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RESEARCH REPORT

Biofuels—At What Cost?

A review of costs and benefits of U.K. biofuel policies

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Acronyms and Abbreviations

ASCM	Agreement on Subsidies and Countervailing Measures
CAP	Common Agricultural policy
CO_2e	carbon dioxide equivalent
DECC	Department of Energy and Climate Change
DfT	Department for Transport
EU	European Union
FY	fiscal year
FQD	Fuel Quality Directive
GHG	greenhouse gas
GSI	Global Subsidies Initiative
HMRC	Her Majesty's Revenue and Customs
IEA	International Energy Agency
IFPRI	International Food Policy Research Institute
ILUC	indirect land-use changes
LCOE	levelized cost of energy
MJ	megajoules
Mt	million tonnes
NREAP	National Renewable Energy Action Plan
OECD	Organisation for Economic Co-operation and Development
PPL	pence per litre
PV	Photovoltaic
R&D	research and development
REA	Renewable Energy Association
RED	Renewable Energy Directive
RFA	Renewable Fuels Agency
ROC	Renewable Obligation Certificates
RTFO	Renewable Transport Fuel Obligation
RTFCs	Renewable Transport Fuel Certificates
SPS	Single Payment Scheme
TOE	tonne of oil equivalent
UCO	used cooking oil
U.K.	United Kingdom

Executive Summary

This report evaluates some of the principal issues associated with the United Kingdom's (U.K.) biofuels industry, support policies, employment creation, emissions abatement, and the role of biofuels and other renewable technologies in meeting European Union (EU) renewable energy targets. The report assesses the costs and benefits of the objectives that EU member states, such as the U.K., have set out to achieve—increased energy security, improvements in environmental performance and the generation of additional economic value.

The Renewable Transport Fuel Obligation (RTFO) was introduced in November 2005 by the Government of the United Kingdom to promote the use of renewable fuels. This report focuses on RTFO year four, as it provides a recent full year for available data (April 2011–April 2012). The main mechanisms and policies associated with the RTFO include the use of binding blending targets, a market for trading Renewable Transport Fuel Certificates (RTFCs) in order for obligated parties to meet their targets and an excise tax exemption for biodiesel produced from used cooking oil (UCO).

In the third year of RTFO (2010/2011), bioethanol consumption was reported as 586 million litres, and biodiesel was reported as 854 million litres, with the total number of litres consumed being 1,440 million litres. In RTFO year four, bioethanol consumption was 698 million and biodiesel consumption was 933 million litres, with total consumption at 1,632 million litres (Department for Transport, 2013d).

Support to Biofuels

Support to the U.K. biofuel industry in RTFO year 4 (2011/2012) was estimated at between £44 million and £74 million for ethanol and between £315 million and £371 million for biodiesel. Total support to biofuels was estimated to be between £359 million and £445 million.

The main support mechanism for promoting biofuels in the U.K. are blending mandates that put upwards pressure on EU wholesale biofuels prices, which are then compared to lower world wholesale biofuel prices. It was estimated that the U.K. biofuels sector received market price support of between £42 million and £72 million for ethanol and between £153 million and £209 million for biodiesel via higher EU wholesale prices.

During RTFO year four, 1.9 billion RTFCs were issued and 874 million were traded at an average price of 13 pence per certificate. Biofuel producers' trading certificates were a minor part of the trading system, with obligated parties such as fossil-fuel supply companies undertaking the majority of trades. Additional revenue for biofuel producers trading RTFCs was estimated at around £3 million to £4 million.

Biodiesel production from UCO was supported by a 20 pence-per-litre excise tax exemption up until March 2012, which in RTFO year 4 resulted in £161 million in foregone revenue.

Biofuel Carbon Abatement Costs

UCO-based biodiesel has the lowest abatement costs of all biofuels in the U.K. (around £154 per tonne of carbon dioxide [CO_2] avoided). First-generation biodiesel (not including biodiesel from UCO),[1] on the other hand, is

[1] First-generation biofuels are produced from the sugars and vegetable oils contained in arable crops, which can be extracted using conventional technology. Second-generation biofuels are produced from lignocellulosic biomass or woody crops, agricultural residues or waste, and it is more difficult to extract the required fuel.

responsible for slight emission increases and no abatement cost was calculated. Bioethanol had an abatement cost of around £115 per tonne of CO_2 avoided in 2011. Combining all types of biofuels, an abatement cost a little under £165 per tonne of CO_2 avoided was calculated, mainly due to the low emission profiles of UCO.

Jobs Created by the U.K. Biofuels Industry

The wide range of direct and indirect jobs created by the U.K. biofuel sector was estimated at between 1,356 and 7,500 in 2011. A variety of methodologies for assessing the number of jobs created are applied in measuring biofuel and renewable energy jobs, reflecting the challenges in assessing the numbers and duration of sectorial jobs. The U.K. government tracks the numbers of biofuel-related jobs in order to help assess if biofuel policies are meeting their official objectives.

Energy Security and Biofuel and Feedstock Trade

Trade in biofuels and feedstock is significant for the U.K. RTFO data for year four showed corn sourced from outside of the EU, principally from the United States, was the main feedstock for bioethanol. The main feedstock for biodiesel was overwhelmingly UCO, sourced from the U.K. and within Europe.

Conclusions

The U.K.'s biofuel policy's success at meeting its stated objectives has been subject to debate. This report shows that, in some instances, the benefits to the U.K. biofuels sector and economy from biofuel policies have been few, unclear or require greater monitoring and elaboration in order to examine the related costs and benefits of meeting the U.K.'s biofuel policy objectives.

1.0 *Introduction*

Biofuels can be used as liquid transport fuels and are principally produced from biomass. The two main biofuels in use, bioethanol and biodiesel, can be substituted for petrol or diesel for use in vehicle engines and aviation. The main production process for bioethanol is through a process of sugar and starch crop fermentation. The more common feedstocks are corn, sugar beets and sugarcane. Biodiesel is produced through the transesterification of fats, from vegetable oil feedstocks such as palm oil, rapeseed and soybeans. They can also be produced from waste products, such as used cooking oil (UCO) and tallow, which is rendered fat from animals. A range of production processes that do not use food-based feedstocks is currently being investigated in Europe and elsewhere.

Policy-makers have been trying to tackle the major issue of greenhouse gas (GHG) emissions from burning transport fossil fuels in order to mitigate climate change. Biofuels have been considered a potential way to reduce the use of conventional petroleum products in order to reduce GHG emissions. Crop-based feedstocks remove carbon from the atmosphere as part of photosynthesis during their lifetime, and when they are converted to biofuels and burned in combustion engines, they can propel a vehicle with no net production of GHGs. Biofuels offer a less carbon-intensive transport fuel in a sector where renewable alternatives to transport fossil fuels are difficult for policy-makers to implement.

As energy and climate policy has developed, policy-makers have begun to implement emissions standards and life-cycle calculation methodologies for emissions savings for biofuels on the basis that different biofuel production pathways have different emissions savings and life-cycle emission costs. Emissions have included those generated by chemical inputs and fertilizers, fossil fuels used to run farm machinery and refineries, and emissions from transporting the fuels from the point of production to the point of use. Another source of emissions identified is land-use change linked to human activities such as deforestation resulting from new agricultural land needed to accommodate the increased production of biofeedstocks (Joint Research Centre, 2010a; Joint Research Centre, 2010b). These emissions can be direct or indirect.

1.1 Key Policies

1.1.1 EU Policies and Objectives

The U.K. is obliged to comply with two principal EU Directives: (1) the Renewable Energy Directive (RED) 2009/28/EC (European Commission, 2009a), which requires member states to meet 10 per cent of their transport energy demand from renewable sources by 2020 and (2) the Directive on the Quality of Petrol and Diesel Fuels (Fuel Quality Directive, or FQD, 2009/30/EC) (European Commission, 2009b), which requires that member states reduce the emissions intensity of their transport fuels by at least 6 per cent by 2020. Both the RED and FQD require biofuels to deliver emissions reductions of at least 35 per cent compared to fossil transport fuels. From 2017, this target increases to 50 per cent and from 2018 it increases to 60 per cent for new biofuel production refineries. Support is provided to biofuels on the basis that biofuels can deliver a range of public goods. The key policy objectives of these directives are: (a) reducing GHG emissions, (b) promoting the security of energy supply and (c) providing opportunities for employment and regional development, in particular in rural and isolated areas (European Commission, 2009a).

1.1.2 U.K. Policies and Objectives

In November 2005 the Government of the United Kingdom announced the introduction of the Renewable Transport Fuel Obligation (RTFO), affirming that, together with fuel duty incentives, it would be the country's primary mechanism to deliver the objectives set out in the European Commission's Biofuels Directive (European Commission, 2003).

The RTFO obliges suppliers of fossil fuels (if they supply over 450,000 litres of petroleum per annum) to deliver a specified percentage of the road fuels they supply in the U.K. market as renewable fuels. As well as requiring fuel suppliers to meet targets relating to the volumes of biofuels supplied, the RTFO requires companies to provide reports on the carbon and sustainability of biofuels. Administered by the Renewable Fuels Agency (RFA) until March 31, 2011, when it was closed, responsibility for managing the RTFO now rests with the U.K.'s Department for Transport (DfT) (Renewable Fuels Agency, 2011).

1.1.3 Implementing Targets for Biofuel Blending

The RTFO outlines the levels of obligation on a volume basis—that is to say, the percentage of fuels that must come from biofuels. The following percentages for blending biofuels with fossil fuels by volume were called for in the revised RTFO:

- 2.5 per cent in fiscal year (FY) 2008/2009
- 3.25 per cent in FY 2009/2010
- 3.5 per cent in FY 2010/2011
- 4 per cent in FY 2011/2012
- 4.5 per cent in FY 2012/2013
- 4.75 per cent from 2013 and onwards (DfT, 2013d).

If oil companies do not meet their obligation by delivering enough biofuels, they pay a so-called buyout price currently set at 30 pence per litre (ppl) (NFPAS, 2013b). The buyout price acts as a safety valve for suppliers unable to redeem enough Renewable Transport Fuel Certificates (RTFCs) to meet the required amount of blended biofuel (Kutas, Lindberg, & Steenblik, 2007). The RTFO currently allows suppliers to claim two RTFCs per litre for biofuels derived from waste products. This double counting creates an incentive for suppliers to source these biofuels over agriculturally produced biofuels, which may have undesirable impacts on food prices and lead to land-use change. As a result of this incentive, nearly all biodiesel currently supplied in the U.K. is derived from used cooking oil (UCO) and category one tallow (a type of tallow produced especially for energy production).

The RED sets targets by energy content, rather than volume. Products with lower energy content, such as renewable fuels, will require higher levels of consumption on a volumetric basis in order to achieve the same energetic value. The energy density of biodiesel is around 90 per cent that of fossil-fuel diesel, while for bioethanol it is only around two thirds that of petrol. The number of litres of biofuel needed to travel a certain distance compared to if only fossil fuels were used goes up and can thus increase fuel costs for the motorist, while also increasing tax revenue from the product if it is subject to excise taxation.

The U.K.'s RTFO is based on a set of volume percentage targets. In order to achieve the same percentage target for renewable energy use by energetic value, additional biofuels will need to be consumed given their lower overall energy value (DfT, 2009). The U.K. government is currently considering what policies will ensure that it meets the EU's RED commitment of using 10 per cent renewable transport fuels by energy content (as opposed to overall volume) by 2020.

On October 17, 2012, a legislative proposal was tabled at the European Commission (EC) (European Commission, 2012b) to limit food-based biofuels, counting toward the EU's 10 per cent target for renewable energy in transport, at 5 per cent. Separate from any decision at the EU level, from April 15, 2013, the U.K. blending target for all types of biofuels will be 4.75 per cent of total transport fuel volume.

1.1.4 Objectives of this Study

The study is set against the three key official objectives in EU directives that are used to justify the support given to the EU biofuel industry: (1) reducing carbon emissions from transport, (2) supporting rural development and (3) improving energy security. This study analyzes the cost-effectiveness of this support.

This study reviews a selection of costs and benefits associated with the use of biofuels that are linked to a wide range of stakeholders, including motorists, the general public, taxpayers, the biofuels industry itself and EU farmers. Depending on the method used to assess biofuel use, it may deliver a cost under one scenario and benefit under another. Some costs of using biofuels are: subsidizing the industry, which can be paid for by taxpayers or motorists; increased food prices due to the use of food-based biofuels, which pushes up commodity prices;[2] higher motoring costs because biofuels are more expensive than fossil fuels at the pump; and food-based feedstocks resulting in indirect land-use changes (ILUC) generating more emissions than they displace, leading to biodiversity destruction or negatively affecting vulnerable people.

Some of the benefits of using biofuels are: their ability to displace the use of fossil fuels in order to improve energy security, allowing countries to be less reliant on unstable oil imports for the refining of petrol and diesel; a reduction in emissions from biofuels replacing dirty petroleum transport fuels; employment creation in biofuel refining facilities, other parts of the supply chain and the wider economy; biofuel companies contributing to the tax base of governments through company tax returns; the use of food-based feedstock crops improving farmers' income via higher commodity prices; production of co-products; and bioethanol's use as a fuel additive to improve vehicles' engine performance.[3]

1.1.5 Methodology

For empirical data used in this study, there were a number of discrepancies found among different data sources. European-level data sources such as Eurostat and the European Commission were used, while national data came primarily from the DfT. On issues such as biofuel production, consumption and direct jobs, preference was given to the data compiled by the industry associations (European Diesel Board, ePure) and also used by Ecofys and EurObserv'ER. The authors reviewed the most frequently cited and recent studies, looking at the range of available estimates and best available scientific research.[4] RTFO year four (April 15, 2011 to April 14, 2012) was the reference year for the study (at the time the study was being prepared it provided the most recent full year of data), with some 2011 calendar year data used in some calculations.

[2] A significant amount has been written on the effects of biofuels on food commodity prices, but this report does not address this issue. Ecofys, Fraunhofer, BBH, EEG & Winrock International (2013) found that between 2007 and 2010, EU-27 biofuel production may have contributed to relatively low amounts of between 1–2 per cent of wheat and coarse grain price increases and non-cereal food commodities by about 4 per cent. This issue was outside the scope of this study.

