ECOFYS

sustainable energy for everyone

Trends in the UCO market

- Input to DRAFT PIR –

Trends in the UCO market

- Input to DRAFT PIR –

By: Gemma Toop, Sacha Alberici, Matthias Spoettle, Huygen van Steen
Date: 11 November 2013

Project number: BIOUK10553

ECOFYS UK Ltd. | 1 Alie Street | London E1 8DE | **T** +44 (0)20 74230-970 | **F** +44 (0)20 74230-971 | **E** info@ecofys.com | **I** www.ecofys.com
Company No. 4180444

ECOFYS

sustainable energy for everyone

Table of contents

ECOFYS UK Ltd. | 1 Alie Street | London E1 8DE | **T** +44 (0)20 74230-970 | **F** +44 (0)20 74230-971 | **E** info@ecofys.com | **I** www.ecofys.com

Company No. 4180444

1 Introduction

The Department for Transport (DfT) has asked Ecofys to produce a report focusing on the Used Cooking Oil (UCO) transport fuel market in the UK, as input to the 2013 Renewable Transport Fuel Obligation (RTFO) Post-implementation review. This paper explores a range of issues related to the development of the UCO transport fuel market in the UK, and the impact of the support mechanisms in place specifically for UCO-derived transport fuel.

1.1 Policy support for biodiesel from UCO

In April 2010 the 20 pence per litre fuel duty differential for biofuels in the UK was stopped. However the duty differential remained in place for a further two years for biodiesel derived from Used Cooking Oil (UCO). Since April 2012 (start of Year 5 of the RTFO), the duty differential has been removed. Since December 2011 UCO-derived biodiesel has been eligible to receive two Renewable Transport Fuel Certificates (RTFCs) for each litre supplied. (Between December 2011 and March 2012, both support mechanisms for UCO biodiesel were in place.)

Article 21(2) of the EU Renewable Energy Directive (RED) allows Member States to count biofuels produced from wastes, residues, non-food cellulosic material, and ligno-cellulosic material twice towards their 10% renewable energy in transport target for 2020, and hence such biofuels in the UK are eligible to receive two RTFCs per litre. Member States currently have the responsibility to decide which feedstocks should count twice towards the target. To give stakeholders certainty on which feedstocks can be counted twice, DfT defines a positive list of feedstocks that can be classed as wastes and residues. UCO is on that list. The DfT definition of UCO is based on the definition used by the Environment Agency (Box 1).

Furthermore the European Commission proposal on addressing indirect land use change (iLUC), published on 17 October 2012, proposes to allow biofuel from UCO to be counted twice towards national targets.

Box 1. Definitions of UCO

DfT[1]: "Used Cooking Oil (UCO): Commonly called 'UCO' or 'WCO' (waste cooking oil), this is purified[2] oils and fats of plant and animal origin. These have been used by restaurants, catering facilities and kitchens to cook food for human consumption. They are wastes as they are no longer fit for that purpose and are subsequently used as either feedstock for the production of biodiesel as fuel for

[1] RTFO Guidance – Wastes and residues, valid from 15 April 2013 - v6.0: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/175680/list-of-wastes-and-residues-yr6-v6.0.pdf

[2] Note the word 'purified' is derived from the Environment Agency definition of UCO. It refers to simple filtration of the waste oil and is not intended to mean that the UCO supply chain starts only once the UCO has been processed.

automotive vehicles and heating or as a direct fuel."

Environment Agency[3]: "Waste cooking oils are purified fats of plant or animal origin, which are liquid at room temperature. Like all fats, cooking oils are esters of glycerol and a varying blend of fatty acids, are biodegradable, insoluble in water, but soluble in organic solvent. Cooking oils are generally processed and used in production of products fit for human consumption and do not contain toxic substances."

1.2 UCO supply chain

UCO can be sourced from a variety of sectors and sources. It is typically collected from food manufacturers and restaurants, but may also be collected from sources such as schools, hospitals or even homes. Within a specific sector such as restaurants there may also be a wide variation in the quantity and quality of the UCO produced, depending on the type of restaurant or the time of year.

Compared to other biofuels, the UCO to biodiesel supply chain is most typically characterised by a large number of relatively small feedstock 'producers' with a local collection infrastructure. Sometimes UCO collectors will send UCO directly for biodiesel production, but often there are several stages involved in the collection and aggregation of UCO. There may simply be larger feedstock collectors and aggregators or there may also be some basic filtering and pre-processing to remove impurities such as water and pieces of food before the UCO is sold on for biodiesel production.

The UCO supply chain has not been highly regulated. It is a waste product and one that historically would typically be tipped into the drainage system by those who produce only small amounts. The use of UCO for biodiesel offers a genuinely sustainable outlet for a problematic waste product and one with the potential to offer significant GHG savings. However the large growth in demand for UCO as a biofuel feedstock has led to some concerns from stakeholder groups, which will be the subject of this report.

Stakeholders have expressed concerns about the risks of unintended consequences if the UCO supply chain is not appropriately verified. Specific concerns include the risk of fraud if virgin vegetable oil would be sold as UCO or the risk that UCO is "used" less before being discarded. There is also a risk that one litre of double counting UCO biodiesel could be double counted in more than one Member State, although this is a more general implementation risk with double counting and not a specific concern for UCO.

[3] Environment Agency 2009, Quality Protocol – Biodiesel: End of waste criteria for the production and use of biodiesel derived from waste cooking oil and rendered animal fat http://www.environment-agency.gov.uk/static/documents/Leisure/090612_Biodiesel_QP_V5_final.pdf

Some stakeholders have also expressed concern that UCO might be being diverted from other uses, which could reduce the environmental gain from supporting UCO for biodiesel.

These risks have led to much speculation and concern amongst stakeholders over the last year and DfT has already taken steps, together with EC-recognised voluntary schemes, to address verification rules to ensure that UCO supply chains are appropriately verified to minimise any risks of unintended consequences. This report will further explore the trends in the UCO market with the aim of providing DfT with additional background information with which to ensure that any potential risks from supporting UCO biodiesel can be monitored and minimised.

1.3 Aim of this report

The volume of UCO-derived biodiesel supplied on the UK market has increased markedly since the introduction of the RTFO, peaking during Year 4 of the RTFO when the duty differential was available only for UCO-derived biofuel. Increasing biofuel production from waste materials is a positive development, however the DfT wishes to monitor key aspects of the UCO market to ensure unintended consequences of the support for UCO biodiesel are avoided. This report aims to identify and understand key trends in the UCO market and identify key areas of concern. The report will additionally be used as an input to the 2013 RTFO Post-implementation review.

Key questions addressed include:

- Where is UCO used for biofuel in the UK coming from? (Chapter 2)
- What is the available potential for UCO? Is there a volume of UCO above which DfT should be concerned about unintended consequences? (Chapter 3)
- Has the RTFO incentivised additional recovery of UCO, especially in the UK? (Chapter 3)
- Are there alternative uses for UCO? (Chapter 4)

2 UCO biodiesel use

This section describes the trends in UCO biodiesel reported in the UK since the start of the RTFO.

2.1 Data reported under the RTFO

Figure 1 shows total UCO biodiesel volumes reported since the start of the RTFO. UCO biodiesel volumes have increased significantly since Years 1 and 2, with particularly high volumes reported in Year 4. Volumes of UCO biodiesel reported so far in Year 5 are on course to be similar to those reported in Year 3.

