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Anticipated Indirect Land Use Change Associated with Expanded Use of Biofuels and Bioliquids in the EU – An Analysis of the National Renewable Energy Action Plans

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[2] This report was prepared by IEEP for Transport and Environment and partners

Summary

- This study represents a first analysis and estimate of the effects of Indirect Land Use Change (ILUC) associated with the increased use of conventional biofuels that EU Member States have planned for within their National Renewable Energy Action Plans (NREAPs). These documents specify how European governments plan to deliver their transport targets under the Renewable Energy Directive (RED). 23 NREAPs were available at the time of drafting and the analysis is based upon these. ILUC effects have been calculated using recently released studies by the European Commission.
- The RED target, for 10% of transport fuel to be from renewable sources by 2020, is anticipated to stimulate a major increase in the use of conventional biofuels up to 2020, contributing up to 92% of total predicted biofuel use or 24.3 Mtoe in 2020. This would represent 8.8% of the total energy in transport by 2020; 72% of this demand is anticipated to be met through the use of biodiesel and 28% from bioethanol.
- Member States are anticipating importing significant proportions of these fuels and their associated feedstocks. Figures reported equate to 50% of bioethanol and 41% of biodiesel in 2020. However, actual imported levels of feedstock are anticipated to be higher as it is unclear whether the imports anticipated by Member States refer to feedstock for 'domestic' processing into biofuels as well as imports of processed biofuels.
- Additionally Member States are estimated to be sourcing 4349 Ktoe of bioliquids from conventional feedstocks in 2020. Used for heating and electricity, these will have similar ILUC consequences as for biofuels representing an additional emission source of greenhouse gas emissions (GHG). ILUC impacts from these bioliquids are estimated to equate to an area of between 1 and 1.9 million ha and GHG emissions of between 211 and 400 MtCO2e.
- In 2020 15,047 Ktoe of the biofuels used would be additional to 2008 levels and sourced from conventional ie primarily food crop based feedstocks; this can be considered to be additional demand stimulated by the RED.
- Using currently available data, this additional demand for these fuels is anticipated to lead to between 4.1 and 6.9 million ha of ILUC ie an area equivalent to just larger than Belgium to just under that of the Republic of Ireland.
- This additional ILUC was calculated to result in between 44 and 73 million tonnes of CO2 equivalent (MtCO2e) on an annualised basis ie between 876 and 1459 MtCO2e in total.
- Under the RED biofuels must deliver a required level of GHG savings relative to fossil fuels to count towards the targets. Even when this saving is taken into account estimated additional GHG emissions arising from ILUC are between 273 and 564MtCO2e (for the period 2011 to 2020) or between 27 and 56 MtCO2e annually. The latter equates to up to 12% of emissions from EU agriculture in 2007 or 6% of total transport emissions. Put another way this would be equivalent to between 12 and 26 million additional cars on the road across Europe in 2020.
- Based on this assessment, and the assumptions adopted, use of additional conventional biofuels up to 2020 on the scale anticipated in the 23 NREAPs would lead to between 80.5% and 167% more GHG emissions than meeting the same need through fossil fuel use.
- This analysis was based on what were considered the most appropriate assumptions using the evidence and models available at the time of drafting. However, sensitivity analysis shows that even with far lower estimates of ILUC arising per unit of additional biofuel consumption and of GHG emissions per unit area of ILUC the use of conventional biofuels envisaged in the NREAPs fails to deliver the reduction in GHG emissions required under the RED, and leads to an increase in GHG emissions overall.
- This analysis underlines the need to address the question of ILUC as a priority for biofuels policy and to include ILUC in the criteria for assessing whether biofuels should count towards the delivery of targets under the RED for 2020, and more generally EU European climate change mitigation goals. Moreover, it also raises urgent questions about the appropriateness of projected levels of conventional biofuel use by Member States in 2020. Many have focused little effort in their NREAPs on promoting advanced biofuels or pursuing a greater efficiency in their transport sector so as to reduce the overall climate burden.

1. Introduction

The EU Renewable Energy Directive, RED, on the promotion of the use of energy from renewable sources[3] (Directive 2009/28/EC) is a powerful measure at the heart of European energy and climate policy. It sets out two targets aimed at the promotion of renewable energy. The first requires the delivery of 20% of total energy from renewable sources by 2020, with the level of effort differentiated across the Member States. The second specifically promotes the use of energy from renewable sources within the transport sector, requiring 10% of all transport fuels to be delivered from renewable sources by 2020 across every Member State. When the Directive was adopted, it was unclear precisely what technologies and approaches would be adopted by the Member States in order to deliver these targets. To reveal, open to scrutiny and monitoring, the national approaches to meeting these targets the RED also explicitly requires that each Member State produce a National Renewable Energy Action Plan (NREAP).

The NREAPs are critical to understanding the anticipated consequences associated with meeting the EU RED targets. As of mid October 2010 23 Member States[4] had submitted their NREAP to the Commission. ***This analysis represents a first attempt to analyse the data presented by the Member States to ascertain the characteristics of the demand generated by the targets in one important area: the anticipated use of biofuels***.

To deliver the RED transport target there are a number of potential technologies available to Member States:

- use of conventional, also known as first generation, biofuels;
- use of advanced biofuels, these are specified within the RED under Article 21.2 as those derived from wastes, residues, non-food cellulosic material, and ligno-cellulosic material and count double towards the delivery of the 2020 transport target;
- efficiency gains within the transport sector that reduce fuel needs, therefore, the overall quantity of renewable energy needed to meet the target; and
- the electrification of the transport system, utilising renewable electricity.

Meeting the RED target for transport, and also to a more limited extent the use of bioliquids in heating and electricity generation, is anticipated to increase the demand for conventional biofuel and bioliquid feedstocks[5]. Moreover the RED is an important element of the EU's efforts to reduce greenhouse gas (GHG) emissions. As a consequence the RED specifies sustainability criteria intended to both limit the consequences of direct land use change[6] associated with

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[3] Directive 2009/28/EC can be downloaded at http://www.energy.eu/directives/pro-re.pdf

[4] Austria, Bulgaria, Cyprus, Czech Republic, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden and the UK

[5] These include commodities such as oil seed crops including rape seed and soy, palm oil, wheat, maize, sugar cane and sugar beet.

[6] The RED specifies that biofuel feedstocks used to comply with the EU targets must not be grown on land that held certain environmentally sensitive characteristics after January 2008 ie that is considered highly biodiverse or a significant carbon store. Article 17 of the Directive specifies the land uses to be protected. As a consequence these land uses should be protected from being directly converted to feedstock production to meet expanded EU demand.

expanded demand for feedstocks and requires minimum (GHG) savings to be delivered by all biofuels and bioliquids used to meet the EU targets[7].

While the RED specifies mechanisms for dealing with direct land use change arising from the cultivation of feedstocks, it as yet fails to take into account indirect land use change (ILUC). ILUC is generated by the elevated demand for agricultural commodities as a consequence of biofuel consumption. When biofuels are grown on existing arable land, which will often be the case, ILUC can ensue elsewhere, either in the same country or in other parts of the world. This is because current demand for food and animal feed may well remain unchanged and cannot be assumed to fall. As a consequence pre-existing agricultural production can be displaced into new areas. This displacement will cause some new land to be brought into arable production possibly far from the area in which the biofuel feedstock is being grown, potentially impacting grasslands, forests or other natural habitats. ***The expansion in the area of cultivation leads to land use change, which is associated with significant GHG emissions as a consequence of the release of carbon locked up in soils and biomass. Moreover the expansion in cultivated area and more intensive use of agricultural land can pose a potentially significant threat to biodiversity globally.*** For the RED Directive to deliver the intended goal of contributing towards the EU's effort to combat climate change the additional GHG emissions from ILUC would need to be controlled, ensuring they are less than the savings in direct emission reductions delivered by biofuel use.

Given the information held in the NREAPs and ongoing work to determine the ILUC impacts associated with biofuel use in the EU, it is now possible to estimate the ILUC consequences associated with an individual Member State's biofuel demand driven by the 2020 targets. This paper presents the initial findings of such an analysis based on the 23 NREAPs published to date. The aim of this exercise is to help inform debate on ILUC and its consequences. This is intended to support the Commission's work on ILUC, given that a report and new potential proposals to take account of ILUC are scheduled to be published by the end of 2010 – as specified in the RED.