[3] Some of these issues are explored in an earlier IISD research publication: *Biofuels – At What Cost? A review of costs and benefits of EU biofuel policies* (Charles, Gerasimchuk, Bridle, & Morenhout, 2013). Additional information on these issues is available from intergovernmental organizations, such as the Organisation for Economic Co-operation and Development (OECD), Food and Agriculture Organization of the United Nations, the International Energy Agency (IEA), biofuel industry associations, and a wide range of research organizations.

[4] When interpreting these estimates for policy, the authors were guided by the Precautionary Principle, which states that "when an activity raises threats of harm to human health or the environment, precautionary measures should be taken even if some cause-and-effect relationships are not fully established scientifically" (Wingspread Conference on the Precautionary Principle, 1998). This principle is legally binding for the EU and has taken the form of Article 191 of the Treaty on the Functioning of the European Union (Consolidated Version of the Treaty on the Functioning of the European Union, 2008).

2.0 Background

2.1 The Role of Sustainability in U.K. Policy

U.K. policy-makers have identified two key factors in considering the impact of biofuels: (1) biofuel's ability to deliver emission reductions and (2) evidence that increased production of feedstocks affects food commodity prices. The U.K. government has conducted extensive public consultations assessing the impacts of increasing the overall percentage of renewable transport fuels (DfT, 2011a). There has been considerable debate on whether raising the biofuel blending mandate is the right decision, especially given questions surrounding biofuel's environmental and social impacts. A major U.K. government investigation called the *The Gallagher Review of the Indirect Effects of Biofuels Production* identified that recent research on ILUC resulting from increased biofuel production had shown that "displaced agricultural production causes land-use change, impact on both the greenhouse gas lifecycle emissions of biofuels and biodiversity" (Gallagher, 2008, p. 7). The review also concluded that "biofuels contribute to rising food prices that adversely affect the poorest" (Gallagher, 2008, p. 9) and recommended that targets "higher than 5% by volume (4% by energy) should only be implemented beyond 2013/14 if biofuels are shown to be demonstrably sustainable (including avoiding indirect land-use change)" (Gallagher, 2008, p. 8). Consequently, there are currently no stated plans to increase RTFO blending targets.

2.2 Market Formation and Trends

The market turnover[5] of the U.K.'s biofuel industry is estimated at €1 billion by EurObserv'ER (2013, p. 157). The U.K. biofuel industry has members within the Renewable Energy Association (REA) (REA, 2013) representing British renewable energy producers and promoting the use of renewable energy in the U.K.

Based on EurObserv'ER figures, the U.K.'s bioethanol consumption in the 2011 calendar year was reported as 677 million litres, while biodiesel consumption was 960 million litres (EurObserv'ER, 2013, p. 65). The U.K. DfT publishes biofuel consumption data for financial years based on mandatory reports by fuel suppliers as part of the RTFO's reporting conditions. It also provides data based on feedstock, country of origin, estimated GHG savings and other sustainability data (Bailey, 2013; DfT, 2013d).

[5] Turnover figures calculated by EurObserv'ER are expressed in current euros and focus on the main economic investment activity of the supply chain (manufacturing, distribution and installation of equipment, plant operations and maintenance).

3.0 Support to the U.K. Biofuels Sector

3.1 Purpose

This section provides an assessment and quantified figure for the level of support provided to biofuel production and consumption in the U.K. The support estimate put forward here is principally for conventional biofuels.

3.2 Introduction

This section provides an assessment and quantified figure for the level of support provided to biofuel production and consumption in the U.K. The support estimate put forward here is principally for conventional biofuels, but also refers to support for second-generation or advanced biofuels. Identifying and measuring the various support mechanisms is a complex challenge. Often the necessary data are not available, either because member states do not report on their measures or because official statistical data—for example on trade volumes—are not available

The Global Subsidies Initiative (GSI) method for estimating support is based on valuing individual support programs and a bottom-up approach. The method aims to value individual policies or programs provided by policy-makers at different points in the production and consumption value chain. The benefit of this approach is that it provides better information on who bears the costs of the policy and the potential beneficiaries. For example, it provides a financial value on the benefit of EU mandates for those biofuel producers selling into the EU biofuels market; meanwhile, measuring the cost of excise tax exemptions for biofuel consumption allows for a better understanding of the cost to taxpayers due to foregone revenue.

There are other approaches to measuring subsidies, such as that used by the International Energy Agency (IEA) and described further below. The price-gap approach applied by the IEA is relatively less resource intensive and measures the cost of using biofuels by estimating the additional expense of ethanol and biodiesel per litre (multiplied by the amount of biofuels consumed in a given year and country) versus petrol and diesel. Motorists' additional expenditure on biofuels is estimated as the cost of the policy or subsidy. It does, however, mean the cost of individual policy instruments such as research and development (R&D) grants, capital grants or special excise taxes are not valued, nor are the beneficiaries of these policies clearly identified.

The support estimate provided by GSI assesses a variety of policies (and identifies their beneficiaries). It is a broad estimate that should be considered for the wider biofuels industry or sector, as opposed to specifically for biofuel producers.

BOX 1: CONTEXTUALIZING THE NUMBERS: SUBSIDIES TO BIOFUELS COMPARED TO SUBSIDIES TO OTHER ENERGY SOURCES

All energy sources in the world are subsidized. Historically, the most subsidized energy source is fossil fuels. The IEA estimates that fossil-fuel consumer subsidies in non-Organisation for Economic Co-operation and Development (OECD) countries amounted to US$523 billion in 2011 (IEA, 2012), while the GSI estimates fossil-fuel producer subsidies worldwide at US$100 billion (APEC Energy Working Group, 2012). These estimates of fossil-fuel subsidy value do not include the non-internalized environmental externalities, including the cost of GHG emissions to society. Many countries introduced energy-efficiency measures, subsidies to biofuels and renewable technologies among other objectives with the aim of creating public goods in the form of carbon emission reductions and to level the "playing field" already distorted by subsidies to fossil fuels. The high level of subsidies to fossil fuels, and especially petroleum transport fuels, poses barriers to introducing a diversified energy mix. This is especially true in the transport sector because subsidies to fossil-fuel producers encourage the continued exploration and extraction of fossil fuels, while consumer subsidies lower the price of the final product to consumers.

U.K. support polices included a legally enforceable mandate to blend biofuels, excise tax exemptions, R&D grants to second-generation biofuels and, previously, some regionally focused support policies.

BOX 2: THE MECHANICS OF BIOFUEL SUBSIDIES IN EUROPE

In layman's terms, the word "subsidy" is often thought to refer only to a direct transfer of funds from a government to a private actor. In contrast, under international law, "subsidy" includes a wide range of preferential treatment—financial and otherwise—that governments provide to consumers and producers on various grounds. Subsidies are often justified as public goods that the market has failed to create or as being temporary measures to enable maturation of new technologies and to create a larger market for subsidized products, with the objective of reducing their cost and increasing their competitiveness over time (OECD, 1996).

One of the most authoritative "subsidy" definitions is formulated in Article 1 of the Agreement on Subsidies and Countervailing Measures (ASCM), which has been agreed to by 155 members of the World Trade Organization and covers direct and indirect transfer of funds and liabilities; various forms of tax relief; R&D grants; access to capital, land, water and public infrastructure at below-market rates; and market and price support. Notably, in order to be considered a subsidy, such preferential treatment has to be specific to a company or industry compared to other economic agents.

Importantly for the subject matter of this report, the ASCM definition does not include market price support induced through tariffs or mandates. Meanwhile, consumption mandates have become the main policy providing government support to biofuels in many countries.

Therefore, a number of stakeholders and experts, including the IEA and the GSI, consider the market price support enabled by consumption mandates to be a subsidy (Lang, 2010; IEA, 2011). Mandates act in the same way as other forms of support, driving up market-clearing prices, setting the demand floor and thereby improving competitiveness of biofuel producers (Koplow, 2009a).

3.3 U.K. Support Measures

3.3.1 Market Transfers

Market price support broadly measures the intervention affecting both consumer and producer prices by artificially elevating the price of biofuels. In the EU, mandatory blending rates and border protection through tariffs are among the most important instruments (European Commission, 2011a). The former establishes mandatory requirements for the share of biofuels in transport fuels sold, whereas the latter aims at protecting European production of biofuels through tariffs on biofuel imports. A mandate allows biofuel producers to overcome technical or other barriers imposed by primary fuel suppliers, who may object to the use of biofuels while also providing long(er)-term targets, thus enhancing the predictability of market developments and reducing investment risks. As mandates put upward pressure on wholesale biofuel clearing prices (the price at which a market clears or sells its product) the beneficiaries of this policy are biofuel producers who are able to sell into the EU market at an elevated price if the mandates were reduced or removed. As biofuels are currently more expensive to produce than fossil fuels, the additional costs at the pump are borne by consumers.

Market size (the total value of transactions) can be estimated by measuring the total production or consumption of biofuels and some measure of the market price. To put the following market price support estimates in context, the 2011 market size of the U.K.'s ethanol industry was estimated at £379 million[6] and the biodiesel market at £725 million.[7]

Valuing the support provided to the biofuels sector from mandates is challenging. This paper recognizes that there is a range of factors other than blending mandates that may affect EU wholesale biofuel prices (such as higher production costs, sustainability costs and tariffs on imported biofuels), and hence this is an initial effort to put forward a preliminary assessment of the level of market price support provided via blending mandates in the U.K.

[6] Ethanol's industry's market size in the U.K. in 2011 was calculated as the number of litres of ethanol consumed (698 million) (source: (DfT, 2013c; DfT, 2013d) multiplied by an average EU price per litre price for ethanol (£0.54 per litre) (source: OECD & Food and Agriculture Organization, 2011).

[7] Biodiesel industry's market size in the U.K. in 2011 was calculated as the number of litres of biodiesel consumed (933 million) (source: (DfT, 2013c; DfT, 2013d) multiplied by an average EU price per litre price for ethanol (£0.78 per litre) (source: OECD & Food and Agriculture Organization, 2011).

BOX 3: METHODOLOGICAL NOTE ON ESTIMATING THE SUPPORT PROVIDED BY MEMBER STATE CONSUMPTION MANDATES

The level of support provided by the consumption mandates is assessed from the viewpoint of a theoretical producer of biofuel (whether located inside or outside the EU). A biofuel producer will identify the best market to sell their product based on a range of factors, but principally it will be determined by the price they are able to secure. In the EU, prices for bioethanol and biodiesel are higher than average world prices; hence, a biofuel producer will factor in transport costs for their product, and then estimate the profit they could make from selling into the EU market. The higher price for biofuel in the EU represents demand (and supply) forces. This analysis attempts to estimate the value of biofuel consumption mandates introduced by member states (the consumption mandates help establish a market for biofuels), while recognizing there is a range of other factors affecting biofuel clearing prices (these are discussed further below). The value of consumption mandates implemented by EU member states in support of bioethanol and biodiesel consumption is estimated in this report as the difference between the EU wholesale price for biofuels and a world reference price, minus an adjustment for freight costs. The amount of support estimated is very sensitive to changes in either world or EU reference prices.[8] See Koplow (2009b) for a deeper discussion on the challenges in applying a price-gap methodology.

Limitations to this Analysis

There are a number of factors that complicate this method of assessment. There may also be a range of other factors pushing up (or down) EU wholesale market prices that are not accounted for in this method. These may include:

- **EU biofuel production costs will be higher than production costs in non-EU countries** due to a range of factors including higher energy costs, salaries, and health and safety compliance, etc.
- **The extent to which the EU market prices contribute to world reference prices will also affect any price-gap calculations.** While bioethanol produced in the EU is a small part of the world market (as an average, during 2008–2010 bioethanol was around 6 per cent of world production), biodiesel produced in Europe forms a significant part of the global biodiesel market (as an average during 2008–2010 around 52 per cent of world production[9]) (OECD & Food and Agriculture Organization, 2011).
- **Sustainability costs** involving administrative and reporting requirements to meet EU regulations can result in additional operational costs pushing up EU biofuel prices as opposed to upward pressure from blending mandates. These costs can push up EU prices and the theoretical size of support provided by the mandates (Charles & Wooders, 2011).
- Imported biofuel from outside of the EU is subject to border taxes, such as taxes on undenatured bioethanol of €0.19 and €0.10 on denatured, and import duty on biodiesel (6.5 per cent ad valorem) (Ecofys & German Union for the Promotion of Oils and Protein Plants, 2012). The effect of EU tariffs or anti-dumping duties on bioethanol and biodiesel, while correcting unfair market situations, also pushes up the costs of imported biofuels, thereby increasing EU biofuel prices and increasing the size of the price-gap and the support value.
- There could also be a range of other policies or market forces affecting wholesale market prices.

Due to the complexity of these forces acting on EU whole market prices they were not accounted for as part of the method for measuring market price support.

[8] Reference prices, both EU and world wholesale biofuel market prices used in this report to measure the size of market price support vary slightly from wholesale biofuel reference prices applied in IISD's 2013 study (Charles, Gerasimchuk, Bridle, & Morenhout, 2013), which may reflect any differences in support estimates.

[9] Based on average volumes between 2008–2010.

Market price support for bioethanol was calculated by multiplying production and imports figures by a price gap of between £0.06-0.10 ppl (the difference between EU bioethanol wholesale average price of £0.50-0.54[10] per litre and the world bioethanol average price £0.41 of per litre minus transport and handling charges).