Note that the current data represents only that biofuel for which RTFCs have been claimed to date and therefore the data set is not yet complete for Year 5. Data for Year 5 (15 April 2012 to 14 April 2013) so far represents 77% of biofuel actually supplied during that period. To aid comparison with previous years, we have included an indicative 100% estimate for UCO biodiesel in Year 5, based on a straight-line extrapolation. This estimate should be treated with **caution** as there are no data available to indicate whether the UCO reported to date will be representative of the remaining 23% of the biofuel supplied in Year 5.

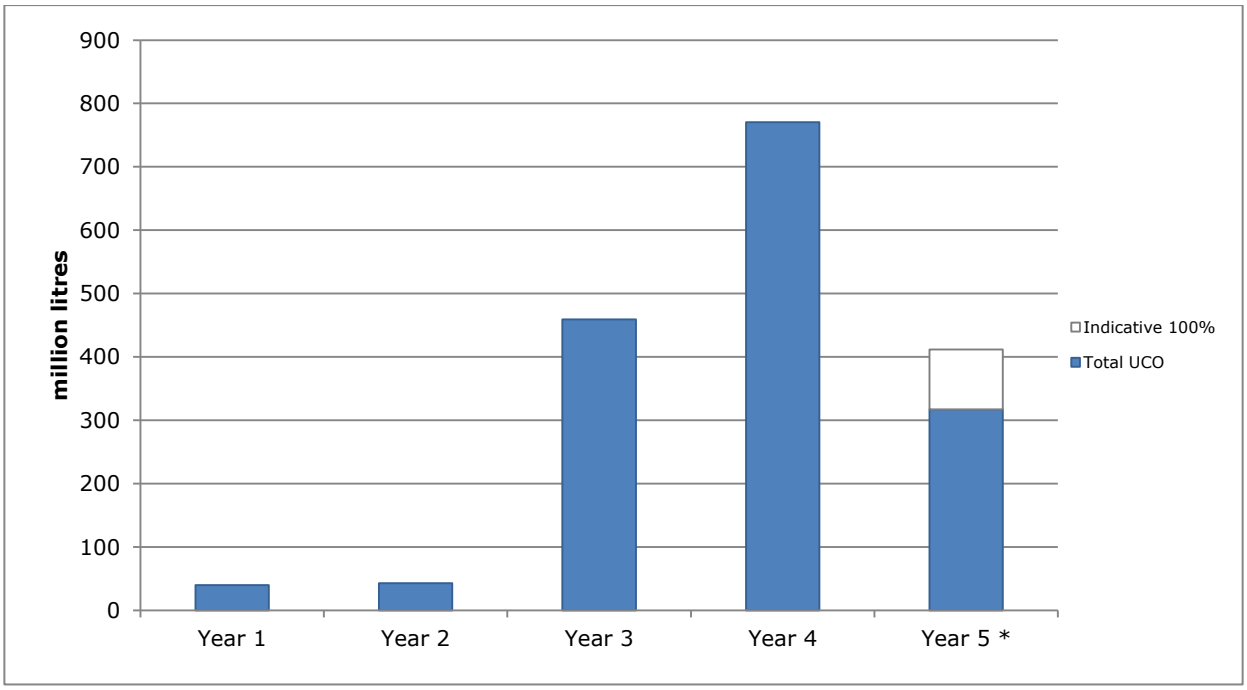
So far for Year 5, 317 million litres biodiesel from UCO have been reported to DfT. As shown in Figure 2, most UCO originated from European sources (67% of UCO biodiesel, including UK) and the USA (25%), with the largest individual country source being the UK (40%, 128 million litres biodiesel). UCO sourced from the UK has increased each year and this trend looks set to continue in Year 5, although the highest rate of increase was from Year 2 to Year 3 when UK-sourced UCO reported under the RTFO trebled. This trend is indicative of the fact that a number of the larger scale biodiesel plants in the UK started to move away from using vegetable oils to waste oils (primarily UCO) at that time. Currently the combined production capacity of larger scale UK biodiesel plants using UCO is over 500 million litres per year[4], although actual production is understood to be significantly lower[5].

The number of countries that UCO is being sourced from has increased significantly year on year. This is reflected in Figure 3, which shows an almost linear increase in the number of countries[6] supplying UCO for biodiesel, with UCO being sourced from 5 countries in Year 1 and 46 countries already reported in Year 5. However the volume sourced from most of these countries is relatively

[4] Including: Harvest (284 – primarily UCO), Greenergy (220), Convert2Green (20), Olleco (16), as well as Argent Energy (60) which uses a combination of UCO, tallow and sewage grease as feedstocks. There are in addition several smaller scale plants currently operating.
[5] An analysis of the UK biofuel industry is covered in a jointly published Ecofys study. See 'UK biofuel industry overview' report.
[6] Category 'Unknown' included. Unknown is most often reported if the biodiesel is certified to an EC-recognised voluntary scheme and the information has not been transmitted on the voluntary scheme certificate. DfT is also working with voluntary schemes to increase the information transmitted along the supply chain.

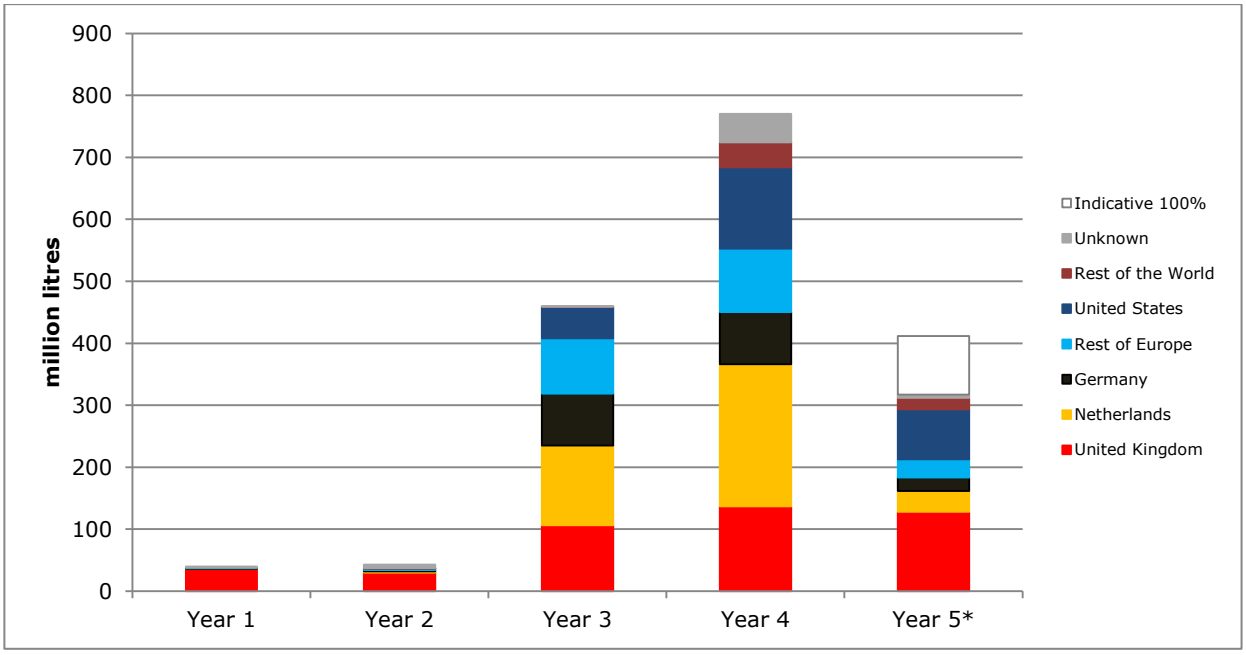
low, with the top five countries (UK, USA, Netherlands, Germany, Spain) accounting for 88% of UCO (see Appendix A: UCO countries of origin).

