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COMMISSION STAFF WORKING DOCUMENT

IMPACT ASSESSMENT

Accompanying the document

Proposal for a

Directive of the European Parliament and of the Council

amending Directive 98/70/EC relating to the quality of petrol and diesel fuels and amending Directive 2009/28/EC on the promotion of the use of energy from renewable sources

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1. SECTION: PROCEDURAL ISSUES AND CONSULTATION OF INTERESTED PARTIES

1.1. Background

Directive 2009/28/EC on the promotion of the use of energy from renewable sources (the "Renewable Energy Directive") established mandatory targets to be achieved by 2020 for a 20% overall share of renewable energy in the EU and a 10% share for renewable energy in the transport sector. At the same time, an amendment was adopted to Directive 98/70/EC[1] ("the Fuel Quality Directive") which introduced a mandatory target to achieve by 2020 a 6% reduction in the greenhouse gas intensity of fuels used in road transport.

The contribution towards these targets from biofuels[2] is expected to be significant. Whilst both Directives (hereafter referred to as the Directives) include sustainability criteria including minimum greenhouse gas saving thresholds, the greenhouse gas emissions associated with indirect land-use change are currently ignored by the legislation. However, the Directives request the Commission to review[3] by 31 December 2010 the greenhouse gas emissions associated with indirect land-use change and, if appropriate, propose ways to address them. The Commission published a report on indirect land-use change on the 22 December 2010[4]. That report (i) identified a number of uncertainties and limitations associated with the available numerical models used to quantify indirect land-use change; (ii) acknowledged that indirect land-use change can reduce greenhouse gas emissions savings associated with biofuels; and (iii) indicated that if action is required, indirect land-use change should be addressed under a precautionary approach. Most importantly, it concluded that the Commission would prepare an Impact Assessment based on the four options identified in the report, accompanied, if appropriate, by a legislative proposal to amend the Directives.

1.2. Organisation and timing

In order to better understand the potential indirect land-use changes and impacts associated with the production of biofuels, a number of analytical studies were commissioned by different Commission Services. An inter-service working group[5] was established in 2009 and met regularly during 2009 and 2010. Discussions in this group have provided an important input to these studies.

Following the publication of these studies in mid-2010, the group focused on the production of the impact assessment report, with meetings of the Impact Assessment Steering Committee taking place in 2011 on 3 February, 17 February, 9 March, 18 March and 16 May. The Impact Assessment is relying mainly on the work of the International Food Policy Institute (IFPRI).

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1 Directive 2009/30/EC.

2 The requirement in the Renewable Energy Directive also applies to bioliquids. References to 'biofuels' in this document should be taken as also applying to bioliquids.

3 Article 7d(6) of Directive 2009/30/EC and Article 19(6) of Directive 2009/28/EC.

4 COM(2010) 811.

5 Meetings of this group were jointly chaired by DG ENER and DG CLIMA. Other Commission Directorates General who were part of this group included the Secretariat General, DG ENV, DG MOVE, DG ENTR, DG ECFIN, DG AGRI, DG DEVCO, DG TRADE and the Joint Research Centre.

This work (*"Global trade and environmental impact study of the EU biofuels mandate"*)[6] takes into account stakeholder feedback collected through the different consultation events outlined above, and has used the most recent biofuel demand estimates up to 2020 as outlined by the Member States in their national renewable energy action plans[7]. The Commission considers this work to represent the best available science with regards to the estimated indirect land-use change impacts associated with biofuels consumed in the EU. The findings of the IFPRI-report were presented to stakeholders at a meeting on 18 November 2011[8].

The Commission also carried out two public consultation exercises on approaches for dealing with indirect land-use change in 2009 and 2010. Moreover, the Joint Research Centre organised various expert consultation meetings with academics and experts in the field in 2009 and 2010. Further detail on these exercises can be found in Annex I.