TABLE 1: MARKET PRICE SUPPORT TO BIOETHANOL, 2011/2012

	2011/2012
*U.K. production of fuel ethanol (million litres)	33
**U.K. fuel ethanol imports (litres)	665
***EU ethanol wholesale average price (£/litre)	0.50-0.54
****World ethanol average price (£/litre)	0.41
*****Transport and handling charges, Brazil to the EU (£/litre)	0.03
U.K. price gap (£/litre)	0.06-0.10
Market price support-production (million £)	2-3
Market price support-imports (million £)	40-69
Total Market price support (million £)	42-72

Currency conversions: OECD World ethanol price of US$0.644/1 converted to EUR at a rate of US$1 = €0.72, as applied in other GSI country reports, then converted to GBP at a rate of €1 = £0.862. OECD EU ethanol price provided in local currency [EUR] converted into GBP at €1 EUR = £0.862. Currency conversion rates are average rates for 2011 drawn from www.oanda.com

Sources:
**Bioethanol production statistics, source: DfT (2013d).*
***Bioethanol imports, source: Author's calculations (consumption for 2011/2012 minus 2011 production figures).*
Bioethanol consumption, source: DfT (2013d); DfT (2013c).
****EU bioethanol wholesale average price: source OECD & Food and Agriculture Organization (2011)*
*****World bioethanol wholesale average price: source OECD & Food and Agriculture Organization (2011)*
******Transport and handling charges, Brazil to the EU (£/litre): source (personal communication, with Brazilian bioethanol expert, February 2013). 0.035 pence per litre for shipping bioethanol from Brazil to Europe was used as a proxy for distribution costs, which would need to be paid by the bioethanol producer (personal communications with Brazilian bioethanol expert, 2013). It is possible that this is a lower-bound estimate, with shipping costs from Brazil to Europe being higher depending on conditions, which would reduce the price-gap figure and the level of support via the mandates to bioethanol.*

Market price support for biodiesel was calculated by multiplying production and import figures by a price gap of £0.16–£0.22 per litre (the difference between EU biodiesel wholesale average price of £0.72–£0.78[11] per litre and the world bioethanol average price of £0.52 per litre minus transport and handling charges).

[10] A sensitivity analysis was provided for the EU wholesale ethanol price to develop a range estimate.
[11] A sensitivity analysis was provided for the EU wholesale ethanol price to develop a range estimate.

TABLE 2: MARKET PRICE SUPPORT TO BIODIESEL, 2011/2012

	2011 /2012
U.K. production of biodiesel (litres)*	155
U.K. biodiesel imports (litres)**	778
EU biodiesel wholesale average price (£/litre)***	0.72-0.78
World biodiesel average price (£/litre)****	0.52
Internal domestic transport and handling charges (£/litre)*****	0.035
U.K. price gap (£/litre)	0.16-0.22
Market price support—production (million £)	25-35
Market price support—imports (million £)	128-175
Total Market price support (million £)	153-209

Currency conversions: Ecofys world Biodiesel price of US$0.822/l converted to EUR at a rate of US$1 = €0.72, as applied in other GSI country reports, then converted to GBP at a rate of €1 = £0.862. Currency conversion rates are average rates for 2011 drawn from www.oanda.com

Note: There may be significant variation in the Biodiesel World Reference Price depending on the data source. The Ecofys Biodiesel world reference price was selected as it was part of a global review of world biodiesel markets and appeared to be most recent assessment of world biodiesel prices available.

Sources:
**Source: DfT (2013d).*
***Source: Author's calculations (consumption for 2011/2012 minus 2011 production figures).*
****Source: BigOil.net (2012).*
*****Source: Ecofys & German Union for the Promotion of Oils and Protein Plants (2012, p. 82).*
******Source: author's calculations: 0.035 ppl for biodiesel distributed within Europe was used as a proxy for distribution costs, which would need to be paid by the biodiesel producers.*

3.3.2 Budgetary Support Linked to Volume Produced or Consumed

To decrease the end price of biofuels to consumers and make them similar to the prices of the conventional petroleum-based fuels, European governments have introduced fiscal incentives for the commercialization of biofuels.

In 2008 the fuel duty rate was simplified to a single rate for diesel and two rates for petrol. The fuel duty charged on both biodiesel and ethanol decreased slightly, to 20 ppl. After April 1, 2010, the preferential rates of duty for biofuels ended with ethanol and biodiesel taxed at the same per-litre rate as petrol and diesel. However, biodiesel produced from used cooking oil was the exception, which benefited from an exemption of 20 ppl for another two years up until March 31, 2012. Table 3 sets out the level of support provided in 2011 (Her Majesty's Revenue and Customs [HMRC], 2013).

TABLE 3: U.K. TRANSPORT FUEL EXCISE TAXES RATES FOR BIODIESEL MADE FROM UCO AND CONSUMPTION LEVELS, 2011

2011/2012 BIODIESEL FROM UCO				2011
Quantity consumed (million litres)	Diesel excise tax (£/L)	UCO biodiesel excise tax (£/L)	Excise tax exemption (£/L)	Loss of fiscal revenue (million £)
800	0.68	0.48	0.20	161

Source: DfT (2013d); HMRC (2013).

3.3.3 RTFCs

Under the RTFO, fossil-fuel suppliers are required to blend a percentage of fuels for road transport supplied in the U.K. from renewable sources that are deemed sustainable, or "that a substitute amount of money is paid" (DfT, 2013a). All fuel suppliers (suppliers of fossil fuels and biofuels) that supply at least 450,000 litres of fuel per year are obligated to participate under the scheme. Companies owning biofuels at the point where duty would normally be paid are awarded one RTFC per litre of biofuel, or kilogram of biomethane, supplied (DfT, 2013a). Fuels produced from certain feedstocks (such as wastes and residues as well as those from lignocellulosic and non-edible cellulosic material) are eligible for double counting—that is to say, they earn two RTFCs. Any company in possession of biofuels, including biofuel producers, may claim certificates that can potentially be sold to obligated companies that may then use them to meet their obligation target. Any companies unable to provide the correct number of RTFCs to match their blending obligation must pay a buy-out price of 30 ppl (DfT, 2013a). As noted by the DfT, the "potential income stream represented by the awarding of RTFCs will become the main government support mechanism for biofuels in the UK" (DFT, 2013a).

Based on DfT data in RTFO year 4, 1.9 billion certificates were issued, with about 874 million traded between all parties. The majority of trading took place between obligated fossil-fuel companies (those companies having to blend biofuels), with biofuel companies only redeeming and trading a small number of certificates. Biofuel companies are likely only selling small volumes of biofuels directly into the fuels market for consumption (and owning the biofuels at the point custom duty is due) so they can claim certificates. Table 4 contains the number of certificates traded by biofuel companies (a subset of the total 874 million certificates traded between all parties) to other biofuel companies[12] or fossil-fuel and biofuel producing and distributing companies[13] applying an average price of £0.13 per certificate (NFPAS, 2013a). The trading of RTFCs theoretically provides a small amount of additional revenue to biofuel companies.[14] This paper recognizes the RTFC system is not principally designed to incentivize biofuel production, but under some circumstances it can provide an additional revenue stream to biofuel producers, as acknowledged by the DfT. Due to the complexity of the transport fuels market and the RTFC allocation and trading system, this is only an illustrative example of a potential revenue stream for biofuel producers resulting from this trading system.

TABLE 4: SUPPORT PROVIDED THROUGH RTFCS FOR RTFO YEAR 4 (2011/2012)

2011/2012*	RTFCS TRADED BY BIOFUEL COMPANIES TO OTHER PARTIES (MILLION)	RTFO YEAR 4 AVERAGE RTFC PRICE (£)**	LEVEL OF SUPPORT (MILLION £)
	27	0.13	3.5

Sources:
**RTFCs issued during RTFO year 4 (April 2011 to April 2012), of which 284 million were double counting from biodiesel produced from UCO, resulting in an additional 284 million RTFCs being issued. Source: DfT (2013b, 2013d)*
***Source: NFPAS (2013a).*

[12] The HMRC code HO930 is used for biofuel companies.
[13] The HMRC code HO10 is used for fossil fuel and biofuel-producing and distributing companies.
[14] The challenges are measuring the value of the potential support calculating the exact price or value of the RTFC and that companies may hold over or bank 25 per cent of RTFCs into the following year. For this analysis the number of RTFCs issued in RTFO year 4 and an average price is taken as a proxy to estimate the additional potential revenue.

3.3.4 Summary of Subsidies to Biofuels

Table 5 summarizes the potential support provided to the U.K. biofuels sector in 2011/2012 through RTFCs, excise tax exemptions and blending mandates.[15]

TABLE 5: SUMMARY TABLE OF BIOFUEL SUPPORT PROVIDED IN RTFO YEAR 4 (2011/2012)

RTGO YEAR 4 (2011/2012)	ETHANOL	BIODIESEL	TOTALS
Excise Tax exemptions (UCO biodiesel production) (million £)		161	161
Market price support through RTFO blending mandates (million £)	42–72	153–209	195–281
RTFCs (million £)	1.75	1.75	3.5
Total subsidy (million £)	44–74	315–371	359–445
U.K. biofuel consumption (million litres)	698	933	1,631

**Summary numbers rounded to the nearest million GBP. When summed, rows or columns may show some variation due to rounding.*

[15] The cost of the RTFO policy based on a 5 per cent biofuel target was estimated by Chatham House (p. 22, 2013) to be £460 million in the 2013/2014 fiscal year. This assessment was based on the additional costs to ethanol and biodiesel motorists versus the cheaper conventional fuels they replace.

4.0 Single Payment Scheme

4.1 Purpose

This section estimates the size of agricultural payments under the Single Payment Scheme (SPS) provided to farmers growing food crops based on their end consumptive use, whether it is for food or biofeedstock markets.

4.2 Introduction

U.K. farmers are eligible for subsidies under the SPS, sometimes referred to as the Single Farm Payment Scheme, which is part of the EU's Common Agricultural Policy (CAP). Introduced in 2005, the SPS was part of the CAP reforms designed to decouple subsidies from production-related aid, and allows farmers greater freedom to switch to alternative enterprises, such as bioenergy crop production. The aim of the regulation was also to help simplify and modernize CAP's administration (Europa, 2009). There are no specific SPS payments or schemes to support biofeedstock production; rather, annual energy crops grown for biofeedstock production (e.g., oilseed rape, sugar beet and cereals) are eligible for the SPS payment, as are other crops that meet the necessary SPS regulations (Business Link UK, 2011). Our analysis does not infer that the SPS payments are a direct subsidy or transfer to the biofuels industry. Instead, we have calculated the portion of the SPS payments going to farmers growing energy crops in order to better understand how the CAP is spent and the type of cropping activities it supports. This will help to support better policy making. *Hence, knowing what percentage of SPS payments accrue to farmers for growing crops destined for the biofuels market versus crops destined for food or feed markets is of public benefit*.

Average SPS per-hectare rates are based on European Parliament figures (see Table 14; European Parliament, 2010), which estimate a flat per-hectare rate for each member state and for the EU as a whole for the year 2013 (after a number of CAP reforms have been implemented).[16]

The following formula was applied to determine the level of SPS payments provided to farmers growing crops for biofuel production:

Hectares used for biofeedstock production per annum X SPS per hectare rate =

SPS payments for U.K. biofeed production per annum

[16] The number of hectares of arable land used for biofeedstock production may be underestimated in certain cases as a result of a lack of data. SPS payments may also be overestimated, as this calculation does not take into account the production of co-products from biofuel production.

4.3 Results

Table 6 shows the amount of land being used to grow biofeedstocks and the SPS payments that have accrued to farmers for this activity.

TABLE 6: SPS PAYMENTS TO AREAS USED FOR BIOFEEDSTOCK PRODUCTION

COUNTRY	HA FEEDSTOCK	YEAR (HA)	AVERAGE (EUR/HA)[1]	TOTAL (EUR MILLION)
European Union	3,600,000[2]	2008	266	958
United Kingdom	72,918[3]	2010	247	18

Sources: 1. European Parliament (2010); 2. Ecofys, Agra CEAS, Chalmers University, IIASA & Winrock (2011); 3. Government of the United Kingdom (2011).

This section summarizes the distribution of SPS payments based on the quantities of land used to produce biofeedstocks, noting that SPS payments are not used to promote energy crops directly and are available to farmers regardless of crops' final end use. Based on available cropping data for 2010, €18 million in farm payments went to the farmers growing crops that went to biofuel production. Of this figure, around €12.5 million in SPS payments went to farmers growing biodiesel feedstock and around €5.5 million to farmers producing ethanol feedstock. The amount of SPS payments provided to farmers growing crops channelled to food or other markets was not calculated.

5.0 *Emission Reductions*

5.1 Purpose

This section estimates the amount of direct and indirect emissions from biofuels based on U.K. government biofuel consumption data and European Commission emission factors, generating carbon abatement costs for ethanol and biodiesel.

5.2 Introduction

Emissions from biofuels can be broadly split up into two categories: (1) direct emissions from the cultivation, processing and transport of biofuels, including direct land-use change, and (2) emissions from ILUC associated with growing biofuel feedstock crops (European Commission, 2012a). This section assesses emissions and emission savings associated with the following fuels and feedstocks: non-land-using biodiesel (produced from tallow and used cooking oil), conventional biodiesel (produced from virgin vegetable oils) and bioethanol. It is based on biofuel consumption in the U.K. for the 2011–2012 fiscal year.

5.3 Methodology

The amount of emissions produced or saved depends to a large extent on which crop or feedstock source is being used to produce the biofuel and the life-cycle emissions profile associated with its production. In most European countries, there is a lack of data on what types of feedstock biofuels consumed in the EU are derived from. The U.K. government, however, does provide a good level of information under the requirements of the RTFO, annually publishing the volume of biofuels consumed and the types of feedstock upon which their production had been based.

This analysis estimates the amount of emissions and emissions savings for FY 2011–2012 based on actual consumption data, and for the 2020 calendar year based on projections of biodiesel and bioethanol consumption in the U.K.'s National Renewable Energy Action Plan (NREAP) (Beurskens, Hekkenberg, & Verthman 2011).[17] The consumption figures for FY 2011–2012 in energy terms amounted to 43 billion megajoules (MJ). For biodiesel for the year 2020, we assumed a business-as-usual scenario from the first half of the financial year 2012–2013; as a result, 100 per cent of biodiesel consumption through until 2020 is based on biodiesel produced from UCO and tallow. However, this assumption could be undermined by specific concerns relating to UCO biodiesel (see below) and the fact that the principal policy support from biodiesel made from UCO and for UCO (double counting) may be adjusted.

