal fats are also an important constituent in pet food. Animal fats provide energy and important fatty acids, and play an important role in increasing palatability of food (as compared to food without fatty content or produced using vegetable oils). This is considered important for cats in particular, which strongly prefer animal-derived food. We understand from conversations with pet food manufacturers that animal fats can make up 6-7% of a typical dry pet food formulation. There is a concern in the pet food industry that the increased importance of biofuel markets to renderers is driving changes in practice that impact the quality of rendered animal fats as pet food ingredients. Biofuel producers are primarily focused on quantity of output across all categories of animal fats and are less interested in questions of quality and fatty acid profile, whereas these are considered to be priorities in the pet food industry. Where renderers have the option to sell to both markets, these priorities are in tension and buyers from the pet food industry may end up with less suitable products. It was suggested that for now demand for animal fats in higher-priced pet foods remains robust and that increased animal fat prices for those products will be passed through to consumers, but that in the longer term and in lower priced products pet food manufacturers will look to replacing animal fats with vegetable oils, and look to reduce the fatty content in at least some feed formulations.

3.3. Indirect emissions from the use of animal fats as biofuel feedstock

The risk of indirect emissions associated with increasing use of animal fats as biodiesel feedstock has been well recognised for over a decade, starting with work undertaken for the UK Government (AEA Energy & Environment, 2008). This work concluded that, "The environmental impact of the shift from the current uses of tallow to biodiesel production is 'negative' in terms of GHG emissions", i.e. that increased use of animal fats for biofuel feedstock may increase net emissions due to substitution with other materials in existing uses.

The major substitutions considered by this 2008 study were fuel oil as a substitute boiler fuel for Category 1 tallow at rendering plants, and palm oil as a substitute feedstock for Category 2 or 3 tallow in oleochemical applications. Fuel oil is problematic as a substitute because the CO_2 emissions of fuel oil per unit of energy delivered can be even higher than those for diesel, and therefore there would be no climate benefit from reducing diesel demand in transport by increasing fuel oil demand. Palm oil is problematic because the palm oil industry is associated with tropical deforestation, and therefore with high estimated 'indirect land use change' emissions (Malins, 2019). Indirect land use change (ILUC) emissions are emissions associated with land clearance to allow expansion of overall agricultural area in order to meet additional demand. If the land that is cleared has higher carbon stocks (as is the case with forest land and peatland) this tends to drive even higher CO_2 emissions.

Further work in the intervening period (Brander et al., 2009; Chudziak & Haye, 2016; Malins, 2017b; Searle et al., 2017) has attempted to further detail the potential substitutes for animal fats and to numerically quantify the potential indirect emissions when tallow is displaced from existing uses.

Past displacement studies have tended to assume that Category 1 & 2 material will be used as biofuel feedstock preferentially. This has proved to be a fair assumption – almost all EU production of Category 1 & 2 fats is now destined for biofuels use, and use of animal fats as on-site boiler fuel has been largely eliminated. Looking forward, the more relevant question is what the implications would be of further diversion of Category 3 material to biofuel use. The existing displacement studies provide insight to this question as well because they generally consider the possibility that availability of Category 3 material for other uses will be reduced either by downgrading or by increased use of Category 3 material for single counted fuel. Emissions results are particularly sensitive to assumptions on the split between replacement in energy and non-energy applications and the carbon intensity of palm oil (and in particular whether and how indirect land use change from palm oil is considered).

The indirect emissions estimates from these previous studies are illustrated in Figure 11. Most of the studies include more than one scenario. Differences between the scenarios are indicated in the reports of the underlying studies. They include questions such as the extent to which markets for Category 3 fats are affected versus only Category 1 & 2 fats, the sectors from which animal fats are displaced and the materials with which they are replaced. In the Cerulogy study (Malins, 2017b), the difference is the inclusion of the "renewable rebound" – in the second scenario it is assumed that a reduction in renewable energy use for boiler heat is compensated by increased renewable energy for heat or power elsewhere.