1.3. Consultation of the Impact Assessment Board

The present Impact Assessment takes into account the recommendations formulated by the Impact Assessment Board on 4 May 2011 and on 24 August 2011[9]. The comments from the Board were incorporate in this Impact Assessment as follows:

- An option evaluating imposing a limit on the contribution of first generation biofuels has been introduced.
- Restructuring of text and further clarifications regarding the nature of the problem and the framing of biofuels and ILUC in a broader context (i.e. the Climate and Energy package, global and EU overall land use change and associated emissions, global trade, linkages with LULUCF, etc).
- The description of the baseline scenario was restructured and extended to better describe the state of industry sectors involved throughout the entire biofuel production and deployment chain i.e. agricultural production, processing capacity (i.e. crushing of oilseeds), production plants for biodiesel, bioethanol and advanced biofuels and developments on the car fleet, down to Member State level where possible.
- The presentation of options has been clarified and the impact analysis and presentation have been restructured to assist readability and enhance the link with the objectives.
- More detail has been provided on the assessment of environmental, economic and social impacts. Further work from the Joint Research Centre on the biodiversity impacts has also been included in the assessment.
- A glossary of technical terms has been added.

6 http://trade.ec.europa.eu/doclib/docs/2011/october/tradoc_148289.pdf.
7 http://ec.europa.eu/energy/renewables/transparency_platform/action_plan_en.htm.
8 http://ec.europa.eu/energy/renewables/studies/land_use_change_en.htm.
9 Insert reference before publication.

2. SECTION: PROBLEM DEFINITION

2.1. Introduction

The Directives impose a number of sustainability criteria aimed at preventing the conversion of land characterised by high carbon stock and high biodiversity for biofuel production. Moreover, they also require biofuels to achieve minimum greenhouse gas emission savings of 35% compared to fossil fuels[10].

The methodology defined in the Directives to determine the greenhouse gas saving takes account of emissions associated with direct land-use change, as well as emissions coming from the production of biofuels. However, emissions associated with indirect changes in land-use are currently not included (a figure explaining both direct and indirect land-use change is provided in Annex II).

In the context of the mandatory targets set by the Directives to achieve the specified greenhouse gas savings, and the 6% reduction in greenhouse gas intensity required by the Fuel Quality Directive, the key problem addressed by this impact assessment is whether greenhouse gas emissions associated with indirect land-use change should be addressed, and if so in which way. As this impact assessment is focused on the specific requirement related to greenhouse gas emissions from indirect land-use change, it does not consider any wider environmental and social impacts associated with the promotion of biofuels. The Commission intends to consider these aspects in the Renewable Energy Directive's biennial reports to the European Parliament and the Council from 2012 onwards.

2.2. Scene setter

2.2.1. The Climate and Energy Package targets

In March 2007 the EU's leaders endorsed an integrated approach to climate and energy policy aimed at combating climate change and increasing the EU's energy security while strengthening its competitiveness and transforming itself into a highly energy-efficient, low carbon economy. As part of this process, a series of demanding climate and energy targets to be met by 2020 were set, including,

- a reduction in EU greenhouse gas emissions of at least 20% below 1990 levels
- a 20% of EU energy consumption to come from renewable resources
- and a 20% reduction in primary energy use compared with projected levels, to be achieved by improving energy efficiency.

Biofuels represent around 1 and 2.5 percentage points of the 20% greenhouse gas reduction and renewable energy targets respectively. However, they are, as estimated in the National Renewable Energy Action Plans[11], expected to be the major contributor towards the sub-targets for 10% and 6% renewable energy and greenhouse gas emission reductions in the

[10] This requirement is progressive as it increases to 50% in 2017 and 60% in 2018 for new installations.
[11] See table 1 in chapter 2.8, introducing the baseline, for the estimates contained in the plans.

transport sector to 2020, as set by the Renewable Energy and Fuel Quality Directives respectively.

2.2.2. *Transport emissions reductions to 2050*

The EU is committed to achieving by 2050 an 80 to 95% reduction in greenhouse gas emissions economy wide compared to 1990 levels. The recent "*A Roadmap for moving to a competitive low-carbon economy in 2050*"[12] foresees that the transport sector needs to reduce its greenhouse gas emissions by around 60% compared to 1990 levels by 2050 to ensure a comparable cost-effectiveness of greenhouse gas emissions abatement in that sector. This objective has been confirmed in the recently published transport white paper *"Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system"*[13].