The very large volume of UCO reported to be of Dutch origin in Years 3 and 4 has decreased markedly in Year 5 after the volume was questioned by DfT. The decrease may simply be because the volume of UCO from that source has decreased or it may be indicative of biodiesel being traded through the Netherlands and therefore potentially misreported as being of Dutch origin (i.e. mistakenly reporting the origin of the biodiesel or the place of purchase of the biodiesel, rather than the origin of the UCO feedstock itself). The DfT has worked with other Member States and with EC-recognised voluntary schemes to highlight the need to ensure full traceability and chain of custody checks throughout the UCO supply chain back to the origin of the used oil (see section 5.3).



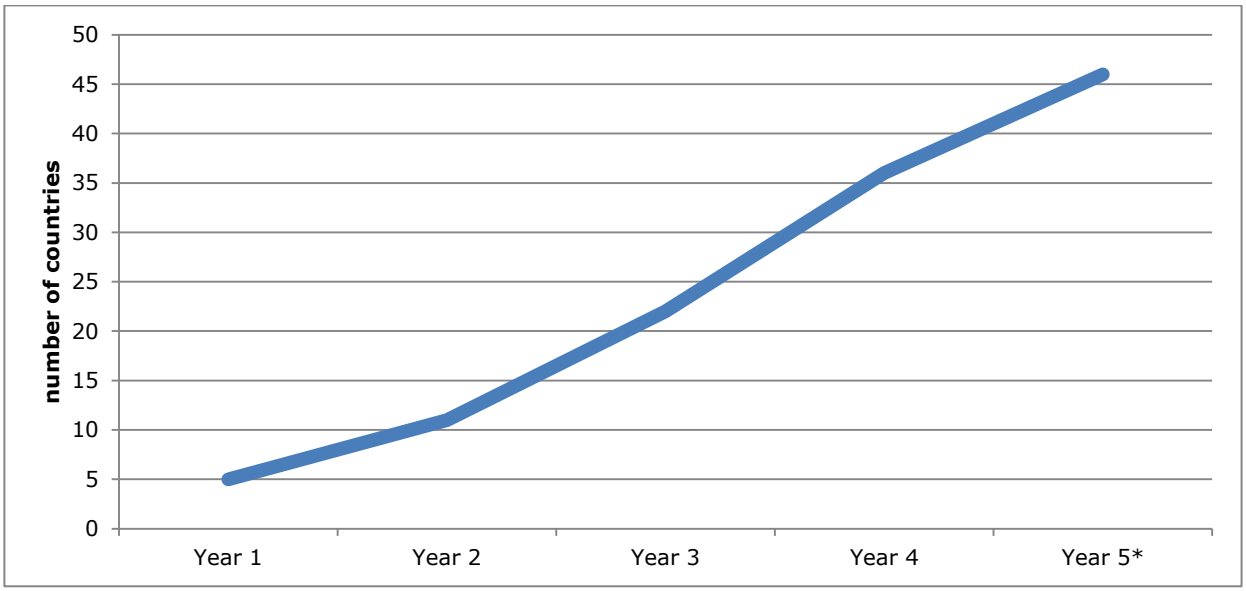
*Incomplete data set. 77% data available for Year 5

Figure 1: Total UCO biodiesel reported under the RTFO in million litres. Source: DfT RTFO Biofuel Statistics



*Incomplete data set. 77% data available for Year 5

Figure 2: Main countries of origin for UCO reported under the RTFO in million litres. Source: DfT RTFO Biofuel Statistics



*Incomplete data set. 77% data available for Year 5

Figure 3: Number of countries supplying UCO for biodiesel as reported under the RTFO. Source: DfT RTFO Biofuel Statistics

3 UCO collection and potential

The trends in Chapter 2 show UCO being sourced from an increasing number of countries, whilst a small number of countries provide the main volume. UCO sourced from the UK is increasing year on year. This chapter looks at estimates of UCO potential and trends in recovery rates.

3.1 Estimating UCO potential

There is a lack of reliable statistics on UCO currently collected or used in any EU Member State (with the exception of the UK RTFO statistics of biofuel use) and hardly any data on UCO traded globally. To estimate the collectable potential of UCO, two alternative methodologies can be applied: a "top-down" approach and a "bottom-up" approach.

- In a **top-down** approach the amount of UCO (including from both vegetable and animal origin) in a country is multiplied with an identified ratio of virgin to used oil (i.e. after cooking) to estimate the total available quantity of UCO in that country.
- A **bottom-up** approach requires the identification of UCO availability at specific UCO generators (i.e. traditional and fast-food restaurants, food processors and snack bars), which is then multiplied with the number of each specific type of UCO generator in the country.

Table 1 below summarises the pros and cons of each approach.

Table 1: Pros and cons of approaches to estimate the UCO potential

	Top-down approach	Bottom-up approach
Benefits	- Statistics on cooking oil use are usually available; - If a reliable UCO to cooking oil ratio can be identified the total quantity of UCO can be estimated in a relatively robust way.	- If done well, the results can be reliable and focus on collectable UCO instead of total UCO potential (i.e. leave households out of the scope); - Enables a focus on the most relevant sectors where UCO becomes available: restaurants and potato snack industry; - Enables an insight into UCO collection practices and the UCO trading market.
Challenges	- Very difficult to establish a reliable UCO to cooking oil ratio; - Cooking oil often does not lead to UCO but is often absorbed in the food product (cookies, margarine etc.); - Large quantities of cooking oil are used in households where it is difficult to collect UCO. Not easy to take this fact into account in the approach.	- Interview process to identify specific UCO factor is time-consuming and difficult, relies on willingness of interview partners to participate; - Approach requires aggregating results of a limited number of interviews to an entire country.

Source: Ecofys 2013

Ecofys applied the bottom-up approach in a project for the German and Dutch governments[7] on estimating the UCO potential in the EU-27 and other key markets (including the USA and China), as it proved very challenging to come up with a meaningful ratio of virgin to used cooking oil that could be used for a top-down estimate. It transpired that even some fast-food chains generating around 4 tonnes of UCO per restaurant per year are not able to determine a meaningful virgin cooking oil to UCO ratio because of the variety of influencing parameters. At fast-food restaurants with a large turnover most of the oil goes out with the consumer product, so less is left in the fryer at the end of the day as waste. Fast-food restaurants with a lower turnover generate more UCO, as for instance a lower number of fried foods absorbing the oil have been sold. In both sizes of restaurant the cooking oil has to be replaced with fresh oil with the same frequency (e.g. at the end of the day for health and safety reasons), but the amount of used oil is higher in less frequently visited fast-food restaurants.

A top-down approach was therefore not feasible. Instead a bottom-up approach was used. Interviews were conducted with UCO collectors and UCO generating entities to establish UCO factors per specific gastronomic entity. These factors were then multiplied by the estimated number of organisations in that category. The focus of this previous project was on the gastronomy sector, so a UCO factor for traditional and fast-food sectors was estimated based on information from stakeholders.

3.2 Literature estimates of UCO potential

This section provides an overview of the UCO potential based on a selection of available reference sources.

3.2.1 UK

The volume of UCO generated across the UK each year has been estimated to be 250 million litres[8]. This is equivalent to 4.2 litres UCO per capita. Assuming a conversion factor of around 90%, if this were all collected it could be converted to up to 225 million litres of UCO biodiesel per year. The highest volume of UK UCO biodiesel reported so far was in Year 4 of the RTFO at 137 million litres, or 61% of this estimated potential. Assuming that some UCO produced in the UK will be exported currently[9], this suggests that a large part of the UK UCO is already being collected.