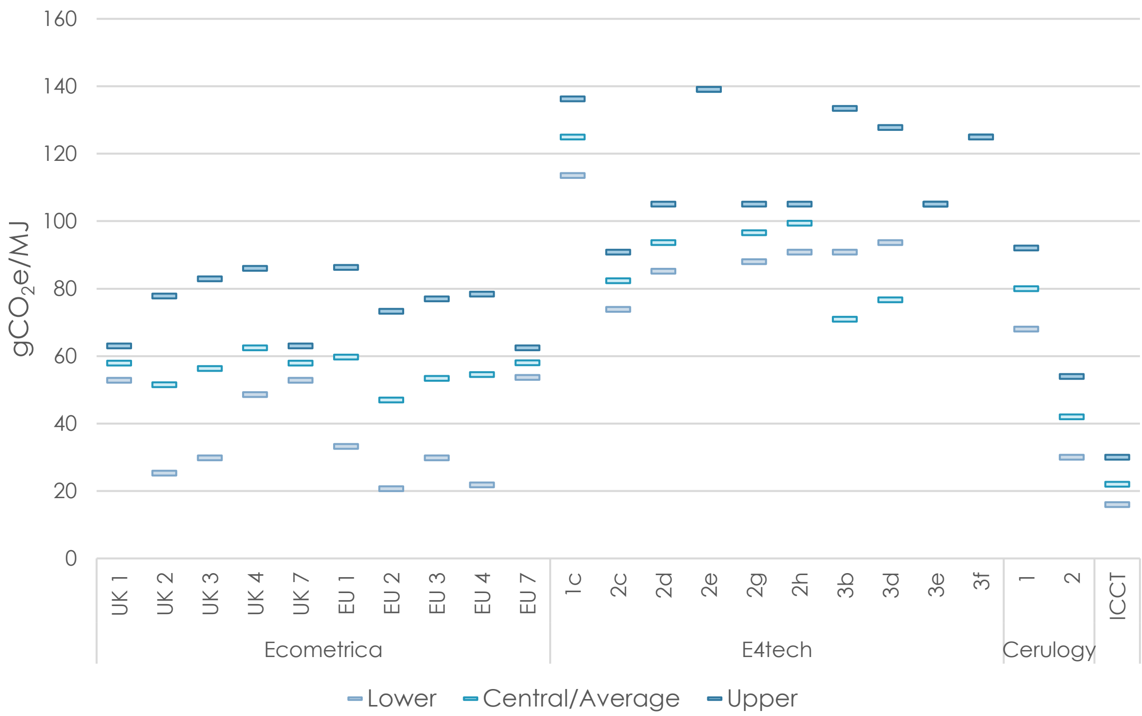

Figure 11. Estimates of indirect emissions from the increased use of animal fats for biodiesel

Sources: Ecometrica - Brander et al. (2009); E4tech - Chudziak & Haye (2016); Cerulogy - Malins (2017b); ICCT - Searle et al. (2017).

Notes: not all scenarios include a central estimate – where no central estimate was given we present an arithmetic average of the lower and upper values given; Ecometrica's 5th and 6th scenarios are not included because they related to other energetic use of animal fats; the second case from Cerulogy includes a term for a 'renewable rebound' which assumes that lost stationary renewable energy generation would need to be replaced to deliver compliance with renewable power/heat targets.

All of these studies conclude that the indirect emissions due to displacing animal fats from current uses are likely to be significant. Any indirect emissions value over about 20 gCO_2e/MJ represents a significant reduction on the presumed GHG emissions reductions from using the biofuel. An indirect emissions value of 50 gCO_2e/MJ or more is high enough to eliminate most of the presumed climate benefit, and an indirect emissions value of 80 gCO_2e/MJ or higher implies that biofuel production increases rather than reduces net emissions. These indirect emissions undermine the climate credentials of policy to support the use of animal fats for biofuel production. In the worst case, moving animal fats out of existing uses could cause a large increase in net emissions rather than any reduction.