For estimates of direct emissions from biofuels, the assessment relied on the emission factors used by the European Commission in its October 17, 2012 proposal to amend the Fuel Quality Directive (FQD) and the Renewable Energy Directive (RED) (European Commission, 2012b). To estimate biofuel-associated emissions from ILUC, the analysis used central ILUC factors proposed by the European Commission in the same proposal. The European Commission uses a zero ILUC factor for biodiesel produced from UCO and tallow feedstocks. These factors are based on the Laborde (2011) study, which the European Commission considers best available science in the area of ILUC-modelling (European Commission, 2012a).

[17] It should be noted that, with the pending proposal to cap food-based biofuels and potential legislative changes of EU biofuels policy, consumption levels may change, affecting the accuracy of the business-as-usual scenario projections.

TABLE 7: DIRECT, INDIRECT AND TOTAL EMISSIONS ASSOCIATED WITH U.K. BIOFUEL CONSUMPTION IN 2011 AND 2020 (IN MILLION TONNES CARBON DIOXIDE EQUIVALENT)

	DIRECT EMISSIONS		ILUC EMISSIONS		TOTAL EMISSIONS	
	2011	2020	2011	2020	2011	2020
Non-land-using biodiesel	0.24	0.96	0	0	0.24	0.96
Conventional biodiesel	0.14	0	0.18	0	0.31	0
Ethanol	0.48	1.91	0.17	0.88	0.65	2.79
Total	0.85	2.87	0.35	0.88	1.20	3.75

Source: Author's calculations

In FY 2011–2012, the U.K. consumed about twice as much biodiesel as bioethanol. Emissions from biodiesel consumption in the U.K. market are not necessarily much higher than those of bioethanol, as a result of the use of tallow and UCO for biodiesel, which has a zero ILUC factor and a direct emissions factor that is lower than other types of biodiesel feedstock. Conventional biodiesel, however, is more emissions intensive, in terms of direct emissions and particularly ILUC emissions. Bioethanol is generally less emissions intensive than conventional biodiesel. This is true for direct emissions, but even more so for ILUC emissions, in which bioethanol emits an amount of carbon dioxide about four times less per unit of energy than conventional biodiesel (Laborde, 2011).

5.4 Direct Emissions

In terms of direct emissions, biofuels consumed in the U.K. were responsible for 0.85 million tonnes of carbon dioxide equivalent (Mt CO_2e); more than half of that was associated with bioethanol, given the low emissions from biodiesel produced from UCO. When projecting forward to 2020, U.K.'s NREAP clearly demonstrates that the proportion of bioethanol in total biofuel consumption is set to increase. That means biofuels will be responsible for direct emissions of around 2.9 Mt CO_2e by 2020, of which 1.9 Mt is associated with bioethanol and about 1 Mt with biodiesel from UCO and tallow.

5.5 ILUC-Related Emissions

What is ILUC?

ILUC refers to the displacement of farming for feed or food production to other areas as a result of arable land being used for biofuel feedstock production. Simply put, when the use of arable land in the EU shifts from food or feed production to the production of biofeedstocks and food or feed demand patterns do not change, extra crops grown on additional land is needed to meet that demand and substitute for biofeedstocks diverted to biofuel production (Joint Research Centre, 2008, 2010a).

This additional demand is often met by increasing the cultivation of food or feed crops in jurisdictions outside of the EU for subsequent exportation to the EU market. When carbon sinks such as forests and peatlands are cleared for such production, indirect emissions as a result of EU biofuel policies occur (Joint Research Centre, 2008; Joint Research Centre, 2010b). In particular, vegetable oil markets are globally linked and thus prone to ILUC. Direct and indirect LUC are not phenomena exclusive to biofuels. Agricultural and trade policies, among others, can have significant land-use change effects.

Measuring or observing the exact extent of ILUC is not possible, as feedstock producers cannot measure land-use change patterns in different parts of the world; however, it is possible to model some estimates (di Lucia, Ahlgren, & Ericsson, 2012). This analysis estimates ILUC-associated emissions in line with the European Commission's proposal for biofuel emission reporting (European Commission, 2012b). The European Commission relies on ILUC factors developed by Laborde (2011).

Background on the International Food Policy Research Institute Model

The Laborde (2011) study is built upon a general equilibrium model that is based on future projections of agricultural productivity, biofuel policies and international trade. Such projections are based on assumptions that are subject to a wide degree of uncertainty (Joint Research Centre, 2008; Laborde, 2011). The most advanced modelling exercise to date was performed by the International Food Policy Research Institute (IFPRI). To reduce uncertainty, IFPRI performed 1,000 rounds of Monte Carlo simulations in which they scrutinized a sensitivity analysis of seven parameters that have the most important effect on the supply side of the model.

Some Key Issues

Uncertainty relating to the projected results is the main reason why models are often criticized. Like any model, the IFPRI model is imperfect. As the author himself recognizes, there is room for improvement with regards to assumptions related to land-use expansion and substitution. Uncertainties related to additional land needed are both independent from and dependent on policies (Laborde, 2011).

Other issues have included whether the model sufficiently accounts for the protein content of biofuel co-products and that palm oil is modelled as a perennial crop. Consequently, the reporting factors in the proposals are criticized for being inaccurate. The French National Institute for Agricultural Research (2013) recently published a report stating assumptions on crop yields for biodiesel feedstocks may be lower than actually observed.

One such issue relating to policy assumptions is how the modelled emissions are partially dependent on the assumption that increased palm oil production will take place on peatland forest areas in countries like Indonesia and Malaysia. According to Delzeit (2012), this is formally illegal according to Indonesian law and the assumption is dependent on political factors such as the non-enforcement of existing regulations. A review of the Indonesian moratorium on new forest concessions found that there have in fact been clearings in primary forest in spite of the moratorium. In addition, the moratorium only applies to new concessions and it excludes secondary forests, which are also large carbon sinks (Union of Concerned Scientists, Greenpeace and World Resources Institute, 2012). Similarly, one could argue that IFPRI's numbers are underestimated, as they assume higher yields in the baseline than most other ILUC models (Marelli, 2013).

The use of Laborde's ILUC factors for consumption in 2011 may also raise some questions, because the ILUC factors in that study are for the year 2020, based on an increase in biofuel consumption relative to a 2008 baseline. In this regard, it is important to note that, as part of the sensitivity analysis mentioned above, the European Commission requested that Laborde investigate the linearity of the ILUC factors. As the European Commission points out in its impact assessment accompanying the proposal, it should be noted that some crops with a strong non-linearity effect will indeed have a lower ILUC factor at lower consumption volumes (European Commission, 2012a). This is particularly the case for vegetable oils like rapeseed.

Nevertheless, based on the Laborde analysis, the European Commission still regarded the factors as the best available approach to estimate ILUC-related emissions of all biofuel consumption today. This is therefore the approach our study follows, until a more sound methodology is developed and published in an authoritative source. We do advise that the uncertainties related to an ILUC emissions estimation for the year 2011 are taken into account when considering the results of our study.[18]

5.6 Estimated ILUC Emissions

In 2011 ILUC emissions associated with U.K. biofuel consumption were around 0.35 Mt CO_2e, of which almost 0.20 Mt was from biodiesel. These numbers are indicative of the high ILUC emissions associated with virgin vegetable oil use for biofuel production: while the consumption of conventional biodiesel represented only 18 per cent of conventional biofuels use, it was responsible for a similar amount of ILUC emissions as bioethanol, which represented 82 per cent of conventional biofuels. In 2020, only bioethanol will be responsible for ILUC emissions, as we assume that, since the second half of 2012, 100 per cent of biodiesel has been produced from tallow and UCO.

5.7 Total Emissions

Total emissions associated with biofuel consumption in the U.K. totalled a little over 1.2 Mt CO_2e in 2011, of which 0.35 Mt was related to ILUC. Eighty per cent of these total emissions come from conventional biodiesel and bioethanol; however, they only accounted for 40 per cent in terms of energy supply. In terms of biofuel use, UCO and tallow perform much better according to current accounting rules.

Current ILUC accounting rules for biofuels from waste products may disregard certain ILUC associated with an increase in demand for these waste products due to their increased value. Bailey (2013) points to potential indirect effects related to a wide variety of other products using tallow, such as soap and animal feed. Chatham House analysis uses research by Brander et al. (2009), who estimated that tallow-produced biodiesel would lead to more modest emission decreases and could even be responsible for slight net emission increases. Bailey concludes that at higher use—which is expected toward 2020—the risk of ILUC emissions increases and "may already be material." This would alter the entire emission balance of U.K. biodiesel, which under current accounting rules, appears very positive at this moment.

For UCO, potential indirect effects are mainly related to its rising price. Double counting of UCO makes waste oil more attractive and pushes up the prices. If these prices are higher than refined palm oil prices and if the price differential is sufficiently large, it is theoretically possible that market participants will import more palm oil, which is consumed quickly and wastefully, to be resold as waste oil (UCO) for biofuel production. In FY 2011–2012, only 17 per cent of UCO came from the U.K., 42 per cent came from within Europe and another 20 per cent from North America. Small amounts came from different places in the world and around 20 per cent had unknown origins. This is particularly concerning since the origin of UCO is the first step in being able to guarantee that UCO is indeed waste oil, and not either virgin oil or virgin oil wastefully and quickly consumed to be resold as UCO.

[18] For di Lucia, Ahlgren and Ericsson (2012) the Precautionary Principle implies the selection of high ILUC factors to guide policy-making that aims to improve the certainty that no negative ILUC occurs. The choice of factors from central values would imply a preventative approach, which aims at reducing the risk of negative ILUC, but has less certainty of its success than higher values. Our analysis is, in line with the approach of the European Commission, based on central ILUC factors.

5.8 Emissions Savings from U.K. Biofuels

Once the total emissions associated with biofuel consumption have been calculated, the next step is to estimate whether biofuels are responsible for net emissions savings or not. To do this, one estimates what level of emissions would be emitted if fossil fuels were used to cover an equal transport energy demand. In line with the European Commission (2012a), the analysis used a fossil-fuel comparator of 90.3 grams per MJ.

The results indicate a large difference between conventional biodiesel and bioethanol. Conventional biodiesel typically is responsible for a slight net emission increase, while bioethanol is responsible for some emission reductions. In 2011 they were a little over 0.6 Mt CO_2e. As projected in the U.K.'s NREAP, an increase in bioethanol consumption could lead to savings of almost 4 Mt CO_2e in 2020.

Tallow-based biodiesel and UCO perform very well in terms of emissions savings, given their low direct emissions and zero ILUC emissions factor. At least this is the case if they are genuinely waste, which is not guaranteed. In our calculations, however, we assumed they were genuine waste. In 2011 these types of biodiesel were then responsible for over 2 Mt CO_2e of emissions savings. In 2020, if UCO and tallow provided 100 per cent of biodiesel consumed in the U.K., the emission savings potential goes up to over 8 Mt CO_2e.

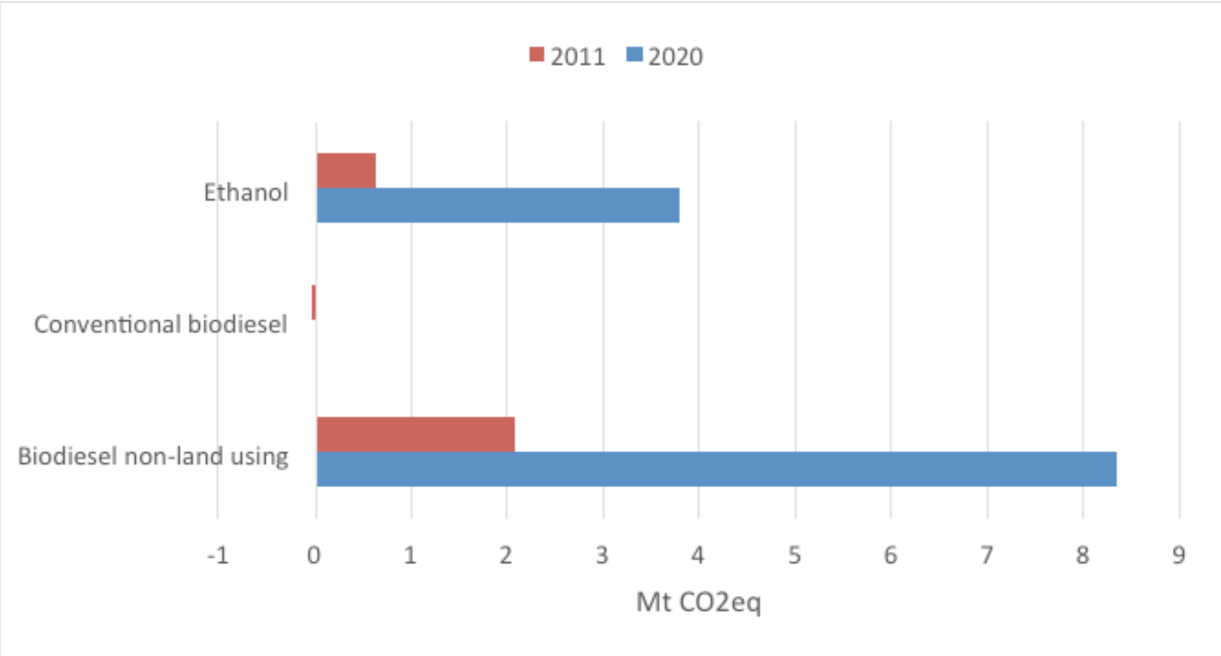

FIGURE 1: EMISSIONS SAVINGS FROM BIOFUEL USE IN THE U.K.

Source: Author's calculations based on DfT (2013d); Beurskens, Hekkenberg, & Vethman (2011); European Commission (2012a).

5.9 Carbon Dioxide Abatement Costs

The abatement cost estimates how much it costs for a given technology to reduce 1 tonne of CO_2e from the atmosphere in order to mitigate climate change. The abatement cost is only calculated for 2011, as this study does not provide biofuel subsidy estimates for 2020. Based on this approach, abatement costs are highly dependent on subsidy estimates, which can be calculated using a variety of methodologies and may vary significantly (they can also change from year to year depending on the policies assessed and estimation method adopted). The abatement cost figure in this study is on a support-cost basis, in which costs have been calculated using a bottom-up approach (see chapter 3, Support to the U.K.'s Biofuels Sector). Another method to calculate abatement costs is based on an economic or fossil-fuel reference, in which the baseline against which the RTFO would be set is not international biofuel prices, but rather fossil energy prices. Generally, this methodology results in higher abatement costs.[19]

In 2011 bioethanol had an estimated abatement cost of around £115 (€132) per tonne CO_2 abated (the overall level of support divided by the amount of carbon avoided to provide a per-tonne carbon abatement cost).