In 2008 a Technical Advisory Group[10] (TAG) working on behalf of the UK Environment Agency estimated that around 108,000 tonnes per year of UCO was collected at that time from catering

[7] Ecofys, 2013. Low ILUC potential of wastes and residues for biofuels: straw, forestry residues, UCO, corn cobs. Available at: http://www.ecofys.com/en/publication/low-iluc-potential-of-wastes-and-residues-for-biofuels/
[8] UKSBA, Written evidence submitted to the Environmental Audit Committee, 23 August 2011: http://www.publications.parliament.uk/pa/cm201012/cmselect/cmenvaud/1025/1025vw08.htm
[9] Harvest Energy estimate that 50 million litres of UK UCOME is exported, mainly to the Netherlands, France and on occasion Italy.
[10] Environment Agency, 2008. Partial Financial Impact Assessment of a Quality Protocol for the production and use of biodiesel derived from cooking oil and rendered animal fat (tallow), Available at: http://ec.europa.eu/enterprise/tris/pisa/cfcontent.cfm?vFile=820080590EN.PDF

premises. The report states "competition amongst collectors, mainly driven by increased biodiesel production, has increased dramatically in recent years. This has led many to suggest that virtually all of UCO generated by catering premises is currently collected and that the amount of UCO collected would only increase by a small amount, if at all, in the future. However, not all TAG members agreed with one suggesting that "up to 250,000 tonnes per year could be available" from catering premises. On top of that 20,000 tonnes per year was produced by food manufacturers, and up to a further 130,000 tonnes per year could be available from households[11], although it was acknowledged that this sector is very difficult to access efficiently. Totalled this would give a UK UCO potential of 128-270 thousand tonnes UCO per year from catering and food manufacturers (equivalent to 131-276 million litres UCOME[12]), or 258-400 thousand tonnes per year if the domestic sector is also included (equivalent to 264-409 million litres UCOME).

UCO was then, and still is, routinely collected from the majority of the major sources, i.e. food manufacturers, restaurants and caterers. Both the estimates quoted above were made at a time when there was no collection infrastructure in place to access UCO from the domestic sector. This sector was, and remains, a significant part of the remaining collection potential. It is not easy to access due to the large number of small point sources, but increasing numbers of local councils are beginning to offer collection points and several examples of domestic collection services are emerging, although it is still at a very small scale.

Box 2. Examples of local council UCO collection schemes

Household recycling centres in **Shropshire** collected 6,740 litres UCO in 2012. The UCO is collected by Living Fuels and refined into bioliquid, which is used in dedicated CHP systems, generating 25,000 kWh of renewable electricity and heat during 2012[13].

In September 2012 **South Norfolk Council** opened collection points for UCO and fats at their local recycling centres. Nearly 2000 litres of oils and fats were collected in the first months from five recycling centre collection banks[14]. Three further collection banks were opened in July 2013 and more are planned. South Norfolk Council estimate that 334,470 litres[15] of UCO is produced in homes in the area each year.

In August 2013 **Durham County Council** opened UCO collection points at 12 household waste recycling centres across the county[16].

[11] Based on an estimate of 5.36 kg UCO per household per year (Jones, P. (2004). The Collection of Used Vegetable Oil at Civic Amenity Sites. MRES Thesis, University of Swansea) and an estimate from the Office for National Statistics that there were 24.2 million households in the UK in 2005.
[12] Assuming a conversion of 90% UCO to UCOME, and 1.136 litres UCOME to 1 kg UCOME.
[13] http://shropshire.gov.uk/news/2013/04/shropshire-powers-ahead-with-cooking-oil-recycling/
[14] http://www.south-norfolk.gov.uk/environment/6150.asp
[15] Population South Norfolk 110,710 (2001 Census: http://www.south-norfolk.gov.uk/community/2174.asp)
[16] http://www.durham.gov.uk/Pages/pressrelease.aspx?pid=6600

3.2.2 Ireland

As far back as 2003, Sustainable Energy Ireland (SEI) published a report which estimated the UCO resource potential in Ireland. The report estimated that 29,200 tonnes of UCO is produced annually across the island of Ireland, which was predicted to rise in line with population and economic growth to 32,300 tonnes in 2010 and 37,500 in 2020[17]. Of the 29,200 tonnes, just under half (14,500 tonnes) was already recovered as UCO, leaving the remaining half to be disposed of by other means.

At that time an estimated 97% of the UCO recovered went into animal feed (banned in the EU since 2004), showing that even with the biodiesel market only in its infancy, it was still economical to collect significant volumes of UCO. SEI estimated that 73% of UCO would be realistically collectable in Ireland (so an additional 5,000 tonnes on top of the 29,200 already collected in 2003). Collection prices then were quoted to be around €20 per 120 litres collected, and crudely filtered recovered vegetable oil is worth circa €170 per tonne. If prices were to increase, of course additional resource may become economical to collect.

The figures from Ireland, although dated, show that UCO collection was already widespread 10 years ago before demand arose from the biodiesel sector.

3.2.3 EU

For the EU-27 Ecofys estimates a maximum *collectable* UCO potential in the *gastronomy sector* of 972,000 tonnes[18]. Although restaurants are the primary source of UCO the potential significantly increases if food processors and households are also taken into account.

According to the BioDieNet project[19], of which Ecofys was project partner, the total UCO potential in the EU-27 is 3.55 million tonnes, which is equivalent to 8 litres of UCO per capita. This estimate, includes the gastronomy sector, food processors and households, and was based on an assessment of both collected and discarded UCO in ten EU Member States, which was then extrapolated to the whole EU. The contribution of the domestic sector is 1.748 million tonnes per year, of which it is estimated that over 60% is disposed of improperly[20]. The BioDieNet project was conducted within the Intelligent Energy for Europe Programme in 2009 facilitating the uptake of UCO to produce biodiesel.

EU Recovery Rates

Restaurants are the major source for UCO followed by food processors and households. In the EU-27 the gastronomy sector is well covered by UCO collectors, with the exception of restaurants in remote

[17] SEI, 2003. A Resource Study on Recovered Vegetable Oil and Animal Fats. Available at: http://www.seai.ie/Renewables/Bioenergy/SEI_study_on_Recovered_Vegetable_Oil_and_Animal_Fats.pdf
[18] Ecofys, 2013. Low ILUC potential of wastes and residues for biofuels: straw, forestry residues, UCO, corn cobs.
[19] BioDieNet, 2009. El Libro, The Handbook for Local Initiatives for Biodiesel from Recycled Oil.
[20] RecOil, 2013. Energy for Sustainability 2013, Available at: http://www.recoilproject.eu/index.php/en/publications/category/4-presentations

rural areas. Recovery rates are expected to increase in areas not yet covered by UCO collection, especially for example in Eastern Europe, as long as economic incentives like double-counting justify the logistical effort.

Major food processors also tend to sell their UCO already or use it in their own anaerobic digesters at the production site. The strong and fierce competition in getting access to the sources of UCO is also clear evidence that many of the large UCO generating entities are already covered. In addition, an increasing number of UCO thefts are reported in the EU, and also in the USA.[21]

Further UCO potential is expected from households. UCO from households is only structurally collected in a few Member States (Austria, Spain and the Netherlands) whereas other Member States currently lack an appropriate infrastructure. The Intelligent Energy Europe funded RecOil project aims to increase sustainable biodiesel production and its local market intake by enhancing household UCO in the EU[22]. Participating countries are Denmark, Greece, Italy, Portugal and Spain. Initial results from a survey of 877 households found that:

- **Collection systems:** As many as 43 collection systems were identified, based around a variety of locations such as schools, supermarkets, car parks and municipal buildings; only 2 systems were based on door to door collection of UCO.
- **Delivery method:** The majority (60%) of UCO is delivered by the public in bottles.
- **Hygiene and safety issues:** The main problems identified were UCO theft (80% of organisations declared that UCO theft risk is medium or high) and vandalism. No hygiene problems were reported in 67% of respondents.
- **Barriers to UCO recycling:** Inaccessible disposal facilities (36%) was the main barrier identified followed by lack of knowledge of where to dispose (24.5%).