A related issue for Category 3 animal fats in the EU lifecycle analysis (LCA) rules is whether the material should be treated as entering the biofuel supply chain with zero associated embedded CO_2 emissions. Under the RED II, biofuel feedstock from crops is allocated GHG emissions intensity values based on the energy use and other GHG emissions associated with growing the crops. 'Wastes and residues', however, "shall be considered to have zero life-cycle greenhouse gas emissions up to the process of collection of those materials irrespectively of whether they are processed to interim products before being transformed into the final product." As Category 3 animal fats are generally understood to be residues in the language of the RED, this means that any emissions associated with energy used in the rendering process itself would be excluded from the lifecycle assessment. Biofuels from Category 3 animal fats therefore have an advantage over vegetable oil based biofuels in terms of reportable GHG intensity – for example, Dutch Government reporting (Dutch Emissions Authority, 2022) shows an average 2021 GHG intensity of only about 6 gCO_2e/MJ for biofuels from Category 3 animal fats. For Category 1 & 2 material where the rendering process can be an important part of safe handling this exclusion of rendering emissions is uncontroversial. In the case that renderers are processing additional Category 3 material to meet high animal fat demand, however, there is a clear argument that this treatment may be unduly favourable. It has been proposed under the Fit for 55 climate package that EU renewable energy in transport targets should give credit on the basis of reportable GHG savings instead of the basis of energy delivered, in which case this treatment would be converted directly into extra value for biofuels from Category 3 animal fats.

The proposed amendments to the RED under the EU Fit for 55 package (European Commission, 2021a) included a suggested measure which would have partly resolved some of these GHG concerns:

> *"Residues that are not included in Annex IX and fit for use in the food or feed market shall be considered to have the same amount of emissions from the extraction, harvesting or cultivation of raw materials, e_{ec} as their closest substitute in the food and feed market that is included in the table in part D of Annex V [the table of disaggregated emissions values for common biofuel pathways]."*

This provision would have provided regulatory acknowledgement that the likely impact of increasing consumption of Category 3 fats for biofuels would be increased production of vegetable oils to replace those fats in existing markets, and would have moderated the advantage that biofuels from Category 3 fats would have in GHG based incentive schemes. It is our understanding, however, that this language was rejected in the trilogue and therefore that biofuels from Category 3 animal fats will continue to receive unduly favourable LCA scores.

3.3.i) Impact on deforestation

If animal fats are replaced in existing uses by virgin oils, in particular by palm oil or soy oil (cf. Malins, 2019), then expansion of these crops will cause indirect land use change, and some of that indirect land use change will lead to deforestation. The link between the palm and soy industries and deforestation in Southeast Asia and South America respectively has been well established. Given that palm oil is identified as one of the most likely substitutes for animal fats in many existing uses, diverting more Category 3 fats from those uses can be expected to contribute to pressure for deforestation.

The deforestation impact of animal fat use can be expected to be at least somewhat reduced compared to creating direct demand for palm oil. This is for several reasons. Firstly, when one tonne of animal fat is displaced from an existing use, that use may not be fully replaced. For example, if pet food prices are pushed up by increased animal fat prices keeping pets may become less affordable for some people, and total pet food consumption could be marginally reduced. This parallels the 'food versus fuel' debate for crop-based biofuels. This debate centres on whether increasing use of agricultural commodities for biofuels makes them unavailable for human consumption, and that by increasing food prices biofuel demand forces people to spend more of their income on food (Malins, 2017a). Secondly, while palm oil may be a quite suitable replacement for animal fats in various applications, it may not be the only possible replacement. For example, Malins (2017b) adopts an assumption of 75% replacement by palm oil and 25% by rapeseed oil in feed applications.

It has also been argued (Repórter Brasil, 2022) that the market for animal fats for biofuel production can support expansion of the livestock industry and thereby drive additional deforestation. It is certainly true that demand for biofuels drives increased oil and fat prices, and that this can marginally improve returns to livestock farmers, whether the fat from their animals is used directly in biodiesel production, or simply obtains a better price being sold to another market. Rendered animal fats only represent a small fraction of the weight of each animal slaughtered and a smaller fraction of the value, and therefore achieving a better price on rendered fats will only have a small impact on the overall economics of livestock raising. Based on EFPRA figures for disposition of a typical slaughtered animal (Woodgate & van der Veen, 2004) and EFPRA data on animal fat yield from rendered material, we estimate that for every tonne of meat output roughly 100 kg of rendered animal fats are produced. For a beef animal with a weight of 530 kg at slaughter, we estimate based on this and on data from FAO GLEAM (FAO, 2018) an output of 23 kg of rendered animal fat. At an animal fat price of €1,000 per tonne, that fat would be saleable for €23. This compares to a saleable value of roughly €1,250 for the full carcass (for a dressing percentage of 59% and at a price of €4,000 per tonne of carcass weight[24]). If the price of rendered fats doubled, it would increase the carcass value by only 2%.