Transport emissions can be reduced through measures which affect *i)* the amount of transport activity, *ii)* the energy efficiency with which that transport is carried out and *iii)* the greenhouse gas intensity of the energy used to perform the transport. Biofuels are one of the alternative energy carriers available that offer the potential to reduce the greenhouse gas intensity of the fuel. The use of biofuels may reduce greenhouse gas emissions provided that direct and indirect greenhouse gas emissions are lower than those from the fossil fuels they replace. Given the overall transport greenhouse gas reduction goal, the degree to which one of the three levers to reduce emissions is not deployed, the more action that will be required from the other two.

2.2.3. *Global land-use and land-use change emissions*

The globe has approximately 13 200 Mha of land, of which around 1600 Mha is used for cropping[14,15]. The IPCC special report on renewable energy[16] estimates that 780 Mha of land are available for bioenergy production without irrigation worldwide, mostly consisting of unprotected grassland and woodland found in Africa (35%), Latin America (21%), North America (16%) and Europe (14%), having the potential to deliver bioenergy amounting to more than 4000 Mtoe. The estimated total biofuel use in the EU in 2020 (27 Mtoe) is in comparison expected to cause a total land use change of less than 3 Mha of land globally[17].

The IEA biofuels for Transport - Technology Roadmap assumes that 27% of total transport fuel demand will be covered by biofuels in 2050. The biofuel demand and resulting land requirements are shown for comparison below.

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12 Available at http://ec.europa.eu/clima/documentation/roadmap/docs/com_2011_112_en.pdf.

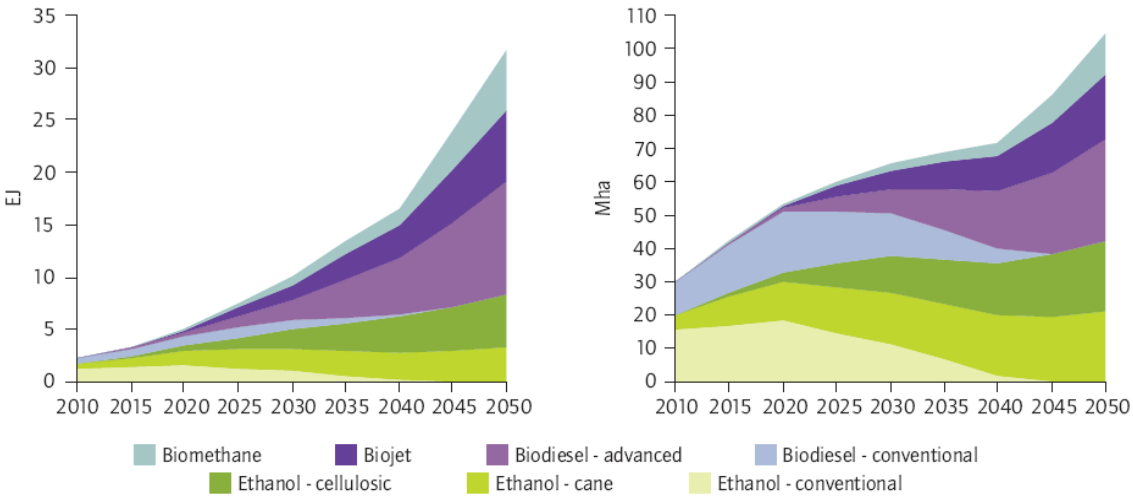
13 Available at http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2011:0144:FIN:EN:PDF.

14 WWF/Ecofys 2011 - The Energy Report, available here: http://www.ecofys.com/com/publications/The Energy-Report-Ecofys.htm.

15 For comparison, total cropland in the EU represents around 107 Mha.

16 Available at http://srren.ipcc-wg3.de/report.

17 This estimate takes into account productivity increases, substitution effects and the estimated land saved by the production of co-products of biofuels.



Note: This is gross land demand excluding land-use reduction potential of biofuel co-products. This assumes 50% of advanced biofuels and biomethane are produced from wastes and residues, requiring 1 Gt of residue biomass. If more residues were used, land demand could be reduced significantly.

Figure 1: Demand for biofuels (left) and resulting land demand (right) assumed in the IEA biofuel technology roadmap (Source: IEA Technology Roadmap[18])

The production of conventional bioethanol and biodiesel increases towards 2020, and then decreases, disappearing around 2045, while bioethanol from sugar cane increases over the whole period. Land-use for biofuels increases from 30 Mha today[19] to around 110 Mha in 2050, which corresponds to around 7% of current cropland.