UCO collectors interviewed in the UK indicated that it was hard to make kerbside collection of UCO economical because of the low volumes used by most people. One indicated that there would need to be a "clever idea" before domestic collection would take off because UCO is also an unpleasant product that people prefer to dispose of straight away rather than collect around their house. The EkoFunnel[23] is a product that has been developed to assist households in collecting their UCO and has been used in-conjunction with UCO recycling campaigns led by municipalities, industry and other organisations. The product was first rolled out in Spain, but has since been deployed in Italy, the Netherlands, Sweden and the UK where it was used by Yorkshire Water in a 2010 campaign ("Doing the dirty").

[21] Ecofys, 2013. Low ILUC potential of wastes and residues for biofuels: straw, forestry residues, UCO, corn cobs.
[22] See: http://www.recoilproject.eu/index.php/en/. The project started in May 2012 and will be running till 2015.
[23] http://www.ekofunnel.com/

3.2.4 Outside EU

A recent Ecofys study estimated that at least 1.3 million tonnes of UCO could be collected in the gastronomy sector for EU biodiesel production from the USA, China, Indonesia and Argentina combined without negative impacts to other UCO uses (see chapter 4 for alternative uses). This could be converted to approximately 1.17 million tonnes of UCO biodiesel. The total potential of collectable UCO from the gastronomy sector in the assessed countries was estimated at more than 4.5 million tonnes. As the focus of that study was on the *gastronomy sector only*, the real collectable potential also including households and the food processing industry will be higher.[24]

Table 2: UCO potential from the gastronomy sector in selected countries outside the EU

Country	UCO collectable potential from gastronomy sector (million tonnes)	UCO potential without indirect impacts (million tonnes)
USA	885,000	407,000
Indonesia	646,800	581,800
Argentina	20,100	17,500
China	3,000,000	300,000
Total	**4,551,900**	**1,306,300**

The UCO potential without indirect impacts has been assessed with the Low Indirect Impact Biofuels (LIIB) methodology, which promotes biofuel production without causing displacement effects. According to the LIIB methodology UCO that is used for other uses like animal feed or oleochemical products cannot be used for biodiesel production[25].

The following paragraphs provide an overview of the situation in the USA and China, as biodiesel derived from UCO from these countries is reported in the RTFO.

USA

In the USA the term "yellow grease" is used to define waste and residues for biodiesel production. Yellow grease mainly consists of UCO, but might also include a small quantity of the lowest quality animal fats from rendering processes. In the USA the terms yellow grease and UCO tend to be used interchangeably.

The most recent study on the use of UCO in the USA is from the US National Renderers Association reported that 885,000 tonnes of UCO were collected in 2012. Of this 278,000 tonnes were processed into biodiesel in the USA and 129,446 tonnes were exported to the EU for biodiesel production[26]. The remainder was mainly used for animal feed, with some used in oleochemicals. Ecofys estimates

[24] Ecofys, 2013. Low ILUC potential of wastes and residues for biofuels: straw, forestry residues, UCO, corn cobs.
[25] For more information on LIIB see: www.liib.org
[26] NRA, 2013. National Renderers Association (NRA), Market Report –US Rendering a $10 billion industry, Render Magazine, April 2013

therefore that up to 407,000 tonnes of UCO could be exported to the EU without decreasing the US internal supply of UCO for animal feed and oleochemical products.[27] Currently the US office of Greenergy exports all their UCO collected in the USA to their biodiesel production plant in the UK.

China

Most of the UCO available in China is referred to as "gutter oil", which is illegally used for human consumption. Gutter oil is derived from already used cooking oil, which is simply processed and blended with fresh cooking oil and then re-sold as cooking oil to the market. There is a huge black market for gutter oil in China which makes it difficult to get reliable information on the UCO potential. In collaboration with our Chinese office Ecofys managed to get some insights by interviewing relevant stakeholders from gastronomy and industry, estimating that around 3 million tonnes of UCO could be collected from the Chinese gastronomy sector. This figure is in line with figures mentioned by Chinese researchers from Wuhan Polytechnic University and Beijing Technology and Business University. It is important to note that out of this 3 million tonnes only 0.3 million tonnes are collected by official collectors approved by the Chinese Government, whereas the remaining share is collected by private collectors with a high likelihood of being sold as gutter oil back to restaurants.

The officially collected 0.3 million tonnes of UCO are used for biodiesel production in China, but due to double counting there is an incentive to export this to the EU instead. There is still a huge potential of 2.7 million tonnes of UCO by diverting gutter oil. Although this will probably have an indirect impact on the use of oil for the food sector in China it would be beneficial for Chinese public health. Including UCO from households and food processing industry, the UCO potential in China could be up to 6.5 million tonnes.[28]

3.2.5 Summary

A summary of the estimates for UCO collection is presented in Table 3 below.

Table 3: Summary of UCO collection estimates by country/region.

Country/region	Estimate	UCO collection source	Reference source	Date
EU				
UK	250 million litres	All	UKSBA	2011
UK	108,000 tonnes (up to 250,000) - catering, 20,000 – food manufacturers, 130,000 - households	Catering premises, food manufacturers, households	UK Environment Agency Technical Advisory Group (TAG)	2008

[27] Ecofys, 2013. Low ILUC potential of wastes and residues for biofuels: straw, forestry residues, UCO, corn cobs.
[28] Ecofys, 2013. Low ILUC potential of wastes and residues for biofuels: straw, forestry residues, UCO, corn cobs.

Country/region	Estimate	UCO collection source	Reference source	Date
Ireland	29,200 tonnes (estimated to increase to 32,300 in 2010 and 37,500 in 2020)	All	Sustainable Energy Ireland (SEI)	2003
EU-27	972,000 tonnes	Gastronomy sector	Ecofys	2013
EU-27	3.55 million tonnes	Gastronomy sector, food processors and households	BioDieNet	2009
Outside EU				
USA, China, Indonesia and Argentina	4,551,900 (of which 1,306,300 has a low ILUC impact)	Gastronomy sector	Ecofys	2013
USA	885,000 tonnes	-	US National Renderers Association	2012
China	3 million tonnes (of which 0.3 million tonnes collected by approved collectors)	Gastronomy sector	Ecofys	2013

3.2.6 Innovative sources

Several UK companies are also investing in exploring additional novel sources of waste oils and fats, for example retrieval of oils from food waste or of waste fats from the sewerage system, but these sources require investment in research and development and modifications to plant which, companies indicate, remains difficult in the current investment climate.

One company that is active in this area is Brocklesby Ltd[29], who are involved in the collection and processing of food waste with high oil and fat content, such as foods such as pies, sausage rolls, pastry and crisps[30]. In 2013 Brocklesby commissioned an innovative processing facility that extracts oils and fats from the waste streams produced by food manufacturers and expect to be processing 1,000 tonnes per week. The company sees further potential in this area and is ready to significantly increase production capacity in 2014.

Brocklesby also entered into a joint venture with Greenergy[31] to build and operate a 50,000 tonne per year output pre-processing unit to enable higher free fatty acid (FFA) and contaminated waste feedstocks to be processed at Immingham. The plant is located at North Cave (East Yorkshire) and was commissioned in 2013 at a cost of £5 million.