Most analysts assume that these small changes will have a negligible effect on the total area on which livestock are being reared, and therefore do not consider this as a driver of deforestation. When considering the overall impact of a biofuel mandate on the economics of livestock rearing the picture is more complicated. While increased animal fat prices benefit livestock farmers, increased prices for feed commodities such as maize and wheat (which are also used for biofuels) could negatively affect their margins. On the other hand, if raising animals in feedlots becomes more expensive it may push more animals into extensive pasture-based systems, which can drive deforestation. In short, the impact of biofuel policy on livestock farming as a whole through prices of rendered fats is probably much less significant than the impacts through driving changes in prices of feed commodities, and possible associated shifts between intensive and extensive livestock rearing.

3.4. Prices

Earlier studies (Chudziak & Haye, 2016; Ecofys, 2012; Malins, 2017b) have noted that the price of Category 3 animal fats is generally closely tied to the price of vegetable oils, in particular being similar to pricing of palm oil. Data on prices for Category 1 and 2 animal fats has generally been harder to come by, but it is understood that they have traditionally traded at a significant discount to Category 3 material. Alberici et al. (2014) suggests that in 2013 Category 1 tallow traded around 22% below Category 3, which traded a few percent below

24 Cf. https://agriculture.ec.europa.eu/data-and-analysis/markets/overviews/market-observatories/meat/beef-statistics_en

palm oil. Chudziak & Haye (2016) quoted German price data for 2014 showing Category 1 material 13% below Category 3 material, which was 10% below palm oil. Data availability has been much improved by publication of Category 1 tallow prices by the brokerage/consultancy GreenEA (GreenEA, 2022). Data for the period from February 2018 to February 2022 is shown in Figure 12, compared against Rotterdam CIF palm oil prices listed by Investing.com UK (2022).

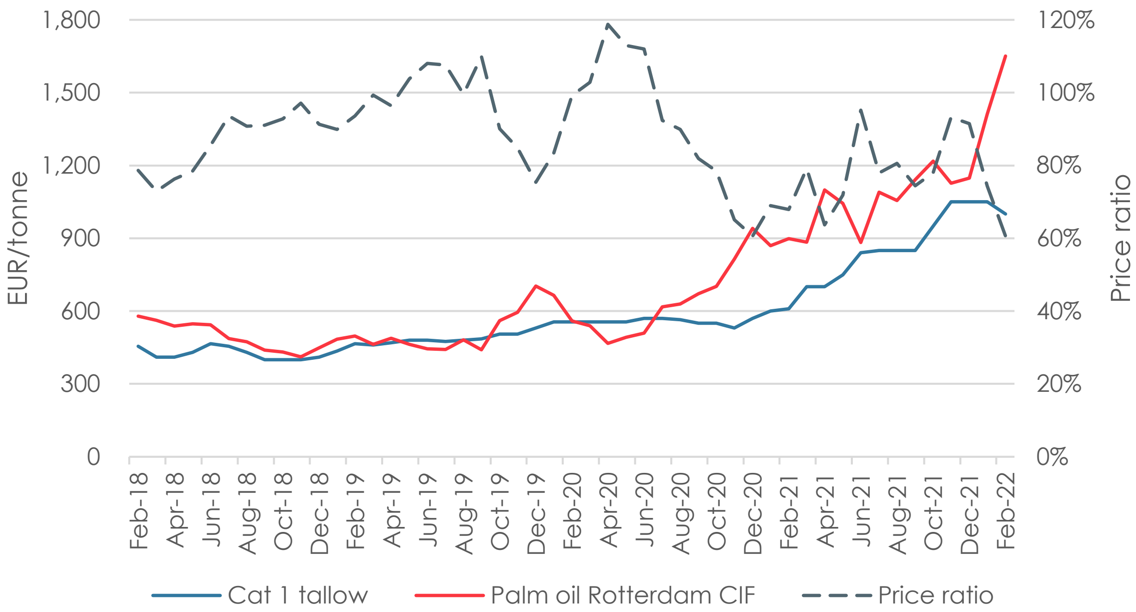

Figure 12. Prices for Category 1 tallow and for palm oil

Sources: GreenEA (2022); Investing.com UK (2022).