2. Methodological Approach

This assessment incorporated 5 key analytical steps set out in figure 1, below. These represent a process starting with the collation of data from the NREAPs and using published data and methodologies to establish an acceptable baseline for measuring the ILUC impact of expanded biofuel demand associated with the RED targets. These methods allowed the anticipated area of ILUC to be estimated along with the volume of associated GHG emissions. The primary data sources used within the assessment were as follows:

- NREAP information per Member State regarding the level of conventional and Article 21.2 biofuels to be used by 2020, bioliquid usage in 2020 and other transport related actions to deliver the RED targets[8];
- DG Energy data on 2008 usage of biofuels by Member State[9];

[7] The RED Article 17.2 requires that biofuels and bioliquids used to meet the EU targets or that are subsidised by Member States deliver a 35% GHG saving compared to the use of fossil fuels (this applies from December 2010 when the EU Directive must formally be transposed by the Member States). The required level of saving rises to 50% from 1 January 2017 and 60% from 1 January 2018 for fuels produced by installations that started production after January 2017.

[8] These can be downloaded at http://ec.europa.eu/energy/renewables/transparency_platform/action_plan_en.htm

[9] This is available at http://www.eurobserv-er.org/pdf/baro198.pdf

– Joint Research Centre (JRC) analysis reviewing ILUC modelling efforts and conclusions regarding potential ILUC impact in terms of land use change measured in hectares (ha) and associated GHG impact[10] (supported by analysis by other groups of ILUC impacts including that by Ecofys[11]);
– Data from the Intergovernmental Panel on Climate Change regarding GHG emissions from land use change[12];
– FAO data on area of agricultural and arable land in EU Member State[13];
– DG Energy data on GHG emissions per Member State in 2007 – both for transport and total GHG emissions (excluding international bunkers and LULUCF)[14];
– Data on anticipated fuel efficiency and car usage up to 2020[15]

Figure 1 – Outline of the methodological steps and approach used within this analysis

	Step	Approach
1	Collation of data from the existing NREAPs on biofuel demands per MS	Proportion of renewable energy in transport sector by 2020 Total demand – biofuels, bioethanol, biodiesel Demand for conventional vs advanced biofuels vs renewable electricity in transport Supply impact ie proportion of domestic vs imported biofuels to be used
2	Identification of increase in conventional biofuel use by 2020 attributable to the RED target	Assumed a basis of Jan 2008 for pre-RED demand for bioethanol and biodiesel Assumed that Jan 2008 usage is 100% conventional biofuels Increase = projected MS usage of bioethanol/biodiesel – 2008 levels
3	Identification of anticipated ILUC associated with the increase in biofuel use	ILUC = anticipated increase in level of bioethanol/biodiesel use by 2020 x ILUC conversion factor ie kHa change per kToe relevant fuel ILUC conversion factors based on parameters derived from JRC analysis of ILUC modelling – provides an upper and lower estimate – see annex regarding calculations for approach to determining ILUC parameters
4	Identifying the GHG emission consequences associated with ILUC	GHG impact = ILUC scale x GHG conversion factor ie tCO2e per kha GHG associated with land use change based on conclusions from the JRC study and estimates from IPCC – lower, central and upper values used to create a mean GHG volumes divided by 20 to provide an annualised level of emissions in line with the RED specification and emission savings associated with biofuel usage subtracted from the total to provide a picture of additional ILUC emissions by 2020.
5	Converting the ILUC estimates into meaningful proxies	Comparing the level of biofuel related ILUC for a single Member States with the total area of arable land in that MS Comparing the GHG impacts for a single Member State to their corresponding transport emissions and emissions from agriculture Calculating the impact in terms of additional cars on the road in 2020 based on additional GHG emissions associated with ILUC

10 European Commission, Joint Research Centre (JRC), Institute for Energy, 2010, Indirect Land Use Change from increased biofuels demand, Comparison of models and results for marginal biofuels production from different feedstocks, Robert Edwards, Declan Mulligan and Luisa Marelli

11 Ecofys, October 2009, Summary of approaches to accounting for indirect impacts of biofuel production, Stijn Cornelissen and Bart Dehue

12 For further details of their work see http://www.ipcc.ch/ipccreports/sres/land_use/index.php?idp=299

13 This can be downloaded at http://faostat.fao.org/

14 Available for download at http://ec.europa.eu/energy/publications/statistics/doc/2010_energy_transport_figures.pdf

15 Details on car usage set out in http://www.transportenvironment.org/Publications/prep_hand_out/lid/568 , details on car emissions determined in discussions with external experts

3. Delivering the 2020 Target

The 23 NREAPs indicate that by 2020 a total of 26 Mtoe (Million tonnes of oil equivalent) of biofuels will be being made use of by the relevant Member States. This represents ***9.5% of energy in transport within these Member States being sourced from biofuels in 2020***, taking account of energy efficiency gains anticipated. This compares to a total for usage of biofuels for all Member States of 10.2 Mtoe in 2008 or 9.4 Mtoe used in the relevant 23 Member States. ***The 2020 target is, therefore, anticipated to stimulate a major increase in the use of biofuels by 2020, with these remaining the primary technology for delivering renewable energy in the transport sector*** and delivering the RED 10% target.

Of this, the majority ie ***over 92% or 24.3 Mtoes of the biofuels utilised are anticipated to be conventional biofuels*** ie sourced primarily from agricultural feedstocks such as oil seeds, palm oil, sugar cane and beet, wheat, soy etc. This would represent 8.8% of the total energy used in transport by 2020. Advanced biofuels are anticipated to account only for 0.6% of total energy in transport by 2020 amounting to 1.7Mtoe by 2020 in the 23 Member States. It had been hoped that the bonus provided for in the RED for the use of advanced biofuels (ie that they count double towards the achievement of the 2020 target) might better stimulate their greater use. Despite this, however, it seems that production of large volumes of advanced biofuels will not be stimulated by the RED.

The anticipated scale of total biofuel use and the selective use of advanced biofuels by Member States is highly varied given the huge differences in the size and make up of national transport sectors. For example Germany is anticipated to use by far the highest volumes of biofuels in 2020, followed by the UK, France, Spain and Italy. This high user group is anticipated to account for a total of 19.5 Mtoe of biofuel by 2020 – see figure 2. All other Member States are each anticipating using less than 1 Mtoe biofuel by 2020.

In terms of use of advanced biofuels, Cyprus states that all its biofuels will be sourced from this group by 2020 while Denmark anticipates using primarily conventional biodiesel but only advanced bioethanol sources. Meanwhile others, including some major users, such as Austria, Greece, Lithuania, Luxembourg, Slovenia and the UK anticipate 100% use of conventional biofuels in 2020. The largest user by volume of advanced biofuels in 2020 is anticipated to be Italy (400 Ktoe ie thousand tonnes of oil equivalent), followed by Spain, France, Finland, Germany and the Netherlands. Advanced biodiesel based fuels are anticipated to account for almost double that of advanced bioethanol (1022 versus 539Ktoe respectively[16]). Figure 2 presents the total projected usage of biofuels split between conventional and advanced biofuels, demonstrating the contrast in volumes. Figure 3 presents the overall percentage use of conventional biofuels by Member State with the proportion standing at over 80 per cent in the great majority.

[16] It should be noted that Romania did not provide details of the break down of biofuel usage within its NREAP hence total figures for advanced biofuel usage different slightly from the breakdown between biodiesel and bioethanol.

Figure 2 – Member State Usage of Biofuels in 2020 based on NREAP figures – comparing total volume usage of conventional and advanced biofuels