With regard to annual global emissions (50.000 Mt CO_2)[20], annual emissions from land-use change represent around 15%[21] of the total (7500 Mt CO_2). In this context, estimated indirect land-use change emissions from EU biofuel consumption in 2020 are likely to represent a very small share (0.1% if based on annual estimated emissions by IFPRI-MIRAGE-BioF at 50 Mt CO_2). However, this level of emissions deserves consideration in the context of greenhouse gas emissions savings offered by biofuels. This is discussed in more detail in section 2.4.3 and 2.8.6.

2.2.4. Bioenergy and biofuel production in a global context

Bioenergy is the dominant renewable energy source, amounting to 10% (1200 Mtoe) of global primary energy supply. The IPCC estimates that the use of sustainable bioenergy will triple[22] towards 2050 in order to meet climate change objectives[23]. Careful policy making, including considerations of indirect land-use change impacts, is necessary to mobilise such quantities in a sustainable way.

Most of today's biofuels are produced from agricultural crops like maize, sugar cane and rapeseed. Total global production of biofuels reached 70 Mtoe in 2008, which represents 1.7% of global oil consumption. While less than 3% of global cropland is used for producing

18 Available here: http://www.iea.org/papers/2011/biofuels_roadmap.pdf.
19 Note that the land savings of co-products produced from conventional biofuels are not considered in the figure.
20 IPCC Fourth Assessment Report (AR4). Available here: www.ipcc.ch.
21 Van der Werf et.al. CO2 emissions from forest loss, Nature Geoscience, vol 2, 2009.
22 The median value of 164 scenarios is at around 150 EJ, while the whole span is 35 EJ – 300 EJ for 2050.
23 To halt GHG concentration to below 440 ppm. Executive summary. For reference see footnote 16.

biofuels, the relative importance of biofuels within certain global markets is significant. For example, globally 16% of vegetable oils (rapeseed, soybean, palm and sunflower oil) are used for biodiesel, 15% of maize and some 2% of wheat is used for bioethanol[24].

Biofuels are traded globally, as can be seen in figure 2 below, which depicts the production and trade of biofuels in 2009.

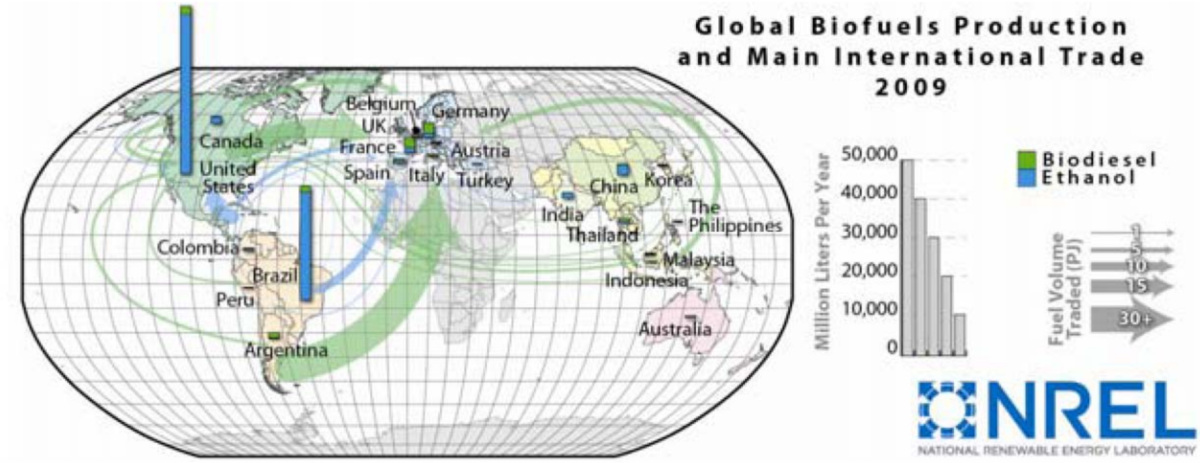


Figure 2: 2009 production and trade of biofuels. Source: IPCC (see footnote 16)

The US (maize) and Brazil (sugar cane) are the main biofuel producers, producing more than the rest of the world combined. The EU is the largest global market for biodiesel because of the dominance of diesel in the car fleet. In 2009, the EU imported soy biodiesel mainly from Argentina and US, and to a significantly lesser extent palm oil from South East Asia. Bioethanol, to be blended with petrol, was imported from Brazil. Two thirds of the biofuels consumed in the EU are currently produced domestically, with the share of imports expected to grow towards 2020 (IFPRI-MIRAGE-BioF estimates that half of biofuels will be imported in 2020).