This price data suggests that Category 1 tallow and palm oil traded at quite similar prices around the end of last decade (2018-20). It is possible that Category 1 fat prices were pulled up by fuel suppliers looking to source double counted fuels to meet 2020 RED and FQD targets. As vegetable oil commodity prices have risen again since late 2020 the gap between Category 1 tallow and palm oil has reopened somewhat, with an average 21% difference in 2021 based on the prices shown.

We have not been able to find a comparable market source for EU Category 3 animal fats prices. Price data for purchases of high-quality Category 3 poultry fats that was shared with us by a FEDIAF member[25] suggests that the price gap between Category 1 and 3 fats narrowed but did not disappear in the period 2018-2020.

Data is available for edible tallow and palm oil prices in the U.S. market (USDA ERS, 2022) and shows no clear hierarchy in the relationship between the two over the period from 2013 to 2021. To the extent that the European and U.S. markets are connected with good price transmission, these U.S. price relationships should be indicative of the EU situation. Consumption of animal fats for U.S. biofuels had reached about 840 thousand tonnes by 2020.

25 Personal correspondence.

Like Europe, the U.S. has experienced a tension between existing users of animal fats and its growing biodiesel industry. For example, the American Cleaning Institute has argued that the introduction of the Renewable Fuel Standard has been responsible for pushing tallow prices above palm oil prices for the first time (ACI, 2016). The U.S. tallow prices here are quite well correlated with the poultry fat price data mentioned above.

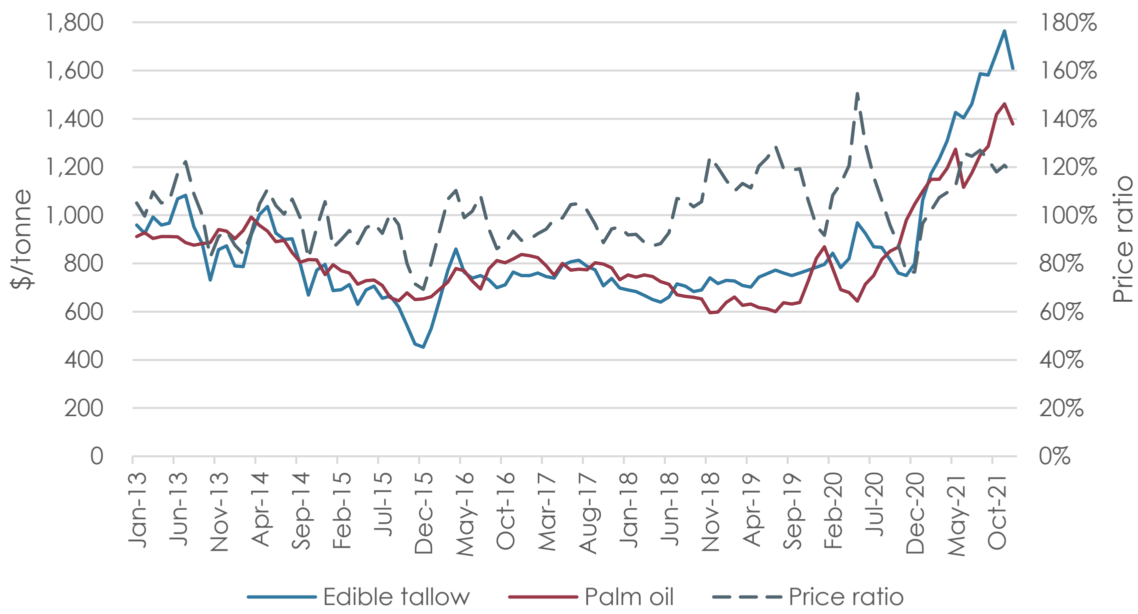

Figure 13. U.S. edible tallow versus palm oil prices 2013 – 2021

Source: USDA ERS (2022).