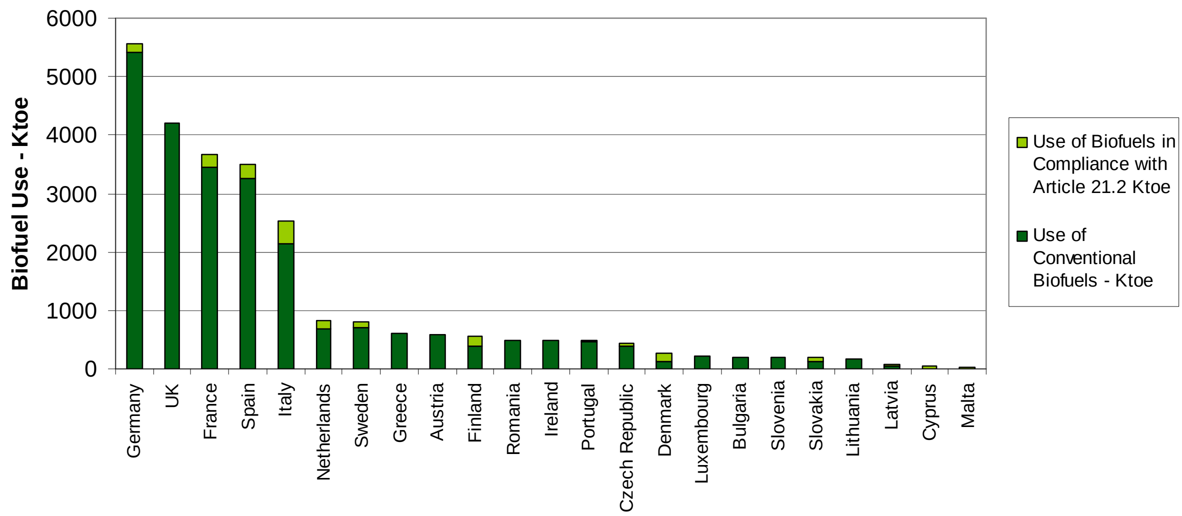
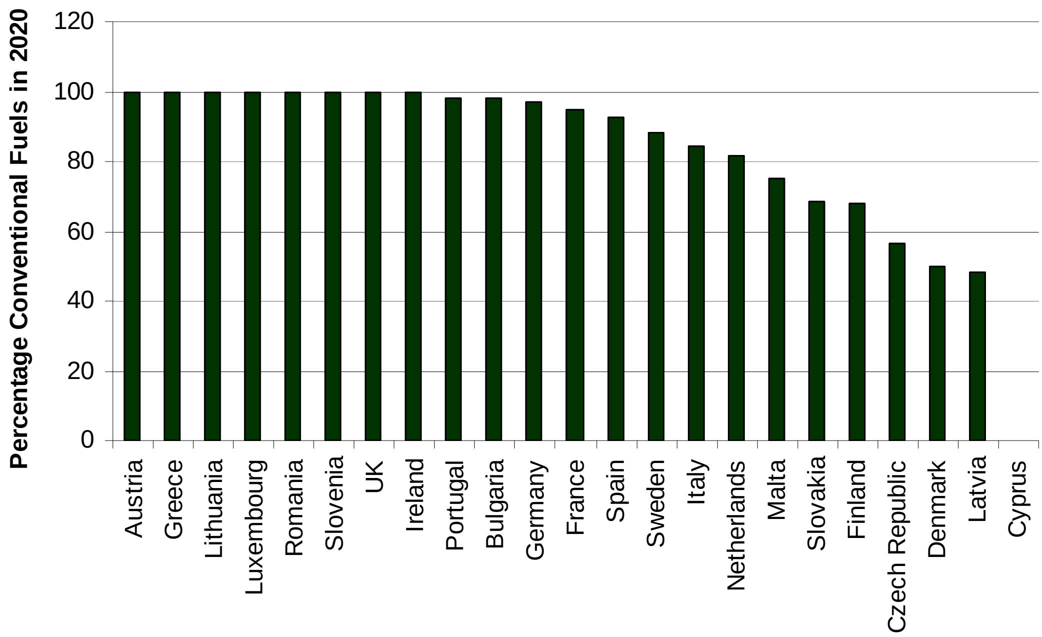


Figure 3 – Percentage of biofuel use anticipated to be from conventional biofuels by 2020

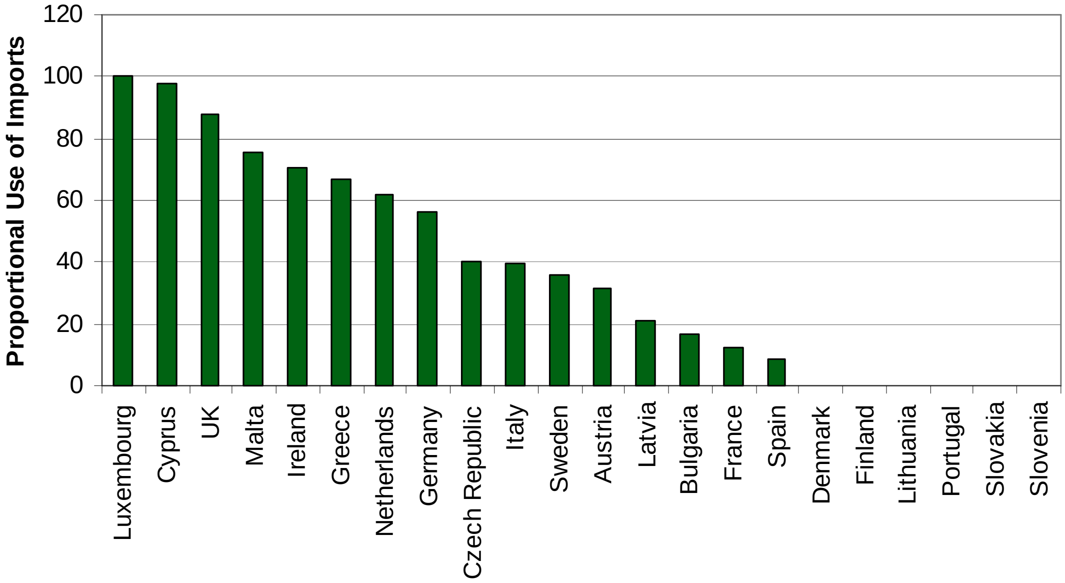


There is much higher usage of biodiesel anticipated in 2020 than bioethanol; 72% of biofuels are anticipated to be sourced from biodiesel. In total 18.9 Mtoe of biodiesel are anticipated to be consumed in 2020 compared to 6.2 Mtoe of bioethanol. Only Sweden anticipates making use of over 50% bioethanol in 2020; by contrast Slovenia and Luxembourg would be utilising approximately 90% biodiesel.

In 2020 Member States are certainly not all anticipating to be sourcing their biofuels domestically with ***many relying on a high proportion of imports*** to secure biofuel supplies. On average the 23 Member States are anticipating importing 50% of bioethanol and 41% of biodiesel in 2020, equating to 3.1 and 7.7 Mtoe respectively. The reliance on imports and the total volumes involved varies significantly across the Member States, with imports accounting for between 100% and 0% of biofuels depending on the country. It should, however, be noted that it is unclear from many of the NREAPs whether the figures for imports relate explicitly to the importing of all materials to be used as biofuels in 2020 into the country concerned ie whether they include both raw feedstocks for conversion to biofuels in country and pre-processed biofuels or whether they relate only to pre-processed biofuels. Examining the figures it is considered that a mixture of approaches to this calculation has been applied by national governments. Therefore, overall levels of imports related to biofuel consumption may higher than reported. Imports relate to levels entering the market in that particular Member State, therefore, probably include exports from other EU countries.

The UK is anticipated to be importing by far the largest quantities of bioethanol in 2020, anticipating use of 1.5 Mtoe of imported bioethanol or 81% of its total bioethanol usage; levels of imports of bioethanol by all other Member States lie below 450Ktoe. Germany and the UK anticipate significantly greater volumes of biodiesel imports than other Member States, 2.9 and 2.2 Mtoe respectively or 64 and 91% of their biodiesel usage. ***In total the UK is expected to be the highest importer of biofuels by volume utilising 3.7 Mtoe of imported biofuels in 2020.*** Figure 4 presents the anticipated reliance on imports of biofuels per Member State in percentage terms.

Figure 4 – Reported reliance of the Member States on the imports of Biofuels to Meet Demand in 2020



*It should be noted that Romania did not report the breakdown between different biofuel sourcing and usage within the NREAP therefore they are excluded from this figure.

Liquid fuels from biomass can also be used in stationary energy sources, such as diesel generators or space heaters replacing fossil fuels to provide heat and power. These bioliquids would be anticipated to be sourced in the same manner to biofuels and are subject to the same sustainability criteria under the RED. For those countries utilising bioliquids this would result in impacts additional to those associated with transport demand. Consequently, bioliquids should also be considered in any ILUC assessment for biofuels and also within policies designed to alleviate this. The scale of additional impact associated with bioliquids is discussed in section 8 of this report. ***Within their NREAPs only eight of the 23 Member States explicitly specified that they anticipate making use of bioliquids within these stationary sources, generating an additional demand for 5,462Ktoe primarily associated with heating*** - anticipated usage by Member State is presented within Table 1. Additionally the UK noted in their NREAP that they have yet to determine levels of bioliquid usage.

Table 1 – Anticipated use of bioliquids in heating and electricity supply

Member State	Total bioliquids in stationary sources – Ktoe by 2020
Austria	3
Denmark	9
Finland	3021
Germany	836
Italy	568
Portugal	932
Slovenia	28
Sweden	65
Total	5,462

4. Anticipated Increase in Biofuel Usage Associated with the RED

To assess the ILUC impacts associated with the increase in biofuels use generated by the RED it is necessary to understand the baseline usage of biofuels prior to the Directive coming into force. Within this analysis the baseline usage of biofuels is assumed to be equivalent to total consumption in 2008, based on data reported in the Eurobserver. This baseline is equivalent to others used within the RED to determine the limit of its influence. The additional biofuel demand generated by the RED would, therefore, be the difference between 2008 figures and predicted figures for 2020.