Conventional biodiesel is very different from non-land-using biodiesel such as UCO and tallow. Since 90 per cent of biodiesel consumed in the U.K. is UCO based, the portion of the market price support estimate (the level of subsidy provided by blending mandates and estimated in chapter 3, Support to the U.K.'s Biofuels Sector) has been allocated to UCO-produced biodiesel consumption, given that it is the main source of biodiesel used (effectively, the cost part of the equation received a proportion of the subsidy estimate split by the level of consumption). In addition, UCO-based biodiesel received an excise tax exemption of £0.2 per litre. As a result, UCO-based biodiesel has an abatement cost of around £154 (€178)[20] per tonne of CO_2 abated. It should be noted that this figure is based on a cost-calculation that still includes the £0.20 per litre excise tax exemption for UCO. This tax exemption represented £161 million in support out of the total support of £315 million to £371 million for UCO-based biodiesel in 2011. Therefore, abatement costs for UCO-based biodiesel without the excise tax exemption are significantly lower.

On average, biofuel use, including the net emissions increase from conventional biodiesel use in FY 2011, results in an overall net abatement cost of around £165 (€189) per tonne of CO_2 abated in the U.K.[21]

[19] One example of such an approach for the calculation of abatement costs for biofuels in the U.K. can be found in Bailey (2013).

[20] Abatement costs are converted from GBP to EUR based on average 2011 exchange rates.

[21] While this analysis estimates the cost of carbon abatement, further analysis would be valuable to assess the cost of carbon if no action on climate change was undertaken.

6.0 *Employment Creation*

6.1 Purpose

This section provides a review of employment estimates generated for the U.K. biofuels sector and the geographical distribution of jobs within the U.K.

6.2 Introduction

In a time of economic recession, the U.K. government, like many EU governments, considers the potential impacts of biofuel and energy-sector policy options on employment. As this section illustrates, if job creation is considered an important objective for supporting the development and deployment of biofuels, the level of detailed information available on employment effects is probably inadequate.

BOX 4: BIOFUEL PRODUCTION: WHAT TYPES OF JOBS ARE BEING CREATED?

The biofuel industry involves the construction of biofuel plants, which can provide short-term construction-related jobs, including labourers, civil works personnel, surveyors, structural engineers, quantity surveyors and electricians (Kretschmer, B, et al., 2013, p. 45; Greene & Wiley, 2012).

Once the plants are completed, examples of jobs in general administration and management include: plant and operations managers, office administrators, health and safety managers, environment officers, labourers, financial accounting staff, feedstock purchasers, marketing and logistics personnel (IEEP, 2011, p. 45; Greene & Wiley, 2012).

Liquid biofuels for transport differ from wind and solar renewable energy, as they involve energy inputs that are not freely available (in contrast with the wind and solar radiation) such as crops used as biofeedstocks or residues from various industries. The production of agricultural commodities used as biofuel feedstocks results in jobs in agriculture—notably those of farmers and seasonal workers (Charles, Gerasimchuk, Bridle, & Morenhout, 2013).

To the extent that they are based on residues or waste products, the collection and pre-treatment of second-generation biofuels generates jobs in this stage of the production process. Refining bioethanol and biodiesel requires technically skilled labour, like chemists, plant operators and engineers, before the biofuel can be distributed for sale (ePure, 2012a).

Research and development activity is carried out by the industry and can also involve academic institutions throughout the U.K. (Kretschmer, B, et al, 2013, p. 45; Greene & Wiley, 2012).

Bioethanol and biodiesel industry representatives claim an expansion of biofuel consumption, either first- or second-generation fuels, would create direct jobs within the industry and additional jobs in other sectors, such as agriculture (ePure, 2012a; European Diesel Board [EBB], 2012).

6.3 Is It a Numbers Game? Jobs in the Bioethanol and Biodiesel Industries

Based on an employment factor[22] proposed by the European Renewable Ethanol Association (ePure), for every 1 million litres of domestically produced renewable bioethanol, approximately 16 jobs are created (ePure, 2012). Based on an employment factor for the EU biodiesel industry extrapolated from a EurObserv'ER figure of 0.007 jobs per

[22] Employment factors: estimates the average number of jobs per unit of capacity installed or fuel generated in litres, multiplied across the production base or volume of litres produced in the EU in a given year (data sources could include reports and studies, surveys in industry and farming, case studies, national statistics on consumption and production capacities).

tonne of oil equivalent (toe), every 1 million litres of biodiesel produced in the EU is roughly estimated to create 5.3 jobs[23] (EurObserv'ER, 2012, p. 157). Table 8 summarizes employment estimates based on a selection of biofuel production figures and employment multipliers.

TABLE 8: BIOFUEL-RELATED JOBS IN THE U.K.

	U.K. ETHANOL PRODUCTION	NUMBER OF JOBS	U.K. BIODIESEL PRODUCTION	NUMBER OF JOBS	TOTAL NUMBER OF JOBS
2011 Industry production figures (litres)	320,000,000	5,120	246,776,000	1,308	6,428
2011/2012 RTFO year 4 production figures (litres)	33,423,734	534	155,328,209	822	1,356

Sources: ePure (2012b); EBB (2012); DfT (2013d); DfT (2013c); ePure (2012a); EurObserv'ER (2012, p. 157)

The table above shows that the number of biofuel-related jobs ranges from 1,356 to 6,428 depending on the level of biofuel production assumed. Figures generated by the REA (2012, p. 29) estimated approximately 3,500 U.K. biofuel jobs in 2010/2011 spread across 200 supply chain companies. The report noted the Vivergo Fuels plant in Hull was "creating around 80 permanent, full-time, highly skilled jobs" (REA. 2012, p. 49) and supporting over a 1,000 jobs through the company's supply chain. A report published by EurObserv'ER (2012, p. 173) estimated U.K. employment across the biofuel supply chain at 7,500 in 2011. There appears to be a broad range of employment numbers for direct and indirect jobs in the U.K. depending on which calculation methods were used.

One challenge to the claims that the biofuels sector creates new indirect jobs is that many of the agricultural-related jobs could likely exist with or without the biofuels sector. A key issue is one of additionality, in that the additional jobs created by the biofuels sector are likely those associated with biofuel processing facilities or transport (due to the increased use of tankers to move biofuels given the challenges in transporting them through piping networks) (Swenson, 2006).

6.4 The Long-Term Security of Jobs

If job creation is a key goal for supporting the biofuels industry, the sustainability and quality of jobs are important issues. Increasing amounts of imported biofuels and feedstocks (such as rapeseed, soybeans, wheat and corn) are being observed (DfT, 2013d). Increased imports will lead to reduced biofuel production in the EU and lead to a decrease in jobs within the U.K. and EU, and an increase in jobs in foreign countries exporting biofuels to the EU market (Charles, Gerasimchuk, Bridle, & Morenhout, 2013). Furthermore, the U.K. government is considering whether to halt an increase in RTFO blending mandates in response to sustainability concerns. If support to the EU biofuels industry is steadily reduced overtime, this may affect U.K. or EU biofuel production levels with the number of biofuel-linked jobs falling (or increasing) based on changing domestic production levels.

There is currently a lot of interest in the number of jobs created through the development of renewable energy. It is estimated that the U.K.'s offshore wind sector will create 16,200 jobs across 790 companies, with the turnover[24] of the sector being £2.1 billion. Solar photovoltaic (PV) is anticipated to create up to 25,000 jobs by the end of 2011,

[23] The EurObserv'ER based its estimate of the socioeconomic impacts of EU biodiesel and vegetable oil production on an assumption of 0.007 jobs per toe (EurObserv'ER, 2012, p. 157).

[24] Turnover as defined in this study includes companies in the supply chain where 20 per cent of their turnover is supplied into the sector, with only the sales activity relating to the renewable sector included in the analysis as turnover (Greene & Wiley, 2012).

across 2,200 individual companies (REA, 2012, p. 27) with a turnover of £1.8 billion in FY 2010–2011. Governments find it challenging to compare the relative effectiveness of investing in one renewable energy sector over another with the objective of creating employment. The sustainability and quality of jobs will likely be a factor of the specific industry's ability to continue without ongoing regulatory support.

6.5 Rural Development and the Geographical Location of Jobs

The EU supports the use of biofuels in order to pursue "opportunities offered by biofuels in terms of economic activity and job creation within the context of the cohesion policy and rural development policy" (European Commission, 2006). The geographic spread of jobs is seen as important, with many rural areas of Europe experiencing higher-than-average unemployment, and average incomes being lower in rural areas compared with cities. Hence, bioethanol and biodiesel industry jobs in rural areas are seen to correspond to one of the original policy objectives for subsidizing biofuels: rural development.

Table 9 provides an illustrative breakdown of the potential spread of biofuel-related jobs between EU-designated Competitiveness and Employment regions and Convergence regions based on a formula that incorporates the distribution of production capacity between regions and their surface land.

TABLE 9: BREAKDOWN OF BIOFUEL-RELATED JOBS IN THE U.K. BASED ON EU DEVELOPMENT REGIONS IN 2011[25]

EMPLOYMENT FIGURES BASED ON 2011 PRODUCTION FIGURES				
	ETHANOL		BIODIESEL	
EU designated region	Number of jobs	Percentage split between region	Number of jobs	Percentage split between region
Competitiveness and Employment region	1,164	89%	4,557	89%
Convergence region	144	11%	563	11%
Total	1,308	100%	5,120	100%

Source: Ethanol production: ePure (2012b); biodiesel production: European Diesel Board (2012). Biofuel production numbers are converted into number of jobs based on employment multiplier factors. Bioethanol: ePure [2012a]; Biodiesel: European Biodesel Board, EurObserv'ER (2011).

The locations of U.K. biodiesel and bioethanol plants[26] represented in Figure 2 are shown in relation to the European designations for Convergence Regions (where per capita GDP is less than 75 per cent of the European average) and Competitiveness and Development Regions. A variety of factors affect the selection of biofuel refining plants, such as the local road network and access to ports and feedstocks. Any jobs created in the agricultural sector are likely to be located near biofuel plants, as feedstocks are generally sourced locally unless they are imported.

[25] The employment figures represented in this table are illustrative and the number of jobs separated by region does not represent specific U.K. job figures. To estimate the number of jobs in the U.K. that have both Convergence regions and Competitiveness and Employment regions, the surface area of the Convergence region was divided by the total surface area of the U.K. (Internet World Stats, 2013) to establish the percentage surface area of the country with Convergence designated areas. The geographic location of U.K. biofuel refineries was then plotted between Convergence regions and Competitiveness and Employment regions; a percentage of the countries' installed production capacity was estimated for each region. The two percentages (for the amount of land designated as either Convergence or Competiveness and Employment regions and the average distribution of installed production capacity split between the two regions) were then averaged out and used as the factor multiplied with biofuel production for that year in order to estimate whether jobs were situated in Convergence regions or Competitiveness and Employment regions.

[26] The U.K. biofuel plants plotted on the U.K. map are listed in Annex A. The list of pants may not be exhaustive.

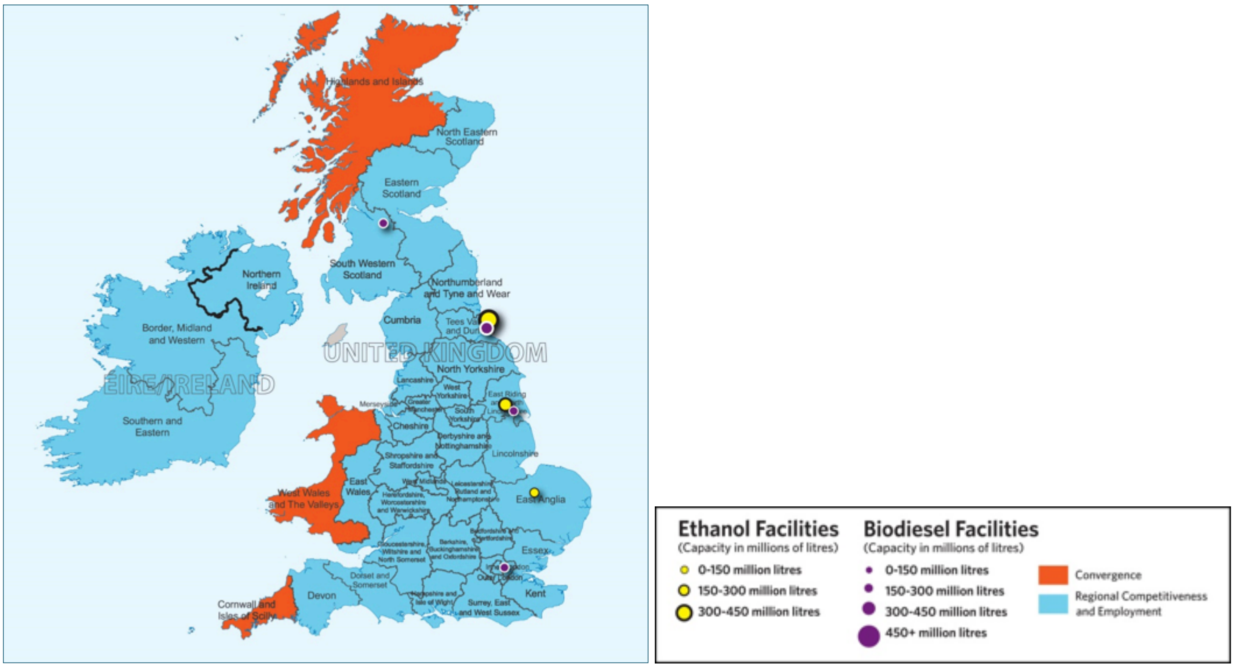

FIGURE 2: U.K. BIODIESEL AND BIOETHANOL PLANTS

Source: GSI data collection (a list of biofuel plants, locations and refining capacity is located in Annex A)
Map of the U.K. showing Convergence or Competiveness and Employment areas, source: European Commission (2013). Reprinted with permission.