Another interesting comparison is the relationship between reported prices for Category 1 tallow versus used cooking oil, as shown in Figure 14. Over the period available we see a significant gap between the two Annex IX feedstocks, despite prices reported by GreenEA (2022) for biodiesel from Category 1 tallow and UCO being very similar (biodiesel from Category 1 tallow being only up to 5% less expensive than biodiesel from UCO). A lower sale price for Category 1 tallow therefore presumably reflects higher handling costs for biofuel producers when transporting and processing this material after purchase. We see that there was a period during which UCO was systematically more expensive than palm oil, by an average of 190 €/tonne from July 2018 to October 2020. This counterintuitive price hierarchy (with the used material more expensive than the virgin material) is explained by double counting – as noted above, double counting can make it rational to pay hundreds of € more per tonne for UCO as feedstock. While this price hierarchy is rational, it does create a fraud risk, as it becomes increasingly financially attractive to relabel palm oil as UCO (cf. Haye et al., 2021). This hierarchy did not extend to palm oil and Category 1 tallow except for some short periods[26], however. On the assumption that Category 3 and edible animal fat prices remained close to palm oil through the period, this suggests that Category 1 prices have generally remained below Category 3 prices despite double counting.

26 It should also be noted that given that the prices quoted are from different sources they may not be totally comparable, so small differences should not be over interpreted.

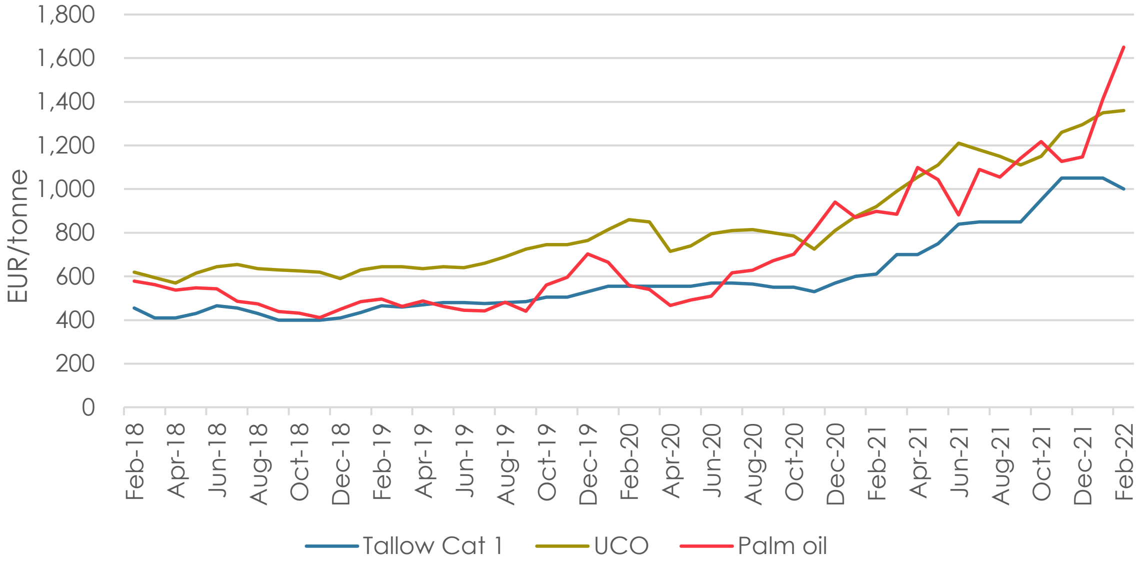

Figure 14. Prices for Category 1 tallow, UCO and palm oil

Source: GreenEA (2022); Investing.com UK (2022).