[29] http://www.brocklesby.org/index
[30] These food products typically have an oil content >20%. Only foods which are not fit for sale, for example because they are misshapen, overcooked or past their sell by date are sourced.
[31] http://www.brocklesby.org/index

In other countries too, such as the USA[32], it is reported that there is a trend to go deeper into waste streams from waste from restaurants to waste from waste water treatment plants, due to lower feedstock prices. However this requires techniques to deal with higher amount of unwanted FFAs[33].

[32] BioCycle (2010), Recycling local waste and grease into biodiesel, July 2010
[33] BioCycle (2010), Recycling local waste and grease into biodiesel, July 2010

4 Alternative uses for UCO

This chapter explores the alternative uses for UCO in and outside the EU.

4.1 EU

UCO can be used for energy production (incineration or biodiesel), for oleochemical products or for the production of animal feed. The latter is mostly prohibited in the EU following the implementation of the Animal By-Products Regulation EC 1774/2002 in October 2004, as a reaction to the BSE[34] scare from 1993 to the early 2000s. Certain high quality sources of UCO are still permitted to be used for animal feed (e.g. from food manufacturers where the oil has been in a controlled environment throughout), although the main alternative use in the EU for UCO now is the oleochemical industry.

Figure 4 shows an overview of UCO uses in the UK prepared by the Environment Agency back in 2008. This picture has almost certainly changed (in terms of the numbers of companies operating) but the categories of uses for UCO remain the same.

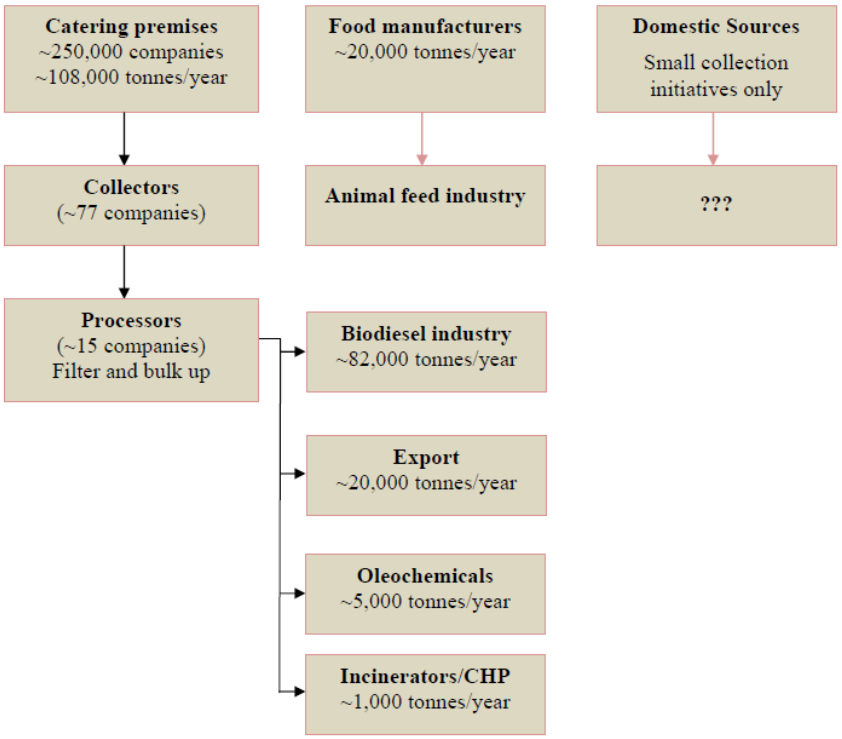


Figure 4. Breakdown UCO market in UK 2008. Source: Environment Agency, 2008.

[34] Bovine spongiform encephalopathy (BSE) is an animal disease also known as 'mad cow disease'.

4.1.1 Oleochemicals

The oleochemical industry relies on animal fats and UCO for the production of a variety of products ranging from consumer products like shampoo and candles, to plastics and building materials. According to APAG, the European association of the oleochemical industry, the relation between UCO and animal fat used in the industry is 1:9 (i.e. for every 10 tonnes of raw material, 1 tonne is UCO and 9 tonnes is animal fat). The relatively low UCO share is explained by its variable quality, due to the variety of sources from different entities using different vegetable oils. For the oleochemical industry the carbon chain profile is important. Palm oil has a C14 chain, while rapeseed and soy have C16 and C18 chains respectively. A UCO mix could therefore comprise of carbon chains ranging from C14 to C18. Consistency of the raw material stream is only guaranteed by UCO that originates from food processors or fast-food companies, which always use the same vegetable oil inputs for the same products with strict internal regulations for replacement.[35]

Ecofys estimates that 90% of the UCO in the EU-27 is currently used for biodiesel production and 10% is used by the oleochemical industry[36].

4.1.2 Animal feed

Certain high quality sources of UCO, such as from food manufacturing processes where the inputs are pure and uniform and the processes are well controlled, are permitted to be used for animal feed in the UK[37]. In 2008 the UK Environment Agency estimated that approximately 20,000 tonnes UCO from food manufacturers was going into animal feed in the UK[38].

Lywood[39] (2013) indicates that this 20,000 tonnes per year that was being used for animal feed is now being diverted to biodiesel production, with the main substitute used for animal feed being soy.

4.1.3 Disposal

If UCO is not otherwise collected, the most common outcome is that it is simply put into the local drainage system or sent to landfill, despite these disposal options being prohibited under UK law[40]. Several stakeholders indicated that most of the additional UCO recovery witnessed over the last few years is from customers (e.g. restaurants, pubs) who used to pour their waste oils into the drains, but are instead choosing to have it collected, in part due to the price they now receive for it from UCO collectors.

[35] Ecofys, 2013. Low ILUC potential of wastes and residues for biofuels: straw, forestry residues, UCO, corn cobs.
[36] Ecofys, 2013. Low ILUC potential of wastes and residues for biofuels: straw, forestry residues, UCO, corn cobs.
[37] http://www.food.gov.uk/multimedia/faq/wasteoilfaq/#.UoI2ZuKxPl8
[38] Environment Agency, 2008, Partial Financial Impact Assessment of a Quality Protocol for the production and use of biodiesel derived from cooking oil and rendered animal fat (tallow) http://ec.europa.eu/enterprise/tris/pisa/cfcontent.cfm?vFile=820080590EN.PDF
[39] Lywood, 2013, Indirect effects of "advanced" biofuels
[40] The Waste Industry Act 1991 prohibits the discharges of UCO to the sewer, and since October 2007 liquid waste may not be disposed of at landfill.

The UK currently has limited collection of UCO from domestic sources, and so it is inevitable that a high share of this oil is disposed of down the drain or otherwise sent to landfill. (The RecOil project identified disposal down the drain as the main disposal option for households, with 38% of all respondents, see section 3.2.3.) In 2011, Defra estimated that 150,000 blockages per year are caused by fat, oil and grease being poured into the drains, at a cost to utility companies of £15 million per year[41]. Since that estimate, reporting of biodiesel from UK UCO in the RTFO has trebled and UK UCO collection might be expected to have increased by a similar amount, yet still relatively few examples exist of collection from the domestic sector. In summer 2013 there was a widely publicised example of UCO collection from drains following the discovery by Thames Water of a 15 tonne 'fatberg' in the London sewers[42], highlighting that UCO is often still dumped into the drain to a large extent.

4.2 Outside EU

The situation with regard to UCO uses outside the EU is completely different, as animal feed production from UCO is allowed in for instance the USA and China.