In general, there is not a high degree of correlation between the economically underdeveloped Convergence Regions and the locations of plants in the U.K. However, it should be noted that the U.K.'s Midlands (where some of the biofuel plants are located) is economically less developed than the south of England (Department for Communities and Local Government, 2007, p. 5) and would benefit from employment creation initiatives.

6.6 Conclusions

Due to the complexity of job counting, it is difficult to estimate the number and quality of sectoral jobs in the biofuels sector, or in the renewable energy sector more broadly. The range of different employment estimates produced for the biofuels sector is not directly comparable given varying methodologies. Previous reports have identified the question of additionality in job counting for biofuels, arguing that farm-based agricultural jobs in the biofuel supply chain would still exist without the biofuel industry. There are also concerns about a substitution effect, whereby jobs created along the biofuel supply chain are displacing jobs in other sectors, such as the petroleum supply industry. Given the economic slowdown in Europe and high unemployment rates, job creation is an important factor for policy-makers, and jobs created in the biofuels industry can be viewed as important to an economy in recession, especially if they are in poorer rural areas. The biofuels sector may deliver net economic and employment benefits if related jobs are sustainable and not linked to ongoing subsidies. Better monitoring of the number of biofuel sector-related jobs will help contrast the anticipated benefits from the industry against any associated costs.

7.0 Energy Security and Biofuel Trade

7.1 Purpose

This section discusses international trade in biofuels and feedstocks and the role of biofuels in supporting energy security objectives through displacing the use of crude oil or petroleum products imported from outside of the EU.

7.2 Defining Energy Security

The IEA defines energy security as the uninterrupted availability of energy products at an affordable price (IEA, 2013). The European Commission adds a sustainability dimension by describing security of energy supply as:

> [T]he uninterrupted physical availability of energy products on the market, at a price which is affordable for all consumers (private and industrial), while respecting environmental concerns and looking toward sustainable development. (European Commission, 2000)

Energy security can be improved by increasing the security of supply of traditional energy sources (through long-term contracts or investments), increasing the diversity of energy sources (both geographically and the types of fuels), reducing demand (by improving energy efficiency) and increasing flexibility within the energy sector.[27]

The European Commission's strategy for energy security is linked to its strategies for diversification, emissions reduction and energy efficiency. Biofuels have the potential to improve energy security by diversifying fuel supply, including from primary sources that are locally available and more widely distributed than crude oil (European Commission, 2006). The same considerations are as valid for the EU as individual member countries, including the U.K.

There are two key parameters to assess the effectiveness of meeting the objective of improving energy security through expanding the share of biofuels in the energy mix:

- Quantifying the amount of imported fossil fuels replaced with biofuels.
- Analyzing to what extent the biofuels replacing fossil fuels are domestically produced or imported (in the case of imports, concerns over energy security remain).

Table 10 illustrates the amount of petrol and diesel displaced by biofuel use in the U.K.

TABLE 10: PETROLEUM PRODUCTS DISPLACED BY U.K. BIOFUEL USE IN 2011/2012

	LITRES OF BIOFUEL CONSUMED 2011/2012 (LITRES)	MJ/TOTAL**	PETROL AND DIESEL DISPLACED BY 2011/2012 (LITRES)***	TOTAL PETROL AND DIESEL CONSUMED IN THE U.K. IN 2011 (LITRES)****
Ethanol	*676,539,175	14,396,753,644	447,104,150	16,548,681,462
Biodiesel	*959,668,795	31,765,037,126	884,819,976	28,547,483,643

*Source: * DfT (2013d).*
***Calorific Values (CV) (MJ/litre): bioethanol 21.28, biodiesel 33.10, gasoline 32.20, diesel oil, 35.90.*
****Source: author's calculations. 2011 energy consumption figures: diesel—20.99 million tonnes converted at 1,360 litres per tonne; petrol—13.89 million tonnes converted at 1,191 litres per tonne. Source for conversion factor: DfT (2011d).*
*****Source: Department of Energy and Climate Change (DECC) (2012).*

[27] There is trend in Europe to reduce energy consumption due to the economic slowdown. Consumption was down 6 per cent between 2008 and 2011 (Eurostat, 2013b), though some modes of transportation showed increases in absolute terms, with energy consumption in road transport use in the EU-27 rising by 20 million toe between 2000 and 2010 (Eurostat, 2013b).

Generally, trade balance data in the EU may be confusing because of third-party trade (re-export and re-import). Further, Harmonised System trade codes do not always distinguish between feedstocks and other commodities being imported or exported for biofuel production or other purposes (for instance, bioethanol is also used for technical purposes other than road transport fuels and in the beverages industry).[28] Therefore, analyzing trade flows of biofuels and their feedstock in the EU necessitates a lot of assumptions and caveats. However, the U.K.'s DfT provides relatively clear figures on the type of feedstock (reported in litres) and country of origin as part of the RTFO reporting.[29]

The share of bioethanol feedstock source and country of origin for RTFO year 4 is displayed in the following diagrams. Corn is the main feedstock, providing 517 million litres out of a total 674 million litres consumed in the 2011/2012[30] year (DfT, 2013d). A significant reduction of sugarcane feedstocks sourced from Brazil has been observed compared to previous years (Bailey, 2013).

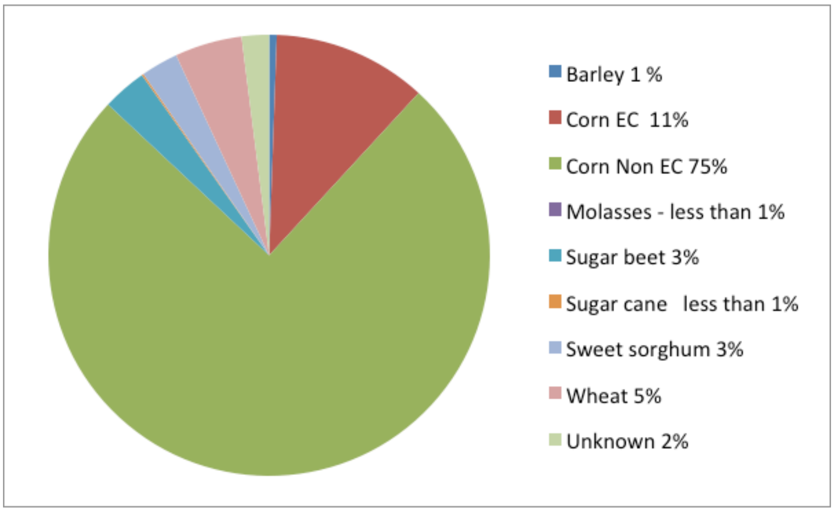

FIGURE 3: BIOETHANOL CONSUMED IN THE U.K. BY FEEDSTOCK (FY 2011/2012)

Source: DfT (2013d).
Note: Percentages may not equal to 100 per cent due to rounding.

Currently, bioethanol feedstock is mainly sourced from outside of the U.K. and Europe, with corn from the United States being the main source. In terms of energy security, having such a significant amount feedstocks sourced from outside the U.K. or EU may pose some concerns.

[28] Biofuels can also be traded as blends with fossil fuels, and trade statistics do not always make a clear distinction of pure and blended products.

[29] Other trade statistics are available on biofuel and feedstock, such as USDA Global Agricultural Information Network (GAIN) EU-27 and national reports (USDA, 2011). Trade data is generated as part of RTFO obligations requiring fuel suppliers to submit information on the volume of all renewable or partially renewable fuels that are covered by the RTFO and the origin of biofeedstocks (DfT, 2013c).

[30] Ethanol consumption figures for FY 2011/2012 may vary slightly to consumption figures represented in other parts of the paper due to the way data has been presented in DfT RTFO year 4 data spreadsheets.

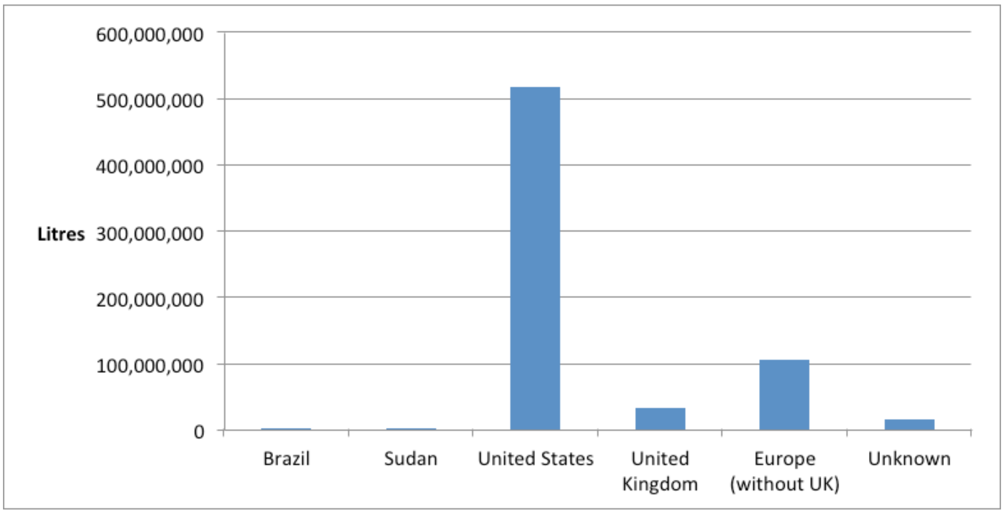

FIGURE 4: COUNTRY OF ORIGIN FOR BIOETHANOL FEEDSTOCKS (2011/2012 REPORTING YEAR)

Source: DfT (2013d).
Notes: Europe includes Serbia and the Ukraine.

The main feedstock for biodiesel production is overwhelmingly from UCO, making up 88 per cent of all feedstocks.

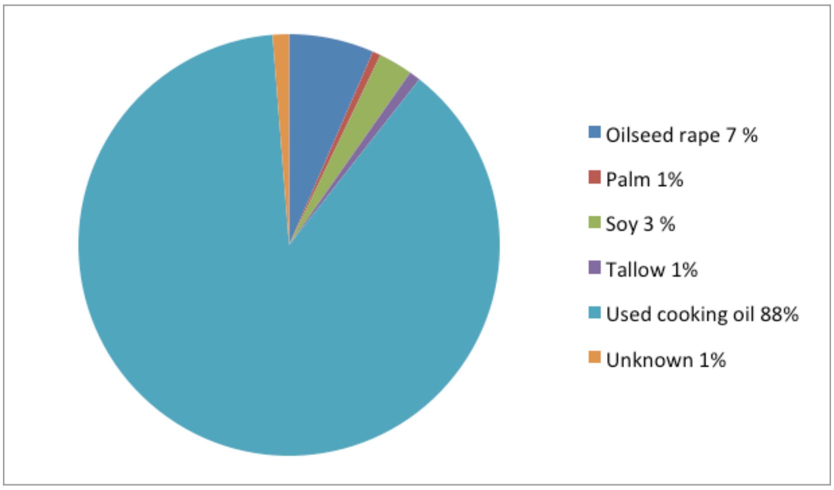

FIGURE 5: BIODIESEL CONSUMED IN THE U.K. BY FEEDSTOCK (2011/2012 REPORTING YEAR)

Source: DfT, (2013d).

The majority of biodiesel and feedstocks are sourced from inside of Europe: 461 million litres from a total 874 million litres consumed in the U.K. originated from within Europe. After Europe (excluding the U.K.), the U.K. was the next largest source of biofeedstock, providing 155 million litres. The origin of biodiesel and feedstocks do not pose major security of supply concerns for U.K. biodiesel consumption. However, if additional food commodities must be imported to replace feedstocks directed to the production of biodiesel, as is likely, then energy security benefits may be eroded due to the requirement to import additional food commodities.

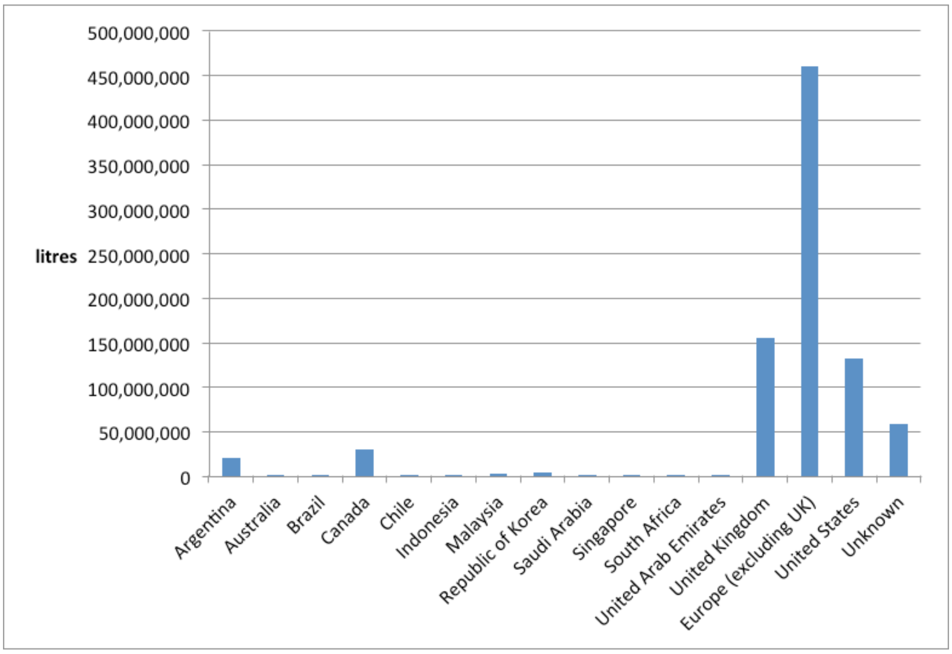

FIGURE 6: COUNTRY OF ORIGIN FOR BIODIESEL FEEDSTOCKS (2011/2012 REPORTING YEAR)

Source: DfT (2013d) Notes: Europe includes Switzerland and Ukraine.