At present ILUC assessments have only been completed to assess the impact of conventional biofuels. ***While it is noted that advanced biofuels, especially those based on lingo cellulosic technologies or non-food crops will also place demand on land it is not currently possible to appropriately estimate their impact with much accuracy***. As a consequence this assessment of the increase in biofuel consumption is confined to the anticipated rise in the consumption of conventional biofuels up to 2020. Given the limited market penetration of advanced biofuels in 2008 it is assumed that all biofuel usage in that year was conventional. For the purpose of this analysis the increase in conventional fuel use associated with the RED is, therefore, total EU 2020 biofuel consumption less total 2008 biofuel use and minus any use of advanced biofuels in 2020. The uncertain impacts of advanced biofuels, which will be responsible for some additional ILUC, are thus set aside.

Based on the data specified in the NREAPs by ***2020 total additional usage of conventional biofuels is calculated to be 15.1 Mtoe, with a split of 72% new biodiesel demand and 28% new bioethanol demand***. While the UK will not be the highest user of biofuels in 2020, it foresees the greatest increase in conventional biofuel use due to the relatively low 2008 baseline, the lack of use of advanced biofuels and low assumptions regarding energy efficiency in the transport sector by 2020. Germany, while the largest overall user of biofuels in 2020 drops to third place in the ranking of additional demand due to the relatively high 2008 baseline and the inclusion of advanced biofuels and higher levels of other renewable energy sources in the transport mix in 2020. Amongst the 23 Member States reviewed ***the UK, Spain, Germany, Italy and France account for 72% of the additional biofuel demand between 2008 and 2020***.

Table 2 – Increase in conventional biofuel usage anticipated as a consequence of the RED, between 2008 and 2020

Country	Increase in Bioethanol Usage, 2008 to 2020 (Ktoe)	Increase in Biodiesel Usage, 2008 to 2020 (Ktoe)	Increase in Biofuels Usage, 2008 to 2020 (Ktoe)
UK	1640	1764	3403
Spain	255	2380	2635
Germany	396	1963	2360
Italy	442	972	1414
France	160	916	1076
Greece	414	136	550
Czech Republic	66	396	462
Ireland	121	304	425
Netherlands	143	252	394
Sweden	250	123	373
Romania	140	228	366
Portugal	27	313	340
Finland	26	280	306
Bulgaria	42	150	192
Luxembourg	22	150	172
Slovenia	17	154	171
*Denmark	-5	130	125
Lithuania	20	85	106
Austria	25	79	104
Slovakia	43	22	65
Latvia	0	11	11
Malta	6	3	9
*Cyprus	0	-14	-14
Total	4250	10797	15047

*Cyprus and Denmark show negative figures as they anticipate making use of a high proportion of advanced biofuels by 2020. Given that it is not possible to take account of the impacts of these fuels at present these negative figures were excluded from further analysis.

** It should be noted that in their NREAP Romania did not report the split between different biofuel uses in 2020, in order to enable further calculations the total figure for Romanian biofuel usage was differentiated between bioethanol and biodiesel sources based on the average split across all other Member States.

5. Calculating Indirect Land Use Change

To convert the increase in biofuel demand generated by the RED into an approximation of ILUC impact it is necessary to apply a conversion factor predicting the anticipated extent of ILUC in terms of area change per unit of additional biofuel consumed. There are a number of economic models that have been developed to estimate the impact of a marginal increase in biofuel production. A comparative analysis of the outputs of these models has been undertaken by the Joint Research Council (JRC)[10]. The JRC analysis presents a range of potential factors that could be used to convert estimates of biofuel consumption into estimates of associated land use change and enables these to be compared and contrasted. For the purposes of this study the comparative analysis completed by the JRC has been used as a basis for determining robust ILUC conversion factors, which have been applied using upper and lower bounds.

While the scenarios specified within the JRC study as a basis for modelling efforts are not perfectly tailored to the anticipated fuel mix in 2020, they provide the best available proxy for converting a given volume of biofuel use to anticipated area of associated ILUC. Clearly this can be achieved only at an aggregated level. The assumptions in the different models have an important influence on the resulting outcomes. To ensure the overall rigour of this exercise and that the model results and conversion factors were appropriately applied, we consulted a number of experts within the field and examined in detail the model assumptions to develop the best set of conversion factors for this analysis.

The ILUC conversion factors used within this assessment are presented in table 3. A summary of the logic behind the determination of these factors is presented in the Annex of this report, calculations. Lower and upper bounds were used in the analysis to take account of the differences in outcomes associated with variable modelling assumptions and consequent outputs. The ILUC conversion factors are multiplied by the anticipated additional usage of conventional bioethanol and biodiesel in 2020 to provide an estimated area in hectares of the potential ILUC.

Table 3 – ILUC conversion factors, expressed as thousand hectares of ILUC resulting from 1 Ktoe of additional biofuel consumption.

Fuel	ILUC conversion factor; 1000 ha per Ktoe	
	Lower	Upper
Bioethanol	0.39	0.52
Biodiesel	0.23	0.44

It should be noted that the factors derived represent relatively conservative estimates of ILUC based on the JRC analysis and are likely to underestimate real GHG impacts associated with the expanded agricultural production arising from ILUC. This is a consequence of the assumptions used within the modelling exercises. In particular the majority of models assume higher levels of yields than are likely to be realised on land that is drawn into arable production at the frontiers of cultivation. The JRC study also notes that the mix of feedstocks used in the production of biodiesel in some cases over estimates anticipated yield increases expected in the palm oil sector. Moreover, as noted above, advanced biofuels and bioliquids will also have a land use impact additional to those arising from conventional biofuels, which it is not possible to take into account here. Finally, the calculations of GHG impacts associated with ILUC, and more generally with increased biofuel demand, are likely to inherently underestimate GHG emissions, as noted below.

Estimates for emissions associated with ILUC only take into account the one-off release of GHGs associated with the change of one land use to another. As such they do not take account of the following additional sources of GHG emissions that would be associated with expanded and more intensified cultivation of crops:

- there is no allowance made for any sequestration forgone into the longer term by removal of a previous land cover, which might be significant in the case for example of young growth forest converted to arable;
- estimates for ILUC often do not take into account that much land brought into arable use will likely be less suited to cultivation than the existing area and therefore give lower yields for a given level of inputs, hence emissions from cultivation may be higher than the average; and
- all the ILUC models assume in addition to land use change a certain proportion of intensification of existing agricultural production, which in turn is anticipated to lead to higher GHG emissions per tonne of crop harvested. This would, for example, be associated with use of nitrogen rich fertilisers or loss of soil organic matter during ongoing cultivation.

6. Anticipated Indirect Land Use Change – the Size of the Challenge

The ILUC impacts attributable to additional conventional biofuel usage by 2020 in all 23 Member States assessed within this study are between 4.1 and 6.9 million ha. At the lower end this would be approximately equivalent to land use changing across the total area of arable land[17] in Hungary or double that in Denmark, Finland or Lithuania; or at the upper end would be equivalent to doubling the total area of arable land in the UK or a 50% increase in arable land in either Poland or Spain[18]. This would also equate to at the lower end an area slightly larger than Belgium or just smaller than the Netherlands and at the upper end an area slightly larger than Latvia or Lithuania[19] and just under that of Republic of Ireland. Another way of putting this would be that this is the same area as between 82% and 138% of land used for palm oil production in Indonesia during 2008[20].

Table 4 presents the ILUC estimates arising from projected biofuel usage per Member State. It should be noted that this land use change is unlikely to take place in the country in question but will impact either within or beyond Europe, with the nature of this determined by the feedstocks used; as a consequence this represents a significant European footprint across the globe. To continue the comparison with the area of palm oil production in Indonesia, ***at the upper end of the estimates, the UK, Spain and Germany would each be responsible for an ILUC impact that was equivalent to more than 20% of land currently used for Indonesian palm oil production***.

To provide a sense of scale of the anticipated ILUC impact figure 5 compares the anticipated change associated with a Member State's consumption of conventional biofuels to the area of arable land in use within that Member State. In this respect the proportionate ILUC impact is highest in those Member States with limited area of arable land per capita ie effectively those characterised by denser development patterns and higher per capita transport needs. ***The UK, Slovenia, Malta and Luxembourg would all be responsible for ILUC (at the upper level) equivalent to more than 20% of their own arable land area***.

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17 Arable land is defined by the Food and Agriculture Organization of the United Nations (FAO) as: land under temporary agricultural crops (multiple-cropped areas are counted only once), temporary meadows for mowing or pasture, land under market and kitchen gardens and land temporarily fallow (less than five years). The abandoned land resulting from shifting cultivation is not included in this category. Data for "Arable land" are not meant to indicate the amount of land that is potentially cultivable - this is a wider category under the FAO statistics, called agricultural land.