In Indonesia, UCO can even be reused as a cooking oil for human consumption. The latter is explicitly forbidden in China, but it is reported to happen to a large extent. A black market, employing 300,000 people in Beijing alone, has emerged and sells simply processed UCO blended with fresh oil back to the restaurants. This so-called 'gutter oil' is a big threat to the health of Chinese consumers and the Chinese government is establishing official UCO collectors who sell their UCO for biodiesel production.[43]

[41] UKSBA, Written evidence submitted to the Environmental Audit Committee, 23 August 2011: Available at: http://www.publications.parliament.uk/pa/cm201012/cmselect/cmenvaud/1025/1025vw08.htm
[42] http://www.bbc.co.uk/news/uk-23585413
[43] Ecofys, 2013. Low ILUC potential of wastes and residues for biofuels: straw, forestry residues, UCO, corn cobs.

5 UCO market and traceability

The market for UCO collection in the UK (and also in the EU) is reported to be strong, to the extent that UCO theft has been reported as being a major problem. Prices paid for UCO vary across a wide range, according to quality, location of the UCO source and the time of year. This chapter explores some of these aspects in further detail, as well as a move to increase traceability in UCO biodiesel supply chains.

5.1 Industry structure

The UCO collection industry has been operating in the UK for over 30 years, and was initially set up to service the animal feed market. UCO collectors were forced to find an alternative market following the EU-wide ban on using UCO for animal feed in 2004. The biofuel industry began to develop at this time providing UCO collectors with a convenient alternative market. Since then the industry has undergone significant expansion with several new entrants to the UCO collection business, many of which are also involved in processing UCO into biofuel. At this time biodiesel production represents by far the largest market for UCO in the UK and across the EU (see chapter 4 for further information on alternative uses for UCO).

Consultancy company LRS indicate that there are four main types of UCO collection companies operating in the UK[44]:

- **Suppliers and collectors:** Companies that both supply virgin cooking oil and collect it again when it is used.
- **Waste collectors:** Waste companies that will collect UCO as part of their commercial waste collection service.
- **Specialist commercial collectors:** Companies that operate UCO collection as a commercially viable business. Collectors may also be processors, refiners and blenders.
- **Closed-loop collectors:** Some larger companies, such as McDonalds, have contracted collectors for all premises they operate across the UK and then use the UCO biodiesel in their transport fleets or for energy production.
- **Other:** Smaller companies that collect oil at no cost and generally use it for personal consumption.

Several parties we interviewed indicated that the UCO industry has evolved and professionalised especially over the last few years as demand for UCO has increased through the biodiesel industry and consequently the price paid for UCO has risen.

[44] LRS, 2013. The market for biodiesel production from used cooking oils and fats, oils and greases in London. Available at: http://www.lrsconsultancy.com/documents/The%20market%20for%20biodiesel%20production%20from%20UCOs%20and%20FOGs%20in%20London%20-%2028%20March%202013.pdf

5.1.1 UCO theft

Demand for UCO has risen in recent years to the extent that several companies interviewed indicate that UCO theft is a big issue currently in the UCO industry, and the biggest issue facing collectors. There are many reported cases of theft of UCO from catering sites, with some reported that as much as 20% of contracted UCO volumes are being stolen before the contracted collector arrives[45]. In some case it is reported that criminals are even posing as legitimate waste removal companies in order to steal the oil from catering establishments. One company, Olleco who collect UCO and convert to biodiesel, reported 216 thefts of UCO in February 2013 alone.

Stolen UCO is suspected as being used by the criminals themselves directly to produce biodiesel and then sold on the black market illegally without paying duty or VAT. The fuel can be sold at a significant discount to regular biodiesel, reportedly as low as 20 pence per litre. A further issue is that some biodiesel producers are reported to have been ignoring the HMRC threshold of 2,500 litres of biofuel production before duty and VAT has to be paid. Over 20 illegal biodiesel sites have been shut down by HMRC in the last year.

The legitimate biodiesel industry believes that the biodiesel black market is costing the Treasury £25 million a year in lost revenue.

5.2 Prices

5.2.1 Raw material prices

The UCO market has changed dramatically over the past few years, although it is still relatively immature and can be intransparent. To the restaurant or food processor the UCO is primarily a waste. Prices paid for UCO are therefore reported to vary widely. In 2008 the Environment Agency stated "some collectors charge to collect UCO, some collect for free and some pay the premises to receive their UCO". Competition in the UCO market is reported to have increased dramatically. Today collectors would generally not charge to collect UCO, although a few are reported to still charge a very minimal amount.

Prices paid for UCO are dependent on its quality and also on the location of the UCO source. For example, UCO generators in city centres will generally be paid more than those in more rural areas as the cost of collection in more remote areas might negate the price for the feedstock. The time of year is also reported to be a factor as UCO is used less in biodiesel, or in lower blends, in winter months due to fears over the cold flow ability[46]. LRS for example indicate that UCO is sold by

[45] http://www.bbc.co.uk/news/uk-21858841
[46] LRS, 2013. The market for biodiesel production from used cooking oils and fats, oils and greases in London.

collectors to biodiesel processors for around £400 to £500 per tonne in winter months and £600 to £700 per tonne in summer months.

5.2.2 Supply chain prices

The price of UCO naturally increases along the supply chain from the generating source to final UCOME (biodiesel), as the UCO is continuously processed to improve its quality. The estimations provided here are based on stakeholder interviews which were conducted by Ecofys in 2013. Whereas restaurants sell UCO for a maximum of 30 (€)ct/kg, small UCO collectors could charge up to 55 (€)ct/kg for filtered UCO. Larger UCO collectors and melting plants sell purified UCO ready for biodiesel production for 80-88 (€)ct/kg. The final product, UCOME, is currently sold for around 1€/litre.[47]

5.3 Traceability

Stakeholders have expressed concerns about the risks of unintended consequences if the UCO supply chain is not appropriately verified. Specific concerns include the risk of fraud if virgin vegetable oil would be sold as UCO or the risk that UCO is "used" less before being discarded. There is also a risk that one litre of double counting UCO biodiesel could be double counted in more than one Member State, although this is a more general implementation risk with double counting and not a specific concern for UCO.

In Year 4 of the RTFO DfT were alerted by a very much higher than expected volume of UCO being reported from the Netherlands. DfT investigations found that in many cases chain of custody checks were only going one step back in the UCO supply chain from the biofuel producer (and therefore potentially an incorrect country of origin was being reported). In other words checks were not going back to the origin of the material (e.g. the restaurant or the food manufacturer) and were therefore not going back far enough to provide evidence that the oil was indeed UCO. DfT did not identify specific cases where fraud had occurred, but without sufficient chain of custody checks, there is a risk that possible unintended consequences would not be identified by verifiers.

There have also reportedly been some cases of the same litre of biofuel being reported in more than one Member State, hence double counting being claimed for the same litre in more than one Member State.

DfT clarified to all UK stakeholders that chain of custody checks must be carried out by companies (and their verifiers) far enough back to assure the origin of the material. This might not necessarily mean auditing restaurants, but it would mean checking back as far as the first collector and ensuring

[47] Ecofys, 2013. Low ILUC potential of wastes and residues for biofuels: straw, forestry residues, UCO, corn cobs.

that they keep up-to-date paperwork on the companies that they collect from and the corresponding volumes.

DfT is also working with other Member States through REFUREC[48] and with EC-recognised voluntary schemes to raise the issue as a concern and to ensure that it is addressed appropriately in legislation and in schemes. Voluntary schemes are currently working together aiming for a consistent and practical yet robust approach to increase chain of custody checks for UCO supply chains, which are characterised by a large number of small feedstock 'producers'.