7.3 Conclusions

Trade in biofuels and feedstock is significant for the U.K. RTFO data for year 4 showed corn sourced from outside of the European Union, principally from the United States, was the main feedstock for bioethanol. An overreliance on one country can be risky if corn production in the United States drops. If this happened, the ability of the U.K. to source feedstocks from other countries would depend on spare capacity in countries such as Brazil to meet demand. The main feedstock for biodiesel was overwhelmingly UCO sourced from the U.K. and within Europe.

8.0 Renewable Energy Options

8.1 Purpose

This section evaluates the costs of meeting EU renewable energy targets while reducing the role of food-based biofuels due to EU caps and increasing the contribution from other forms of renewable energy.

8.2 Renewable Energy Targets

The U.K.'s NREAP anticipates the overall EU target for renewable energy in final energy consumption coming from the electricity, heating and cooling, and transport sectors. These sectors have the following subtargets for the amount of renewable energy to be generated: 31 per cent electricity (RES-E), 12 per cent heating and cooling (RES-H&C) and 10.3 per cent in transport[31] (RES-T), coming from renewable forms (European Renewable Energy Council, 2011). The renewable energy generated as part of these sectoral subtargets aggregated together results in 15 per cent of all final energy consumed coming from renewable sources (European Renewable Energy Council, 2011).

In their report for ECN, Beurskens, Hekkenberg, and Vethman (2011) find that the U.K. has projected a total of 20,510 toe (238,531GWh) of renewable energy generation in 2020, according to the NREAP. It is expected that the majority of this energy generation will be derived from electricity production (48 per cent), followed by heating and cooling (30 per cent) with a smaller contribution from transport (22 per cent). This level of renewable energy generation is projected to account for between 13.7 per cent and 15 per cent of total consumption depending on adjustments made for additional energy-efficiency measures and aviation. In the reference scenario, the overall contribution of energy from renewables is 13.7 per cent. This is in line with the overall target agreed by the U.K. government and the EU for 2020.

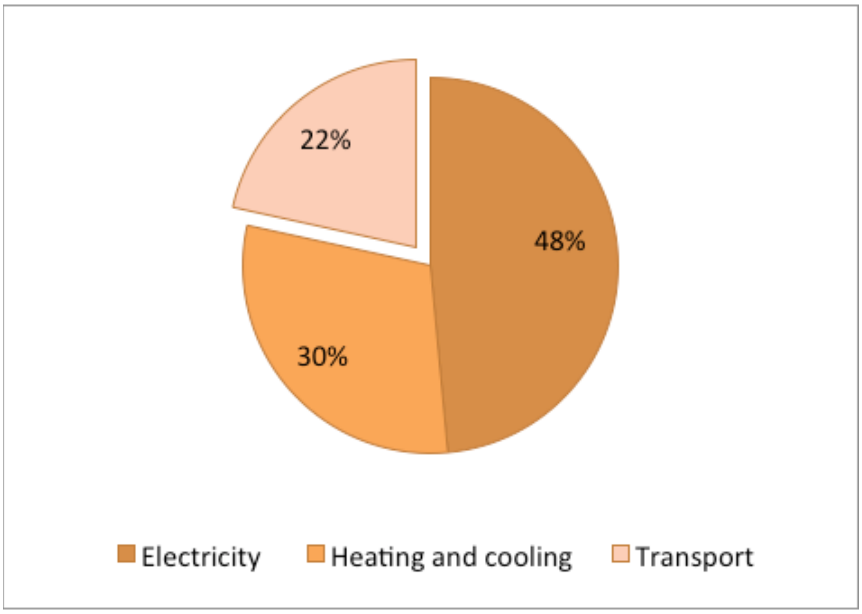

FIGURE 7: PROJECTED RENEWABLE ENERGY GENERATION IN THE U.K. IN 2020

Source: Beurskens, Hekkenberg, & Vethman (2011)

[31] The sectors across the economy in which energy is consumed have been divided by EU policy-makers into renewable electricity, heating & cooling, and transport sectors. These sectors are typically further subdivided to address specific subcomponents of the sector.

In 2011 the majority of renewable energy in final consumption was generated in the form of electricity (62 per cent), with the remainder being split between heat (12 per cent) and transport fuel (26 per cent). The historical generation of electricity, heat and fuel for transport is shown in Figure 8. To meet the targets set out above will require a relative increase in the contributions from heat and transport fuel.

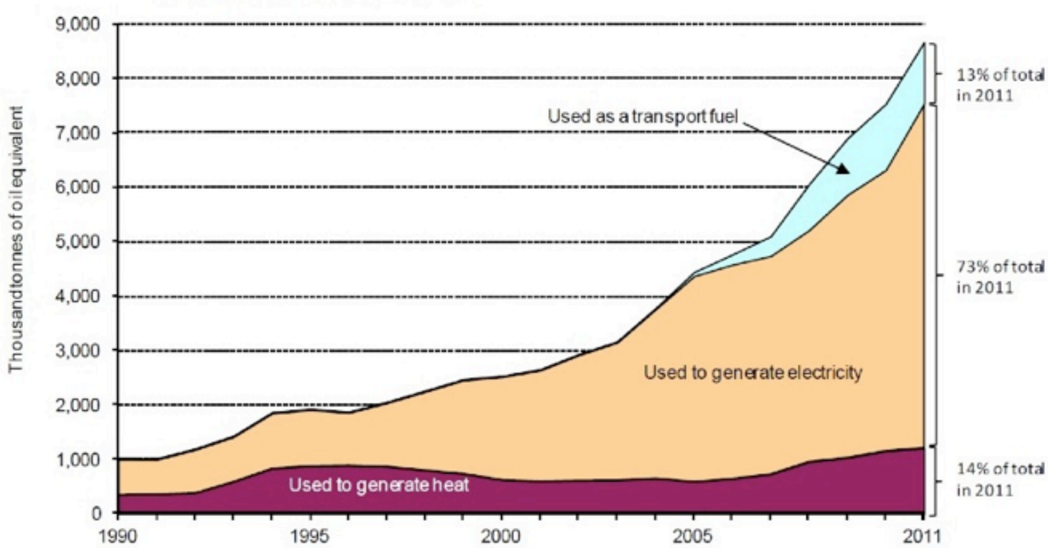

FIGURE 8: RENEWABLE SOURCES USED TO GENERATE ELECTRICITY HEAT AND FOR TRANSPORT, 1990 TO 2011

Source: DECC (2012a).

The economic, social and environmental concerns around the production and consumption of biofuels that have led to the EU proposal to cap food-crop-based biofuels raise the question of whether it would be possible to reach the target for the total generation of renewable energy without expanding the use of biofuels and instead increasing generation of renewable energy from electricity or heating and cooling.

8.3 Deployments of Renewable Energy in Transport Fuels in the U.K.

To promote renewable energy in the U.K., the government has used a number of measures, most notably the RTFO. U.K. energy statistics show that the current use of renewable energy in transport is broadly in line with EU targets (DECC, 2012a). However, in response to concerns over the sustainability of biofuels, the U.K. government has no plans to increase the obligation on road transport fuel providers beyond 5 per cent (Department for Transport, 2012). If the RTFO mandate is not increased through to 2020, future targets may not be reached. The U.K. government will need to scale up other renewable energy technologies or energy efficiency in order to meet RES-T targets. Figure 9 shows this comparison.

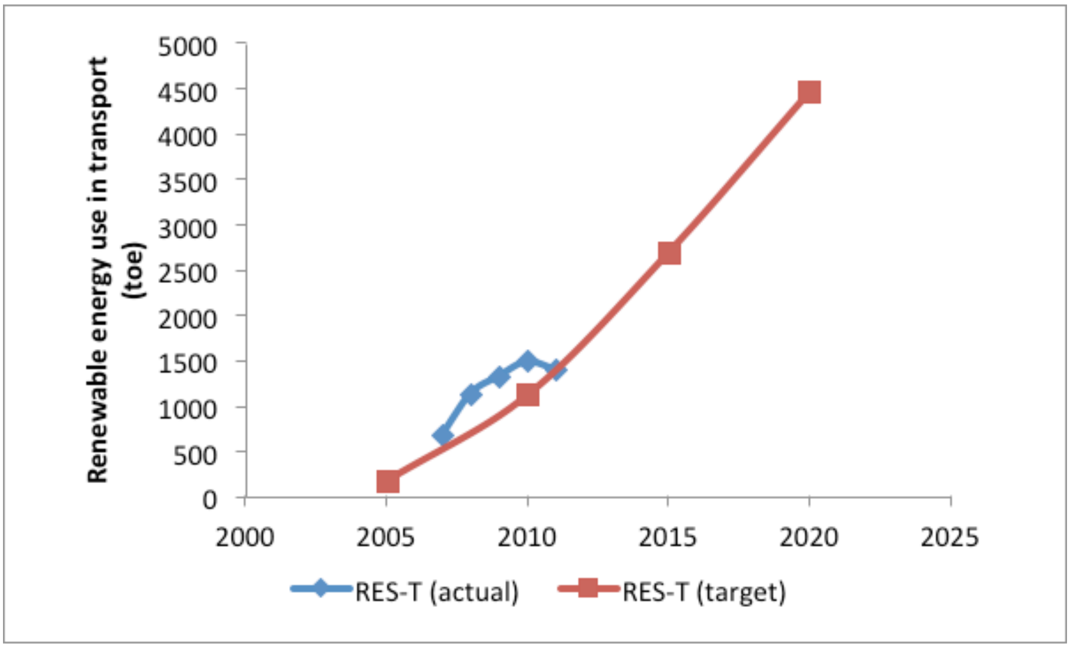

FIGURE 9: RENEWABLE ENERGY USE IN TRANSPORT

Source: Beurskens, Hekkenberg, & Vethman (2011); DECC (2012a).

8.4 Costs

At an economic level, the cost implications of shifting from biofuels to other forms of renewable energy depends on the energy content and production costs of biofuels compared to other options. Data for biofuels production costs was taken from the IEA *World Energy Outlook* (IEA, 2012) and data for the cost of energy from renewables was taken from a recent IRENA (2012) report on generation cost. Figure 10 shows a summary of this comparison.

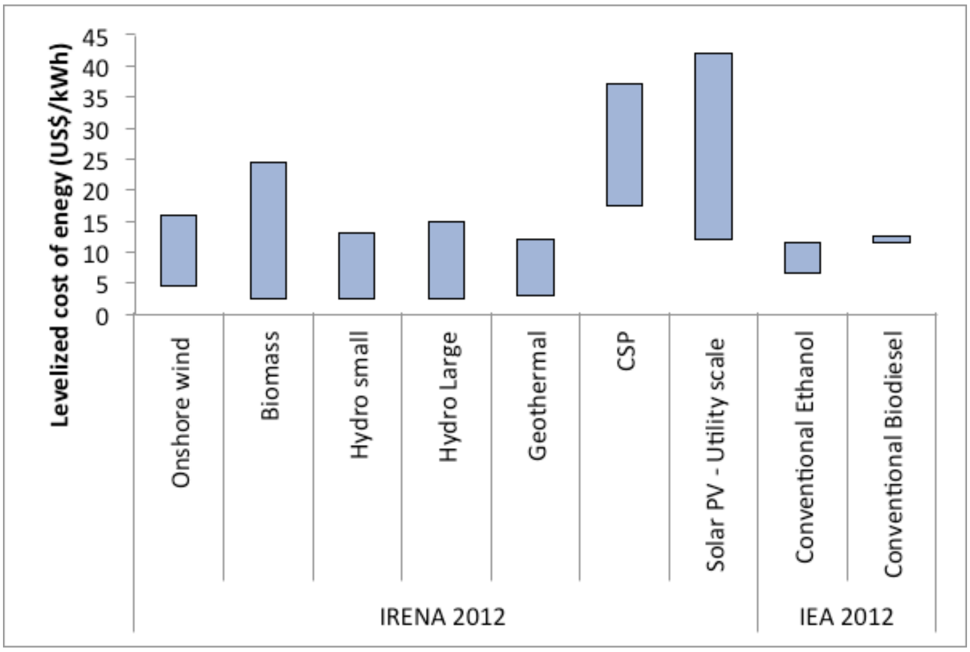

FIGURE 10: COSTS OF ENERGY GENERATION FROM VARIOUS RENEWABLE ENERGY TECHNOLOGIES, BIOFUELS AND PETROLEUM PRODUCTS

Source: IEA (2012); IRENA (2012); author's calculations.

The levelized cost of energy (LCOE) is a measure of the total cost per unit of energy generated. It includes all the costs associated with the production of energy, including the cost of investment and operations plus maintenance and any inputs. LCOE provides a single value for the cost of energy to allow a comparison of technologies with different investment and operating costs. However, the comparison does not account for the usefulness of each of these forms of energy. Liquid fuels are easy to store and very energy dense, but conversion to mechanical work has a lower efficiency than electric motors. Electricity must be consumed instantaneously (or stored chemically), which is currently expensive. Despite the shortcomings of LCOE, it provides a useful comparison of the cost of energy, particularly in the context of our analysis in this report of the cost of meeting the EU target for renewable energy production.

The comparison presented in Figure 11 shows that the costs of biodiesel and conventional bioethanol are similar to other renewable energy technologies, although the midpoint of the ranges is higher than for some of the more widely deployed technologies, including wind and biomass. Data from IRENA is not available for offshore wind, a technology that is expected to expand considerably. However, other sources generally indicate that offshore wind is considerably more expensive than onshore wind (Mott Macdonald, 2011) and therefore is likely to be the same or more expensive than renewable energy from biofuels. However, the potential for future cost reductions is not the same for all technologies. Solar PV costs have fallen at a rate of 15–24 per cent, with each doubling in production since 2004 (Bazilian, et al., 2013). The LCOE from wind power declined by a factor of three between 1980 and 2003, but rose between 2004 and 2009 before falling slightly in recent years. From 2013 to 2030 both PV and wind are projected to see further reductions in the LCOE (BNEF, 2013; Lantz, Wiser, & Hand, 2012). The cost of material inputs for the production of renewable energy technologies such as wind turbines and solar PV panels can be estimated with some level of accuracy, while feedstock costs used to produce first-generation biofuels are more difficult to predict due to volatility in market prices. First-generation biofuels have a relatively low potential for cost reduction, in part because so much of the cost is tied to the feedstock (IEA, 2011).