While it is difficult to draw any firm conclusion from the data available to us on the extent to which demand from the biofuel industry has caused animal fat prices to increase in relation to vegetable oil prices, one thing which is clear is that prices for both have risen significantly in real terms. This is true in the medium term – for example, the six-year average palm oil price reported by the World Bank for the period 2013-2018 after the food price crises of 2007-2012 was 40% above the six-year average for the period 2001-2006 before the crises. It is also true in the short term – the World Bank's 2022 average palm oil price was another 60% above the 2013-2018 average. **The upshot of this is that manufacturers of pet food, animal feed and oleochemicals are paying about twice as much in real terms for Category 3 animal fats as they were 20 years ago.**

For the pet food industry in Europe, paying an extra 500 € per tonne for animal fats implies additional expenditures in the region of €200 million per year that ends up coming from the pockets of pet owners. **There is great concern within the animal fat consuming industries that the ongoing renewable diesel boom will continue to push Category 3 prices higher** – one pet food industry stakeholder stated that they anticipate a further 50% increase in costs for animal fat purchases in the next few years.

4. Conclusions – implications for the supply and use of Category 3 animal fats

The subsidy from the RED II (of the order of €420 per tonne of animal fat in the Dutch case discussed above) makes biofuel production a very attractive market for animal fats. Despite only being eligible for single counting, the use of Category 3 animal fats as biodiesel feedstock has gradually increased since the introduction of the Biofuel Directive in 2003, such that in 2021 EFPRA reported that 800 thousand tonnes were used for biodiesel production out of a total supply of 2.4 million tonnes. In the absence of the biofuel market, this material would have been available for other uses.

The increase in the use of Category 3 animal fats for biodiesel has been very significant, but the biodiesel market has not yet systematically outbid all existing users for this material – according to EFPRA two thirds of Category 3 fats are still used in feed and oleochemical applications. While this is true for now, the biofuels industry is expanding its renewable diesel production capacity and has more than enough capacity to use these Category 3 fats if they can be diverted from their existing users.

The continued use of Category 3 animal fats in other uses despite 20 years of biofuel incentives shows that these uses have been at least somewhat robust against competition. Of course, this is contextualised by the fact that since the start of the biofuel boom it is not only animal fat prices that have risen – the prices of the vegetable oils that they could be replaced by in other uses have also increased. Other users of Category 3 fats therefore have no simple solution to avoid high material prices except to attempt to fundamentally reformulate some of their products. This said, there has clearly been an overall gradual shift of animal fat resources away from existing feed, pet food and oleochemicals uses, and a robust market for biofuels from animal fats is likely to continue that process through the rest of the decade. If animal fats are eligible in aviation and maritime fuel use to meet REFuelEU Aviation and FuelEUMaritime targets, and they remain a more attractive option than food-oils for on-road biofuel targets, pressure on other uses will continue to intensify.

The International Energy Agency (IEA, 2022a) anticipates that this competition between markets will come to a head over the next five years, and that the biofuel supply will be the winner. In the 'main case' for biofuel production forecast for its Renewables 2022 report, the IEA anticipates that global production of biofuels from animal fats will double by 2027 driven by national and regional mandates, commenting that, "the use of used cooking oil and animal fats nearly exhausts 100% of estimated supplies over the forecast period" (IEA, 2022b).

We suspect that this forecast is a little overstated. While the stakeholders from industry we consulted for this report are highly concerned about ongoing expansion of the biofuel industry, for now they are concerned about ongoing cost increases and quality changes rather than about their industry segments entirely losing access to these feedstocks. In the face of continued growth of the renewable diesel/jet industry it seems likely that consumption of Category 3 fats in other sectors will decline gradually, but it does not seem likely to the author that these uses, which have persisted through a doubling in feedstock cost over twenty years, will disappear by 2027.

This picture in the EU biofuel market is somewhat complicated by a recent proposal to significantly expand Annex IX Part B of the RED by adding a number of new feedstocks (European Commission, 2022b). These are primarily waste and residual materials, but intermediate crops are also included in the proposal. The proposal has been put out to consultation, and is likely to be finalised later this year. Haye et al. (2021) identifies that some of these added feedstocks could be available in fairly significant amounts, although it is difficult to robustly identify the true economically viable potential. If there are viable models of intermediate oil-cropping that fall within the definitions added to Part B of Annex IX, then this supply of crop-oils could potentially relieve some of the expected pressure on the animal fat and UCO markets, though it must be noted that concerns persist about how concepts like 'intermediate crop' will be defined in practice and whether these cropping systems will truly represent a more sustainable biofuel production model than conventional food-based fuels (Searle, 2021).