18 Based on data for 2007 from the FAO

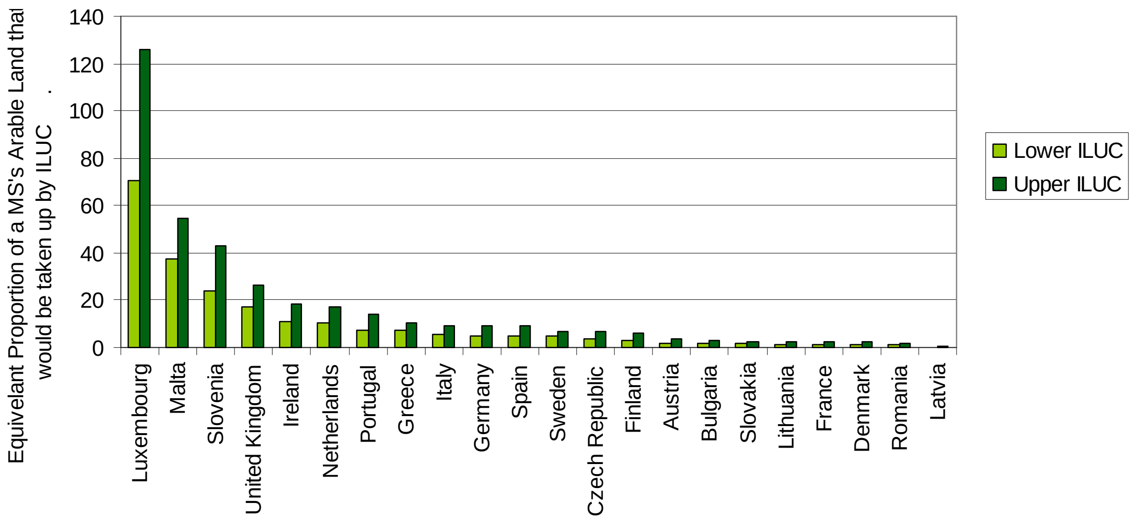
19 Based on Eurostat data from 2004 regarding country area.

20 Based on figures for production in 2008 from the FAO - http://faostat.fao.org/site/567/DesktopDefault.aspx?PageID=567#ancor

Table 4 – Estimated ILUC per Member State associated with increased demand for conventional biofuels between 2008 and 2020.

	Lower estimate of total ILUC - 1000 ha	Upper estimate of total ILUC - 1000 ha
United Kingdom	1044	1615
Spain	647	1167
Germany	606	1059
Italy	395	651
France	273	481
Greece	192	273
Sweden	126	183
Ireland	117	195
Czech Republic	117	206
Netherlands	113	183
Romania	107	172
Portugal	83	150
Finland	74	135
Bulgaria	51	87
Luxembourg	43	77
Slovenia	42	76
Denmark	30	56
Austria	28	48
Lithuania	28	48
Slovakia	22	32
Malta	3	4
Latvia	3	5
Total	4143	6902

Figure 5 – Estimate of Member States' proportionate ILUC impact – comparing the area of ILUC from conventional biofuels to the area of arable land available in each Member State.



7. Indirect Land Use Change – The GHG Consequences

GHG emissions associated with land use change are the consequence of a loss of carbon from soils and pre-existing biomass. They represent a one-off 'hit' of emissions associated with that land's change in status. It is these emissions that are estimated here, based on the anticipated level of ILUC calculated above. To convert land use change into consequent GHG emissions a conversion factor must be applied. The level of GHG emissions associated with land use change will vary depending on prior land use; therefore, there is a wide range of possible conversion factors. To take this into account emission levels were calculated based on three different factors utilised in other similar assessments[21].

Table 5 – The range of default values used to convert land use change in ha to GHG emissions

Default values for land conversion - GHG impact		
Lower (based on IPCC lower default value for conversion to cropland)	38	tC/ha
Central (adopted by JRC as a basis for its calculation)	40	tC/ha
Upper (based on IPCC upper default value for conversion to cropland)	95	tC/ha

For simplicity the figures presented within the rest of this section represent a mean of the values gained from applying all three conversion factors – in essence equivalent to 57 tC/ha[22]. This is justified given that in reality a number of different land types will be converted as a consequence of ILUC. Using this assumption, table 6 presents the average total GHG emissions resulting from ILUC as a consequence of the anticipated increase in biofuel use up to 2020. As this is a one off emission of GHGs associated with the change in land use it has been converted to annualised emissions, based on the 20 year time horizon specified in the RED. For total ILUC associated with biofuel use within the 23 Member States the ***annualised emissions are between 44 and 73 Million tonnes of CO2 equivalent. At the upper end this is the equivalent to the total GHG emissions generated by either Bulgaria or Hungary in 2007. Put another way this would represent just under 16% of emissions from the EU's agricultural sector or just over 7% of total EU transport emissions in 2007.***

[21] It is noted that there are conversion factors that sit above and below the levels specified in table 6. The range proposed is considered the most appropriate for conversion to croplands.

[22] Using the figures set out in Decision 2010/335/EU on guidelines for the calculation of land carbon stocks for the purpose of Annex V to Directive 2009/28/EC - http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:151:0019:0041:EN:PDF this mean would be broadly akin to the conversion of sustainably managed grassland to use for annual cropping under a normal system of tillage under a dry, temperate climate – with a level of 53.3tC/ha calculated for this conversion in worked examples by Ecofys http://ec.europa.eu/energy/renewables/biofuels/doc/ecofys_report_annotated_example_carbon_stock_calculation.pdf

Table 6 – Total ILUC related GHG emissions based on the mean values for land conversion – The table presents the totals per Member State in terms of ILUC emissions to deliver the additional volume of biofuels by 2020 specified in the 23 NREAPs and the annualised GHG emissions per year per Member State, based on a 20 year time horizon (as specified in the RED). @@@

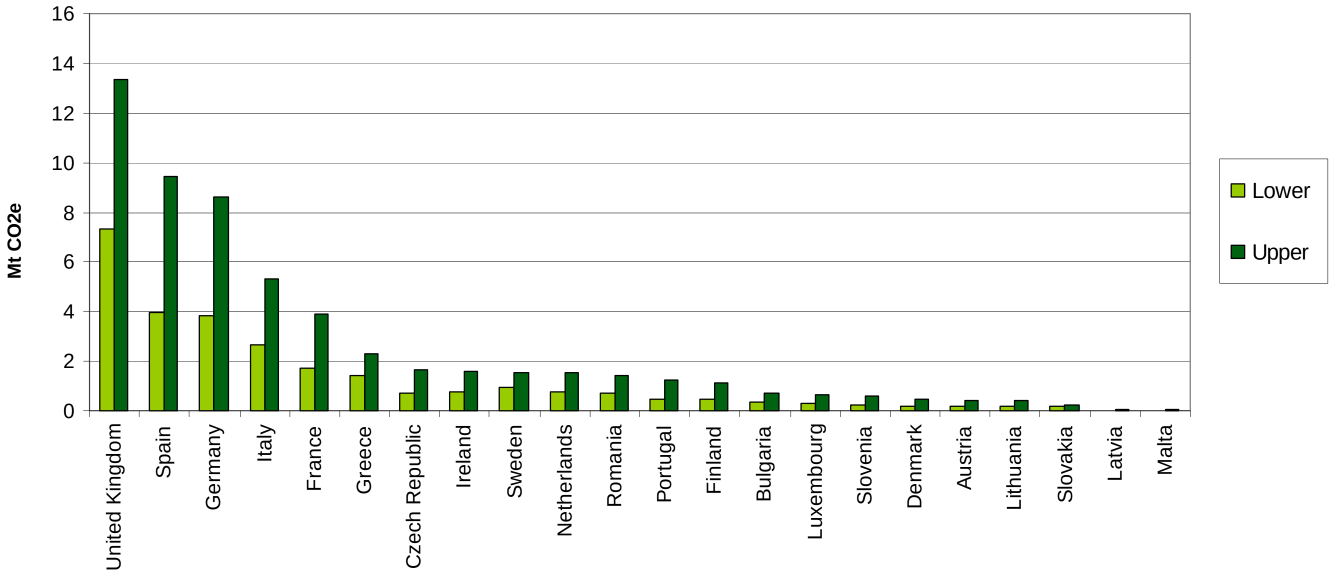
	Total GHG emissions associated with ILUC from additional biofuel use in 2020		Annualised emissions associated with total ILUC	
	Lower ILUC; Mt CO2e	Upper ILUC; Mt CO2e	Lower ILUC; Mt CO2e	Upper ILUC; Mt CO2e
United Kingdom	220.71	341.39	11.04	17.07
Spain	136.71	246.75	6.84	12.34
Germany	128.10	223.89	6.40	11.19
Italy	83.62	137.66	4.18	6.88
France	57.72	101.74	2.89	5.09
Greece	40.66	57.71	2.03	2.89
Czech Republic	24.69	43.64	1.23	2.18
Ireland	24.75	41.20	1.24	2.06
Netherlands	23.99	38.76	1.20	1.94
Sweden	26.56	38.64	1.33	1.93
Romania	22.61	36.27	1.13	1.81
Portugal	17.45	31.75	0.87	1.59
Finland	15.73	28.57	0.79	1.43
Bulgaria	10.76	18.41	0.54	0.92
Luxembourg	9.12	16.23	0.46	0.81
Slovenia	8.89	16.02	0.44	0.80
Denmark	6.31	11.93	0.32	0.60
Lithuania	5.82	10.07	0.29	0.50
Austria	5.93	10.05	0.30	0.50
Slovakia	4.61	6.72	0.23	0.34
Latvia	0.53	1.01	0.03	0.05
Malta	0.63	0.92	0.03	0.05
Total	876	1459	44	73