In the meantime the German government has introduced amendments to their legislation, which must be complied with for UCOME to be double counted in Germany (Box 3). In the UK, many UCO collectors we interviewed who are supplying to larger biodiesel producers indicated that the market now demands them to be certified to the ISCC voluntary scheme. This requires a level of professional traceability and control, which has been introduced by some, but is reported to be creating a burden for smaller scale businesses that do not have the resources to manage the process.

Box 3. Definitions of UCO

In Germany, the German Emission Control Act (BImSchG §36) sets strict requirements for UCO which shall be double-counted. These requirements have to be demonstrated by a specific certificate to ensure the following main conditions:

- Traceability up to the UCO supplier (e.g. restaurants).
- Self-declaration from UCO supplier to UCO collector with exact wording as in BImSchG §36.
- Clear segregation of double-counted certified UCO and single counted UCO.
- For each batch an identification number has to be created to demonstrate when the specific quantity was received or delivered.
- Imported UCO has come from an eligible country. China (with the exception of Hong Kong), Argentina and Indonesia are not eligible countries.

As of today the ISCC DE Double Counting Standard is the only sustainability scheme that has fully implemented the requirements for German double-counting. Any UCO certified with another sustainability scheme accepted under RED will only be single-counted in Germany.[49]

[4848] Renewable Fuels Regulators Club

[49] Ecofys, 2013. Low ILUC potential of wastes and residues for biofuels: straw, forestry residues, UCO, corn cobs.

6 Observations and Conclusions

Based on the above, we conclude the following:

- UCO biodiesel volumes reported under the RTFO have increased significantly since Years 1 and 2, with particularly high volumes reported in Year 4. Volumes of UCO biodiesel reported so far in Year 5 are on course to be similar to those reported in Year 3.
- Although the volume of UCO biodiesel overall has fallen from Year 4 to Year 5, the number of countries that UCO is being reported from continues to increase. However the volume sourced from most of these countries is relatively low, with the top five countries (UK, USA, Netherlands, Germany, Spain) accounting for 88% of the total. The UK contribution is 40% of the total.
- The volume of UK-sourced UCO reported under the RTFO has increased year on year from the start of the RTFO, with a large jump from Year 2 to Year 3. This coincides with a time when a number of the larger scale biodiesel plants in the UK started to move away from using vegetable oils to waste oils (primarily UCO).
- There are few in-depth estimates of UCO potential which cover all potential sources. Estimates vary, but the most commonly cited estimate of UK UCO potential is 250 million litres per year. In Year 4 of the RTFO around 61% of this estimated potential was reported under the RTFO (taking into account conversion factors). Assuming some exports, this suggests that a large part of the UK UCO potential is already being collected and used for biodiesel.
- There remains, however, scope for increases in collection, mainly from households and innovative sources such as retrieval from food waste or from sewer blockages, but the increases in UCO are not expected to be large in comparison to what is already collected.
- Within the EU, it is estimated that 90% of the UCO collected is currently used for biodiesel production and 10% is used by the oleochemical industry. UCO from certain controlled sectors of the food industry could still be used in animal feed, but it is believed that in the UK this potential is now used for biodiesel.
- The market for UCO collection in the UK (and also in the EU) is reported to be strong. Prices have risen over recent years, to the extent that UCO theft has been reported as being a major problem.
- The very large volume of UCO reported to be of Dutch origin in Years 3 and 4 has decreased markedly in Year 5 after the volume was questioned by DfT. The UCO market is professionalising and increasing verification to ensure that UCO is traced properly back to its origin to mitigate concerns about risks of mis-selling of virgin oils as used oils. UCO collectors report that certification is increasingly demanded in the market, which does create an additional administrative burden. DfT is working with other Member States through REFUREC and with EC-recognised voluntary schemes on chain of custody verification to ensure that it is addressed appropriately in legislation and in schemes.

7 Stakeholders who provided input

1. Jason Askey-Wood, Uptown Biodiesel
2. Adam Baisley, Olleco
3. Robert Brocklesby, Brocklesby Ltd (and Greenergy)
4. Brian Butler, Dorset Bio Solutions CIC
5. Jim Ebner, Biomotive
6. Herbert Hooper, Devon Biofuels
7. Stephen Hurton, Proper Oils
8. Tom James, Organic Drive Limited
9. Patrick Lynch, Greenergy
10. Warwick Lywood, Lywood Consulting
11. Tracey O'Keefe, UK Sustainable Bio-diesel Alliance (UKSBA)
12. Dickon Posnett, Argent Energy
13. James Ross, Harvest Energy
14. Ian Waller, FiveBarGate
15. Clare Wenner, Renewable Energy Association
16. Phil Yates, Vegetable Oil Management Ltd

Appendix A: UCO countries of origin

Table 4: Countries of origin for UCO reported under the RTFO in million litres. Source: DfT RTFO Biofuel Statistics

Country of origin	Year 1 2008-09	Year 2 2009-10	Year 3 2010-11	Year 4 2011-12	Year 5* 2012-13
Australia			0.04	0.27	0.65
Austria		0.31	2.93	2.72	0.27
Belgium		0.68	20.39	19.50	3.96
Bulgaria					0.04
Canada				30.91	0.84
Chile		0.27	0.23	1.25	0.96
China					0.18
Croatia				0.10	
Czech Republic			0.11	0.88	0.05
Denmark			1.09	1.74	0.22
Egypt					0.02
Finland			0.23	3.66	0.37
France		0.79	16.46	4.91	1.64
Germany	1.25	2.35	83.72	84.23	21.55
Greece				1.06	0.03
Hong Kong				2.57	0.89
Indonesia				0.003	0.82
Ireland	0.85	0.34	2.80	5.33	2.26
Italy			0.28	7.56	1.78
Japan					1.72
Lebanon				0.03	0.42
Lithuania				0.17	0.05
Luxembourg			0.17	0.14	
Malaysia					0.002
Mexico			0.02		0.07
Morocco					0.03
Netherlands		2.08	128.40	229.07	33.39
New Zealand					0.36
Norway				8.57	
Poland				1.87	0.52
Portugal			2.93	0.65	0.43
Republic of Korea				4.38	5.27
Saudi Arabia				0.39	4.44

Country of origin	Year 1 2008-09	Year 2 2009-10	Year 3 2010-11	Year 4 2011-12	Year 5* 2012-13
Serbia				0.07	
Singapore				0.13	0.20
Slovakia				3.74	0.12
South Africa				0.14	1.36
Spain			41.56	39.64	16.04
Sweden			0.38	0.11	0.01
Switzerland		0.31	0.17	0.21	0.12
Syria					0.002
Taiwan					0.38
Thailand					0.04
Tunisia					1.21
Turkey					0.25
United Arab Emirates				0.35	0.42
United Kingdom	35.92	29.75	106.41	136.94	128.18
United States		0.06	50.82	130.95	80.61
Unknown	1.43	5.91	0.11	46.07	4.76
Total	**39.52**	**42.85**	**459.24**	**770.35**	**316.95**

*Incomplete data set. 77% data available for Year 5

ECOFYS

sustainable energy for everyone

ECOFYS UK Ltd. | 1 Alie Street | London E1 8DE | **T** +44 (0)20 74230-970 | **F** +44 (0)20 74230-971 | **E** info@ecofys.com | **I** www.ecofys.com

ECOFYS

sustainable energy for everyone

ECOFYS UK Ltd.

1 Alie Street
London E1 8DE

T: +44 (0) 20 74230-970
F: +44 (0) 20 74230-971

E: info@ecofys.com
I: www.ecofys.com