The cost of meeting a greater proportion of the renewable energy target from other (non-biofuel) sources is likely to be more costly than using biofuels, with the extent of costs being dependent on the ability to employ lower cost renewables such as onshore wind. It is worth bearing in mind that onshore wind is facing a number of challenges, from the availability of good sites to local opposition groups. While solar PV continues to realize cost reductions, it is still significantly more expensive than biofuels on an energy basis. The support required to incentivize production depends on the alternatives and end uses, so a direct comparison requires detailed analysis. However, further expansion of renewable electricity may be limited by access to grid infrastructure, although this may be ameliorated by demand-side management and aggregation. The NREAP plans have been developed considering existing constraints, and further analysis would be required to established the technical viability of replacing biofuels with other sources of renewable energy.

8.5 Subsidies

As a preliminary indication of the costs of reducing the use of biofuels and increasing the use of other renewables, the estimate of total support for biofuels calculated as part of this study was compared with the value of the U.K.'s main renewable energy support mechanism, the Renewable Obligation Certificates (ROCs) (DECC, 2013). Data for the average ROC price were taken from E-ROC (2013). The results of this comparison are shown in Figure 11.

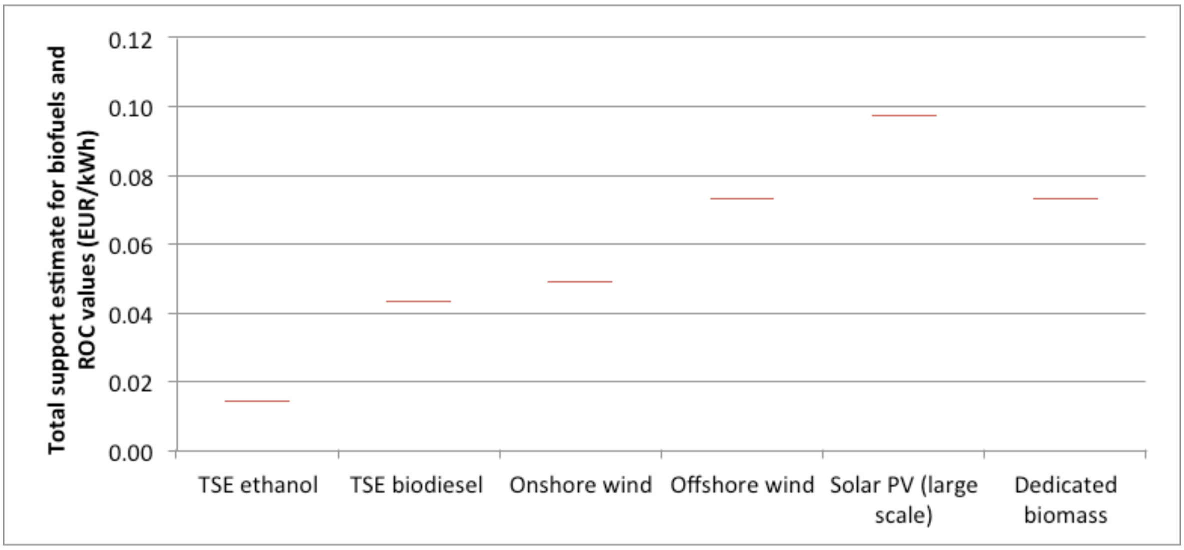

FIGURE 11: COMPARISON BETWEEN TOTAL SUPPORT ESTIMATES FOR BIOFUELS AND U.K. ROC PRICES

Source: IISD (estimated within this report), E-ROC (2013), DECC (2013) and author calculations.

Figure 11 shows that the support to biofuels is lower than the support provided by the main support instruments in the U.K. (this analysis includes only one source of support for renewable electricity production [ROCs] and so is likely to be an underestimate). The cost for biodiesel (based on the subsidy level) is just below onshore wind and the support to bioethanol is significantly lower on a per-unit basis of energy. If it is possible to increase renewable electricity generation from the most competitive technologies, notably onshore wind, then the cost increase may be small. However, if additional generation were to come from more expensive technologies, such as offshore wind or PV, subsidy and deployment costs may increase. These findings indicate a reduction in biofuel consumption and a corresponding increase in other sources of renewable energy, which will possibly increase—or at least not reduce—the cost of meeting the 2020 renewable energy targets. Without detailed analysis and understanding of subsidies to electricity production, it is difficult to understand the magnitude of this change.

While the financial costs of meeting the U.K.'s renewable energy target are a critical issue, they should not be the sole factor in deciding what policies to pursue. A key goal of the 2020 renewable targets is to realize environmental benefits through the deployment of renewable energy technologies. The concern around the environmental impacts of some biofuels may undermine this objective. A shift towards technologies with widely accepted environmental credentials would reduce the cost of environmental benefits, including emissions reductions, if not the absolute cost of meeting the renewable energy targets.

8.6 Other Options for the Transport Target

If the level of renewable energy from biofuels deployed in the transport sector were reduced to 5 per cent (based on the cap on food-based biofuels), this would leave a shortfall of 11 per cent (based on the transport sector's contribution of renewable energy towards the overall 15 per cent renewable energy target) of the renewable energy target, which would then need to be found from other sources.

Other options could include an increase in the use of other transport technologies such as hydrogen or electric cars running on renewable electricity, though it is clear there are a number of challenges to scale up such technologies from currently low levels. Decarbonizing the electricity sector, for example, would allow for much wider deployment of electric road vehicles and rail. Increased use of renewable energy from the heating and cooling sector could also be explored.

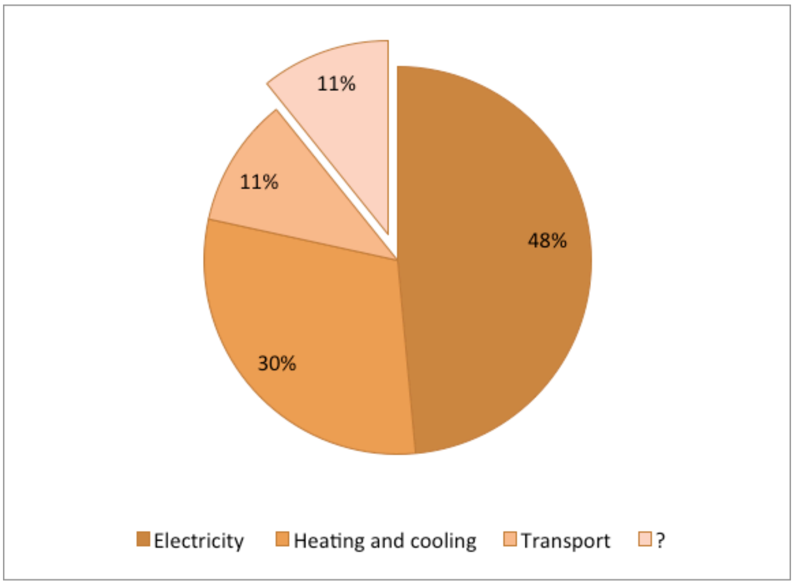

FIGURE 12: 2020 RENEWABLES TARGET WITH BIOFUELS RESTRICTED TO 5 PER CENT AND THE SHORTFALL TO BE FOUND FROM OTHER SOURCES

Source: Beurskens, Hekkenberg, & Vethman (2011), author calculations.

9.0 Conclusion

If the role of food-crop based biofuels in meeting the U.K.'s renewable energy transport target is capped, the cost of scaling up other technologies in its place will be dependent on a range of factors, including the availability of renewable resources, financial and non-financial barriers that may hamper greater deployment, and the learning potential of specific technologies to reduce investment costs and subsidy levels. Given the complexity of factors affecting the ability to bring forward renewable energy technologies, this analysis does not recommend scaling up or substituting specific renewable technologies over others. However, in the context of binding EU targets for renewable energy use, it recommends that the U.K. government policy should support the use of low-carbon technologies that can deliver GHG savings up to and beyond 2020 targets.

9.1 Discussion

The U.K. biofuels market and regulatory framework have some notable points.

The U.K.'s uses a substantial amount of UCO for biodiesel production

RTFO reporting shows UCO was the dominant feedstock for biodiesel consumption, encouraged by a 20 ppl excise tax exemption that expired in March 2012, as well as double counting. In RTFO year 4 (2011/2012), UCO feedstock amounted to 800.4 million litres, which was 49.9 per cent of all feedstock. Relative to food-based biodiesel consumption, UCO provides a more sustainable feedstock in terms of indirect emissions—though there could still be a range of unintended outcomes from its use.

The U.K. and its Blending Target

The U.K. has no stated objectives to increase the blending mandates. The deceleration of the required blending levels was recommended by Gallagher's review and based on a position that the U.K. should proceed cautiously "until the evidence is clearer about the wider environmental and social effects of biofuels" (DfT, p. 7, 2009a). Changes to the investment framework are obviously a concern for investors who seek policies with transparency, longevity and certainty (Deutsche Bank, 2009); however, growing evidence of the impact of ILUC and emissions reductions has meant that governments such as the U.K. have applied the Precautionary Principle to target setting in order to avoid policies that may have a negative environmental impact.

9.2 Policy Recommendations

The recommendations that can be drawn from this study suggest that it is advisable for U.K. policy-makers, along with those at the national government level, to recognize the following:

- **Monitoring, and regularly publishing support figures for biofuels, as well as all forms of energy (including fossil fuels and nuclear), is important for improving the transparency of public policy-making.**
- **The U.K. government could consider improving its official government statistics on the number and types of jobs generated by the biofuels policies further,** in particular by disaggregating indirect and direct jobs created in U.K. This would provide better information on how many jobs within the U.K. economy had been created by the biofuels sector.
- **Biofuel blending targets are a significant intervention in the liquid fuels transport market,** and the U.K. government's current decision to maintain 5 per cent volumetric blending levels is a practical decision due to concerns over the impact of ILUC arising from biofeedstock production.
- **In terms of biofuel GHG emission accounting, if the U.K. government included ILUC as part of its accounting approach, it would be applying a precautionary approach,** and it would ensure that public money does not support biofuels that increase carbon dioxide emissions.
- **Biofuel support policies should differentiate between conventional and second-generation biofuels, bioethanol and biodiesel, and ideally between feedstocks** (such as UCO versus palm oil), given the varying environmental performance of fuels and production processes.

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Annex A: Breakdown of Biofuel Production Plants in the U.K.

COMPANY	LOCATION	CAPACITY (MILLION LITRES)	YEAR OF FIRST OPERATION	CAPEX (MILLION €)	TYPE
British Sugar	Wissington	70	2007	31	bioethanol
Ensus (Wilton)	Wilton	400	2009	372	bioethanol
Butamax - demo	Hull	189	2012	39	bioethanol
Solena/British Airways - 1st commercial	East London	0	2014	project	biodiesel
Greenenergy Immingham plant	Immingham	0.23	2006	28.4	biodiesel
Argent Energy Motherwell plant	Motherwell (Scotland)	50.94	2005	21	biodiesel
Harvest energy	SealSands, Middlesbrough	283	2006	56	biodiesel

Annex B: Research and Development for Advanced Biofuels

The European Union and Member States foster research and development activities in the field of biofuels through various programs; these programs are directed at research and development into advanced biofuels (in contrast to first-generation biofuels) from non-edible feedstocks such as wood and straw.

The European Commission-funded projects listed in the table below generally involve a consortium of organizations often spread across a large number of countries that share the total value of the project funding (often only a smaller portion of the overall project funding is directed to activities within a particular country, such as the U.K.).[32] U.K. government-funded projects will, however, have a U.K. focus.

TABLE B1: U.K.RELATED RESEARCH AND DEVELOPMENT PROJECTS FOR ADVANCED BIOFUELS

PROJECT NAME	DURATION	EU CONTRIBUTION (EUROS)	COORDINATOR	DESCRIPTION	SOURCE
SUSTOIL	06/2008-05/2010	992,197	University of Manchester	Develop advanced biorefinery schemes to convert whole EU oil-rich crops (rapeseed, olive and sunflower) into energy (fuels, power and heat), food and bioproducts.	http://cordis.europa.eu/projects/index.cfm?fuseaction=app.details&TXT=SUSTOIL&FRM=1&STP=10&SIC=&PGA=&CCY=&PCY=&SRC=&LNG=en&REF=87800
VALORGAS	03/2010-08/2013	3,485,462.00	University of Southhampton	Explores how energy potential can be realized through effective collection, pre-processing and optimization of the fuel conversion technology, and considers how integration of these aspects with improving conversion efficiencies.	http://cordis.europa.eu/projects/index.cfm?fuseaction=app.details&TXT=VALORGAS&FRM=1&STP=10&SIC=&PGA=&CCY=&PCY=&SRC=&LNG=en&REF=94057
INTESUSAL	05/2011-04/2015	5,000,000	National Renewable Energy Centre limited	Demonstrates an optimized approach to generate biofuels from algae in a sustainable manner on an industrial scale.	http://cordis.europa.eu/projects/index.cfm?fuseaction=app.details&TXT=INTESUSAL&FRM=1&STP=10&SIC=&PGA=&CCY=&PCY=&SRC=&LNG=en&REF=100473
SUPRA-BIO	02/2010-07/2013	12,318,163	University of Manchester	Focuses on innovative research and development of critical unit operations by improving the economic and sustainable production of fuels, chemicals and materials from biomass requires capture of the maximum energy and monetary value from sustainable feedstock.	http://cordis.europa.eu/projects/index.cfm?fuseaction=app.details&TXT=SUPRA-BIO&FRM=1&STP=10&SIC=&PGA=&CCY=&PCY=&SRC=&LNG=en&REF=94178
The Algae Biofuels Challenge	2008-2015	18,000,000	A range of organizations	The objective is to overcome barriers to the commercialization of microalgae biofuels.	http://www.ccap.ac.uk/documents/BPSJan2010_Carbon-Trust.pdf

[32] Research and development project funding can also be divided across non-biofuel related research activities involving energy or agricultural applications. In addition to the EC funding these projects receive financial contributions from the private sector.

GSI Global Subsidies Initiative

iisd International Institute for Sustainable Development
Institut international du développement durable

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