To qualify towards the delivery of the RED targets, biofuels must deliver a certain proportion of GHG savings, which rises from 35% in 2011 to 50% by 2017. For the purpose of this exercise, it is assumed that biofuels consumed in response to the RED conform to these criteria, aside from their ILUC impact. To understand the overall consequences for emissions associated with additional biofuel usage stimulated by the RED targets this GHG benefit must, therefore, be subtracted from the emissions associated with ILUC[23].

[23] The GHG savings were calculated by assuming a linear increase from 2008 to 2020 in terms of the volume of biofuel usage per year per Member State. The volume of usage in 2008 was then subtracted from this to provide a figure of additional use associated with the RED comparable to the ILUC figure. The additional usage per year was then multiplied by the GHG emission reductions required under the RED for that given year, this reduction was based on the assumption of a linear increase in reductions from 2011 at 35% to 50% in 2017, additional savings were then assumed at the same rate up to 56% in 2020. The GHG emission reductions are based on the savings specified in the RED and the assumptions specified within the Annexes of the RED that fossil based petrol and diesel generate 43 MJ/kg of energy and that for each MJ 83.8gCO2e are released. As the RED only specifies reductions in emissions from 2011 onwards, meaning it is unclear the level of reduction in 2008-2010. As a consequence this calculation of additional emissions was only applied to 2011 to 2020.

When account is taken of biofuels anticipated GHG savings from switching from fossil fuels to biofuels between 2011 and 2020[24] (the dates specified in the RED) total additional emissions from ILUC associated with the increased use of biofuels are still anticipated to range from 273 and 565 MtCO2e or between 2.9 and 6 gCO2e/kgoe. This effectively represents emissions that would be additional to those arising were Europe to remain reliant on fossil fuels to provide for our transport needs up to 2020. This equates to additional GHG emissions of between 27.3 and 56.5 MtCO2e on an annualised basis[25]. At the upper end this is comparable to just over 12% of emissions from agriculture in the EU in 2007 or just under 6% of emissions from transport in the EU in 2007. Put another way, the additional GHG emissions associated with ILUC up to 2020 would amount to the equivalent of placing between 12.4 and 25.6 Million additional cars on the road across Europe in 2020[26]. Based on the assumptions set out in this study the additional emissions from ILUC, associated with the predicted increase in conventional biofuels use within the 23 Member States up to 2020, can be estimated to lead to between 80.5 and 166.5% more GHG emissions than if that same fuel need were met using fossil fuels ie diesel and petrol[27].

Figure 6 – Additional GHG emissions anticipated as a consequence of ILUC associated with the expansion in biofuel demand up to 2020 – these represent emissions over and above what would be expected if fossil fuels were to continue to account for these quantities of transport fuels given that GHG savings associated with biofuel use have been subtracted.



24 Both ILUC emissions and the emissions saved were based on the additional usage of biofuels above the 2008 baseline up to 2020.

25 Annualised figures based on the 20 year discounting period specified in the RED for land use change were used in order to provide the 2011 to 2020 figures – see footnote 22. To provide the annualised data in this instance it is, therefore, appropriate to divide the total ILUC figure up to 2020 by the number of years between 2011 and 2020 to avoid double counting of this reduction.

26 The number of additional cars on the road is calculated by dividing the additional GHG emissions from ILUC on an annualised basis by the estimated level of emissions per car in 2020. The latter is calculated based on the assumption that on average cars will produce 170gCO2e/km in 2020 and will travel on average 13,000km per year. This equates to 2.21tCO2e per car per year. These calculations are based on established scenarios for future car use in Europe.

27 This calculation is based on the standard default values for fossil fuels in the RED, Annex III.

Table 7 – Comparing the additional annualised GHG emissions as a consequence of ILUC due to expanded use of biofuels up to 2020 by Member State and the number of additional cars on the road these figures would equate to in 2020.

	Annualised emissions from additional ILUC		Additional million cars on the road in 2020	
	Lower ILUC; Mt CO2e	Upper ILUC; Mt CO2e	Lower	Upper
United Kingdom	7.31	13.34	3.31	6.04
Spain	3.95	9.45	1.79	4.28
Germany	3.82	8.61	1.73	3.90
Italy	2.63	5.34	1.19	2.41
France	1.71	3.91	0.77	1.77
Greece	1.43	2.28	0.65	1.03
Czech Republic	0.73	1.68	0.33	0.76
Ireland	0.77	1.59	0.35	0.72
Sweden	0.92	1.52	0.42	0.69
Netherlands	0.77	1.51	0.35	0.68
Romania	0.73	1.41	0.33	0.64
Portugal	0.50	1.22	0.23	0.55
Finland	0.45	1.09	0.20	0.49
Bulgaria	0.33	0.71	0.15	0.32
Luxembourg	0.27	0.62	0.12	0.28
Slovenia	0.26	0.61	0.12	0.28
Denmark	0.18	0.46	0.08	0.21
Austria	0.18	0.39	0.08	0.18
Lithuania	0.18	0.39	0.08	0.18
Slovakia	0.16	0.26	0.07	0.12
Latvia	0.01	0.04	0.01	0.02
Malta	0.02	0.04	0.01	0.02
Total	27	56	12	26

Figure 7 –The proportion of 2007 GHG emissions from transport that would be accounted for by the annualised, additional emissions from ILUC. The Member State figures are compared to the overall value for the 23 Member States reviewed to provide a basis for comparison. The position of a Member State will depend on both the level of ILUC associated emissions and the scale of transport emissions in 2007.