As things stand, it seems highly likely that the value signal for the use of Category 3 animal fats in the biofuel market will continue to strengthen over the coming decade, and that this will lead to continued gradual displacement of those animal fats from other markets. It was discussed above that EU biofuel statistics from SHARES seem to justify a concern that some volume of material is being misreported as Category 1 or 2, and that it is possible that this reflects an intentional fraud. Introducing systems that can reliably prevent this type of misreporting would help to moderate the financial pull of Category 3 fats into biofuel production. The current regime of biofuel incentives tends to encourage the use of Category 3 fats in biofuels while discouraging the use of palm oil, and this market pressure could lead to animal feed and pet food producers switching from using animal fats to using palm oil. This is a little ironic given that on quality alone palm oil would be the preferred feedstock for renewable diesel production and animal fats would be preferred in food and feed applications.

Taking a step back, it is not at all clear that a biofuel policy that causes more and more Category 3 animal fats to be turned into transport fuel delivers any significant benefits. Most importantly, the targeted climate benefits are undermined by expected indirect emissions. In addition to this, these animal-fat-based fuels are not cheap for drivers and users in other industries (and the consumers of the products of these other industries) suffer from higher prices, increased expenditure and reduced quality – and cats all over Europe may end up finding their dinner a little less appetising. Equally, it should be recognised that part of these price-related impacts is driven by the generalised increases in oil and fat prices seen in recent years and therefore they could not be entirely reversed if Category 3 fats specifically were no longer turned into biofuels.[27] Even if Category 3 fats were excluded from support under the RED II, the prices of Category 3 animal fats would still be affected by the price of other fats and vegetable oils. If the renewable diesel boom continues to put upwards price pressure on the global vegetable oil market as a whole, there seems to be little prospect of animal fat prices immediately returning to 2013 levels, never mind 2006 levels.

27 There is clear evidence that biofuel demand has contributed to these price rises (cf. Malins & Sandford, 2022), but given the connectivity between markets for vegetable oils and animal fats we would expect Category 3 animal fat prices to follow other vegetable oil prices even if not directly consumed for biofuel.

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Annex A. Estimation of EU Member State animal fat production

Rates of animal fat production in Category 3 and Categories 1 & 2 in each EU Member State were estimated as follows. Firstly, the average production of rendered animal fats per animal was estimated for the main livestock animals (cattle, chickens, pigs, sheep, and turkeys). Animal fat production from other livestock animals and from non-livestock animals is treated as negligible for this calculation. This was done by combining slaughter weight data from the UN FAO GLEAM model (FAO, 2018) with estimates of the average proportion of each animal type that is rendered from EFPRA (2015) and using the ratio of fat production to material processed for each animal from US EPA (1995). It was assumed that 2.7 million tonnes of fallen stock are processed each year (EFPRA data shows a range from about 2.6 to 2.8 million tonnes annually since 2015) and in the absence of specific data it was assumed that these fallen stock are proportionately distributed across the animal categories considered (i.e. assuming that the number of animals fallen in a given year is roughly proportional to the total number of animals slaughtered).

All fats from rendering of fallen stock were treated as Category 1 & 2. Bottom-up estimates of fat produced per animal were adjusted to match EFPRA data so that total 2020 Category 3 fat production summed to 2.54 million tonnes and total 2020 Category 1 & 2 fat production summed to 570 thousand tonnes. The final estimates for fat production per animal are shown in Table 1. Note that because of normalisation to EFPRA's total reported production quantities these values may be slightly inflated against the actual fat physically recovered from each carcass because they implicitly include small contributions associated with non-livestock animals. Total production of fat by Member State in each category was then estimated by multiplying the values in Table 1 by FAOstat data for the number of each animal type slaughtered in 2020.

Table 1. Estimated average animal fat production by category for major EU livestock animals

	Category 3 fat per animal slaughtered (kg)	Category 1 & 2 fat per animal slaughtered (kg)	Category 1 & 2 fat from fallen animals per animal slaughtered (kg)
Cattle	22.7	2.4	1.5
Chickens	0.04	0.004	0.008
Pigs	6.8	0.7	0.8
Sheep	1.8	0.2	0.1
Turkeys	0.2	0.02	0.05