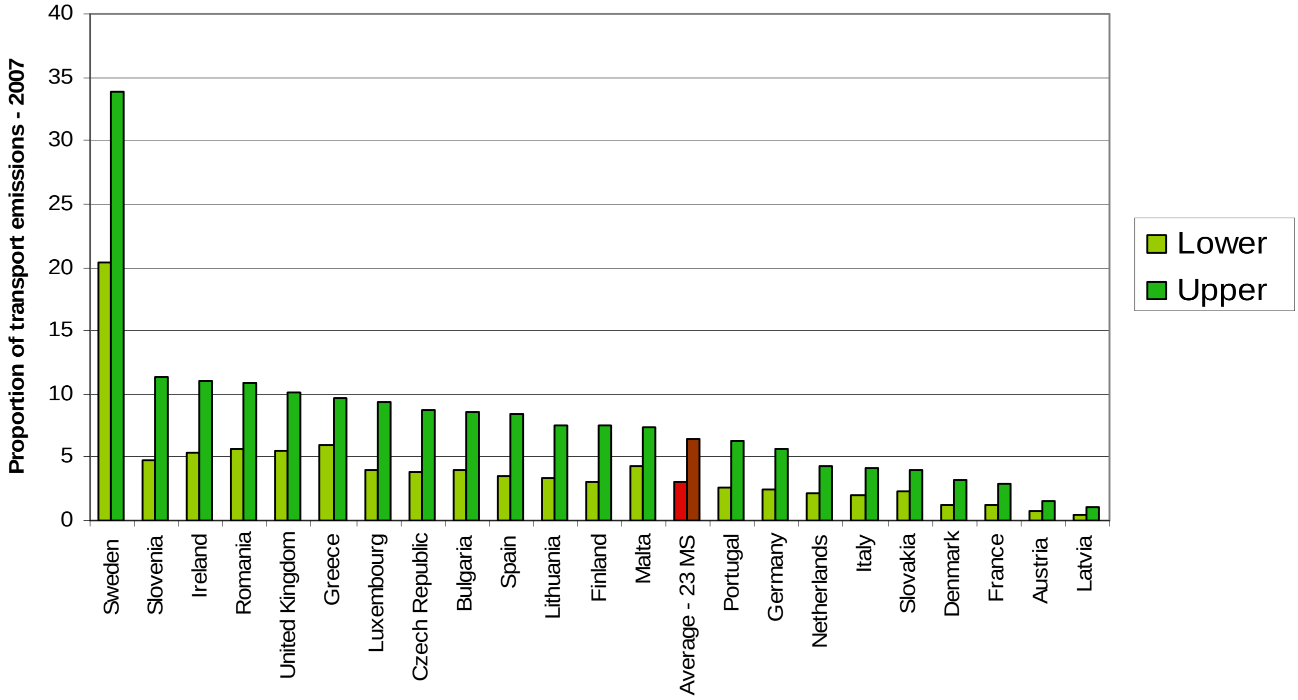
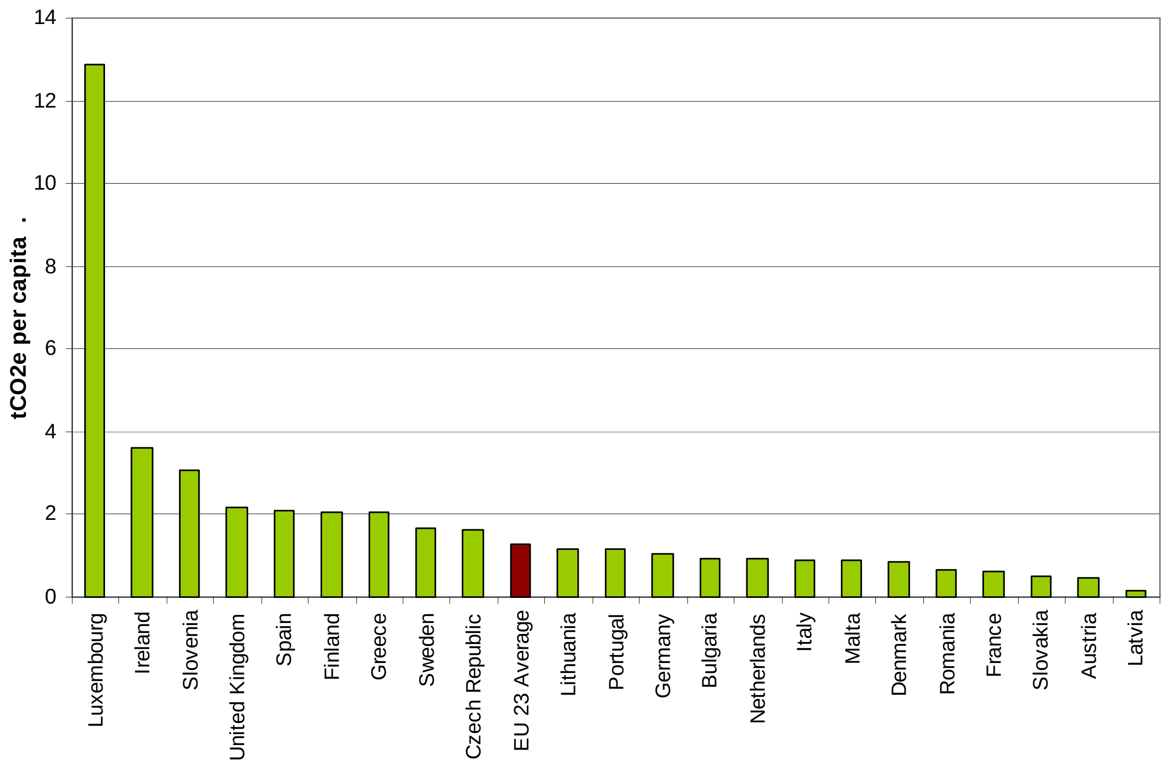


Figure 8 – The per capita CO2 emissions associated with additional ILUC emissions per Member State based on the upper estimates of additional ILUC emissions. This graph demonstrates which Member States are above and below the overall average for the 23 countries reviewed in terms of per capita impact. It demonstrates the intensity of a populations ILUC GHG impact.



8. Assessing the Total Impact including Bioliquids

Eight of the 23 NREAPs available specify that the relevant Member State will make use of bioliquids for heat and power as well as biofuels for transport in 2020 (additionally the UK specifies that it has yet to determine anticipated bioliquid usage). Given that bioliquids are in essence the same product as biofuels, albeit utilised in a different way, and that they are subject to the same rules under the RED the impact of their use alongside biofuels will have a cumulative impact in terms of land use change and more specifically ILUC. This section examines briefly the additional ILUC impact anticipated to be associated with bioliquid use in 2020.

In total the additional use of conventionally produced bioliquids from the eight Member States is estimated to be 4350 Ktoe. Member States were not required to specify the split of bioliquid use between conventional and advanced biofuels, therefore, this figure was calculated using the same proportional usage of conventionally produced bioliquids as was reported for biofuels. This is appropriate given that the sourcing from biofuels and bioliquids is likely to be from the same material streams. ***In total the additional demand for bioliquids would be equivalent to 28% of the total demand for conventional biofuels in 2020***. The majority of this material is anticipated to be made use of by Finland and Portugal. The usage of bioliquids in these Member States is anticipated to be far greater than for conventional biofuels in 2020 – see table 10.

Given the more limited data provided on bioliquid use in the NREAPs, compared to biofuel use, it was necessary to make two assumptions to enable ILUC to be calculated. These were: firstly that bioliquids would be made up entirely of biodiesel in 2020; and secondly that no bioliquids are in use at present for heating and electricity - as there is no comparable baseline data. Based on applying the same conversion factors as for biofuels the following estimates for the area of ILUC and GHG emissions associated with bioliquids were made.

Bioliquids are anticipated to result in an additional area of ILUC between 1000 and 1892 thousand ha, contributing between 211 and 399 million tonnes of additional CO2e - see tables 11 and 12. In total biofuels are anticipated to lead to emissions between 875 and 1459 MtCO2e – based on figures unadjusted for GHG savings. ***Cumulatively, biofuels and bioliquids combined would lead to emission levels of between 1087 and 1858 MtCO2e by 2020.***

Table 10 - Calculating the usage of bioliquids from conventional feedstocks in 2020 based on the proportion of convention biofuel use in the relevant Member State and comparing the scale of usage of bioliquids to biofuels in 2020.

Member State	% conventional biofuel use in 2020	Use of conventional bioliquids in stationary sources in 2020; Ktoe	Additional use of conventional biofuels in 2020 compared to 2008 - Ktoe	Comparing the impact of bioliquids to biofuels; conventional bioliquid use as a percentage of conventional biofuels use in 2020.
Finland	68	2050	306	670%
Portugal	98	916	340	269%
Germany	97	812	2360	34%
Italy	84	478	1414	33%
Sweden	88	57	373	15%
Slovenia	100	28	171	16%

Denmark	50	4	125	3%
Austria	100	3	105	2%
Total		4350	15046	28%

Table 11 – The table sets out the total area of ILUC anticipated to be caused by the use of bioliquids as specified in the NREAPs

	Kha land converted	
Member State	Lower	Upper
Finland	472	892
Portugal	211	399
Germany	187	353
Italy	110	208
Sweden	13	25
Slovenia	6	12
Denmark	1	2
Austria	1	1
Total	1000	1892

Table 12 – Presents the additional GHG emissions anticipated as a consequence of ILUC associated with bioliquids, this is compared to the unadjusted levels of ILUC anticipated from biofuels with a revised total present as to the cumulative GHG impacts of both biofuels and bioliquids.

	GHG emissions from ILUC associated with bioliquids – MtCO2e		GHG emissions from ILUC associated with biofuels – MtCO2e		Total GHG emissions from both biofuels and bioliquids - MtCO2e	
Member State	Lower	Upper	Lower	Upper	Lower	Upper
Finland	100	188	16	29	115	217
Portugal	45	84	17	32	62	116
Germany	39	75	128	224	168	299
Italy	23	44	84	138	107	182
Sweden	3	5	27	39	29	44
Slovenia	1	3	9	16	10	19
Denmark	0	0	6	12	7	12
Austria	0	0	6	10	6	10
Total	211	400	876	1459	1087	1859
Annualised emissions (divided over 20 years)	11	20	44	73	54	93

9. Conclusions

This study shows that the 23 Member States examined are predominantly anticipating using conventional biofuels to deliver their 2020 renewable transport target under the RED, requiring an additional 15.1 Mtoe of supply compared to 2008 levels. As a consequence of this expanded use of conventional biofuel use ILUC could be estimated to account for between 4.1 and 6.9 million ha for biofuels alone.

Assuming there is no further action undertaken to address ILUC, the major increase in the use of conventional biofuels and the consequent change in land use has been calculated to lead to between 44 and 73 million tonnes of CO2 equivalent being released on an annualised basis. Even when the GHG emission savings required under the RED sustainability requirements for biofuels are taken into account, rather than aiding climate change mitigation up to 2020, the use of these biofuels would lead to the production of additional GHG emissions. As a consequence the use of these additional conventional biofuels could not be considered to contribute to the achievement of EU climate change policy goals.

Not only does this study suggest that ILUC associated with the reported additional use of conventional biofuels up to 2020 would lead to additional GHG emissions in 2020, the additional quantities of emissions are substantial. Using the method adopted in this study these additional emissions are estimated to range from 27.3 to 56.4 MtCO2e on an annual basis up to 2020. Indeed, this estimate would represent emissions from ILUC 80.5 to 166.5% worse than would be delivered from continued reliance on fossil fuels in the transport sector. These results clearly depend upon the assumptions adopted within this study, primarily the level of ILUC associated with the use of conventional biofuels and the level of GHG emissions associated with land use change.

Given ongoing uncertainties about the location and consequences of ILUC, every effort was made to adopt the most appropriate assumptions based on the evidence available at the time of drafting. The key assumptions and the rationale for them are set out transparently throughout the report. These assumptions could be improved through better knowledge of the types of feedstock to be used for biofuel production and likely locations of supply, providing a better understanding of likely displacement effects. Hopefully this will become available in due course. It will also be important to seek greater consensus over the assumptions and parameters to be applied during modelling and application of the predicted levels of biofuel use up to 2020 and the ILUC impacts.

Nonetheless, the level of uncertainty is diminishing. ***Sensitivity analysis completed during the work demonstrates that the overarching message of failure to deliver GHG savings from conventional biofuel use remains the same even when far lower estimates of ILUC and GHG emissions from land use change are applied. This underlines the need to address the question of ILUC associated with biofuel use as a priority.*** The current evidence clearly points to ILUC emissions undermining the arguments for the use of conventional biofuels as an environmentally sustainable, renewable technology. Moreover, this analysis raises questions about the appropriateness of anticipated conventional biofuels use by the Member States up to 2020. In addition to action on ILUC the GHG consequences of biofuel use could be reduced substantially by focusing increased effort on alternative routes for delivery of the 2020 targets, for example by greater efficiency savings in the sector and increased emphasis on the use of advanced fuels.

Certain national governments are anticipating making use of a significant quantity of bioliquids to deliver renewable energy for heat and electricity up to 2020, in addition to biofuels. This will require an expansion in the same crops and resources as for biofuels. Eight Member States reported in their NREAPs that they will make use of bioliquids in 2020; amounting to an estimated 4.4 Mtoe of conventionally produced fuels. This would equate to an additional ILUC impact of between 1 and 1.9 million ha and GHG emissions of between 211 and 400 MtCO2e. When figures for bioliquids and biofuels are combined the total area of ILUC would rise to between 5.1 and 8.8 million ha. The total associated GHG emissions would also increase, leading to a combined figure of between 1087 and 1859 MtCO2e or between 54 and 93 MtCO2e on an annualised basis (before any emissions savings are discounted).

10. Annex

Glossary of Terms and Abbreviations

- Advanced biofuels – Also known as second generation fuels, in the context of this study these are defined as the types of biofuels specified under Article 21.2 of the RED as counting as double towards the achievement of the 2020 targets. These include biofuels produced from wastes, residues, non-food cellulosic material, and ligno-cellulosic
- Arable land - defined by the Food and Agriculture Organization of the United Nations (FAO) as: land under temporary agricultural crops (multiple-cropped areas are counted only once), temporary meadows for mowing or pasture, land under market and kitchen gardens and land temporarily fallow (less than five years). The abandoned land resulting from shifting cultivation is not included in this category.
- Biofuels versus bioliquids – Within the RED bioliquids are defined as - liquid fuel for energy purposes other than for transport, including electricity and heating and cooling, produced from biomass; where as biofuels are defined as liquid or gaseous fuel for transport produced from biomass.
- CO2e – Carbon Dioxide equivalent, used as a standardised metric for evaluating GHG impact
- Conventional biofuels - Also known as first generation fuels, in the context of this study these are in essence produced from primarily food crops. This commonly includes maize, sugar cane, sugar beet, wheat, palm oil, oil seeds such as rape and soy.
- Ha - Hectare
- Ktoe or Mtoe- Kilo Tonnes of Oil Equivalent or Mega Tonnes of Oil Equivalent, ie 1 thousand or 1 million tonnes – used as a standard metric for evaluating energy use
- MJ – Megajoules
- NREAP – National Renewable Energy Action Plan – dossier specified in the RED within which Member States must report on how they propose to meet the 2020 targets for renewable energy and renewable transport fuels
- RED – Renewable Energy Directive - Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources - http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:140:0016:0062:EN:PDF

Calculations - Conversion Methodology

The conversion factors used for calculating the scale of ILUC in hectares were divided into upper and lower factors for both bioethanol and biodiesel. These were then combined to provide the overall ILUC figures for biofuels up to 2020. The basis for determining the conversion factors within this study was the comparative study completed by JRC in which various models developed to assess ILUC were reviewed. This included outputs from key EU based and international modelling teams who have developed economic models to determine the extent to which land use will change as a consequence of increased demand for biofuel feedstock commodities. JRC asked the modelling teams to run four standardised scenarios intended to imitate different types of increase in demand for biofuel feedstocks aimed at understanding the consequent scale of land use change. The models assessed by the JRC were AGLINK-COSIMO (from OECD), CARD (from FAPRI-ISU), IMPACT (from IFPRI), G-TAP (from Purdue University), LEI-TAP (from LEI) and CAPRI (from LEI). In addition there is also the IFPRI – MIRAGE model considered separately from the JRC analysis. At the time of drafting, however, concerns regarding the assumptions adopted in this particular model combined with the fact that the results are very substantially lower than for all other studies meant that it was not adopted as a basis for this analysis. It should, however, be noted that the results were used in order to help inform the sensitivity analysis.

Despite attempts to standardise the scenarios the models assessed by JRC produced a variety of results and as a consequence a potential range of ILUC conversion factors that could be applied. This is a result of the variable assumptions applied within the models assessed. To determine the most appropriate ILUC conversion factors for use in this study IEEP evaluated the different model assumptions and likely reliability in consultation with experts from the JRC and with reference to other studies completed on this issue (ie work by Ecofys). Based on this assessment the following judgements were made in order to determine the most appropriate conversion factors for both biodiesel and bioethanol fuels, which were then applied within this exercise.

It should be noted that while the modellers were asked to run certain scenarios for biofuel usage in 2020 none of these fully represented the likely mix of feedstocks used in the EU in 2020. Instead the only way to enable comparison was to shock the models to specify increased demand for specific commodities rather than the whole range likely to be used to produce additional biofuels. As a consequence separate ILUC factors emerged primarily for EU produced biodiesel from oil seeds, palm oil from Indonesia, wheat bioethanol from the EU and corn ethanol for the US. These were taken into account when determining the most appropriate conversion factors for use in this work.

- **Biodiesel** – for biodiesel the conversion factor selected as the lower bound was the AGLINK factor for EU production of biodiesel from oil seeds, while the upper bound was selected as the CARD/FAPRI factor for EU production of biodiesel from oil seeds. Other higher estimates, for example from LEI-TAP for EU produced biodiesel, were discounted, in this case as a consequence of concerns regarding the appropriateness of oil seed elements within the model.

  These upper and lower factors selected were applied to all biodiesel, both imported and domestic production. This was justified on the basis of these appearing, within model results identified for JRC and within other exercises, to be largely similar to the anticipated ILUC impact of palm oil production, based on the change in production area. It should be noted that the output from the G-TAP model for palm oil was much lower than for other estimates, this is considered to be a consequence of over estimates in likely yield increases and this figure was, therefore, discounted.

- **Bioethanol** – For domestic EU production of bioethanol the lower bound selected was based on the figures for EU produced wheat based ethanol from the AG LINK model. The upper bound selected was the equivalent scenario from the G-TAP model. Other estimates from IMPACT, for example, were discounted because of concerns regarding elasticities and assumptions relating to reductions in food consumption leading to a low ILUC estimate. It should be noted that the JRC consider outputs from G-TAP to be more accurate than for other models in terms of bioethanol impacts, this is because of the differentiated way this model takes into account yields on converted land by factoring in a frontier yield effect.

Unlike biodiesel for bioethanol there is likely to be a significant difference between the ILUC impact of domestically produced and imported bioethanol. This is because large proportions of ethanol imports are anticipated to be produced from sugar cane and in a number of studies sugar cane's ILUC impact has proved to be lower than for other crops. Therefore, while the wheat based ethanol figures were used as a proxy for domestic bioethanol production the AG LINK value for sugar cane was applied to imports. Given the wide variety of anticipated imports into Member States an average rate of imports was applied to provide two consistent upper and lower factors for bioethanol. The level of imports was assumed to be 43%.