2.3. The characteristics of Indirect Land-use Change

Most of today's biofuels are produced from crops grown on agricultural land such as wheat and rapeseed. When agricultural or pasture land previously destined for the food, feed and fibre markets is diverted to the production of biofuels, the non-fuel demand will still need to be satisfied. Although this additional demand can be met through intensification of the original production, bringing non-agricultural land into production elsewhere is also possible. It is in the latter case that land-use change occurs *indirectly*, (hence the term indirect land-use change).

While most biofuel feedstocks are being produced in the EU, the estimated indirect land-use change emissions are mostly expected to take place outside the EU, where the additional production is likely to be realised at the lowest cost. In the case that this production is realised through the use of additional land, its conversion could lead to substantial greenhouse gas emissions being released if high carbon stock areas such as forests are affected as a result.

24 Laborde, D.D. Domestic policies in a globalized world: what you do is what I get (2011).

2.4. Modelling of indirect land-use change emissions

Estimating the greenhouse gas impact due to indirect land-use change requires projecting impacts into the future, which is inherently uncertain, since future developments will not necessarily follow trends of the past. Moreover, estimated land-use change can never be validated, as indirect land-use change is a phenomenon that is impossible to directly observe or measure. Therefore modelling is necessary to estimate its occurrence.

No macro-economic models used to estimate indirect land-use change emissions are currently capable of modelling the effects of the EU sustainability criteria, so these criteria are consequently assumed not to have any effect. As such, the models are not able to distinguish between direct and *indirect* land-use change. Nevertheless, the current estimates from the models are considered the best approximation for estimating indirect land-use change emissions.

Several non-economic factors influence what land-use change takes place and where it occurs. Some of these drivers are related to political choices (land-use and agricultural policy, land rights, etc.), others to institutional features (proximity to infrastructure and markets, land-use legislation). Therefore conceptual limitations will always remain. Annex III provides more details on the various modelling approaches, and the related uncertainties and limitations.

2.4.1. Results from modelling indirect land-use change

As set out above, the Commission launched a number of studies in 2009, 2010 and 2011 on indirect land-use change. Further details on the assumptions and results from these studies are provided in Annex IV. A description of one of them in particular, the IFPRI-MIRAGE-BioF model, which is the basis for the modelling establishing the baseline used in this Impact Assessment, can be found in Annex V.

The MIRAGE-BioF model, developed by the ATLASS consortium, has been improved over the last three years in consultation with the Commission to model the consumption of biofuels used in the EU. Although a number of limitations and uncertainties remain, this model has been found to be the most suitable one to estimate the indirect land-use change emissions in the EU context.

The IFPRI-MIRAGE-BioF model is a general equilibrium model, which encompasses all economic sectors and markets and their inter-actions at a global scale. The model is run in a "baseline scenario", and a "policy scenario", where the only difference is the EU biofuel policy. The resulting difference in land-use change emissions is then divided by the additionally produced biofuels. In addition, the Commission has identified a number of other sources illustrating different (indirect) land-use change emissions from different feedstocks. Figure 3 provides a summary of the most relevant modelling exercises undertaken[25]. It sets out calculations of estimated indirect land-use change emissions in gCO_2/MJ for a range of different feedstocks showing the range of volumes obtained, and converted where necessary to a 20 year timeframe[26].

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[25] Lines illustrate ranges when Monte Carlo analysis of the uncertainty has been carried out; shaded bar areas illustrate maximum and minimum values from the analysis when different scenarios have been considered.

[26] The methodology set out in the Directives for calculating land-use change prescribes that such emissions shall be divided by 20 years.

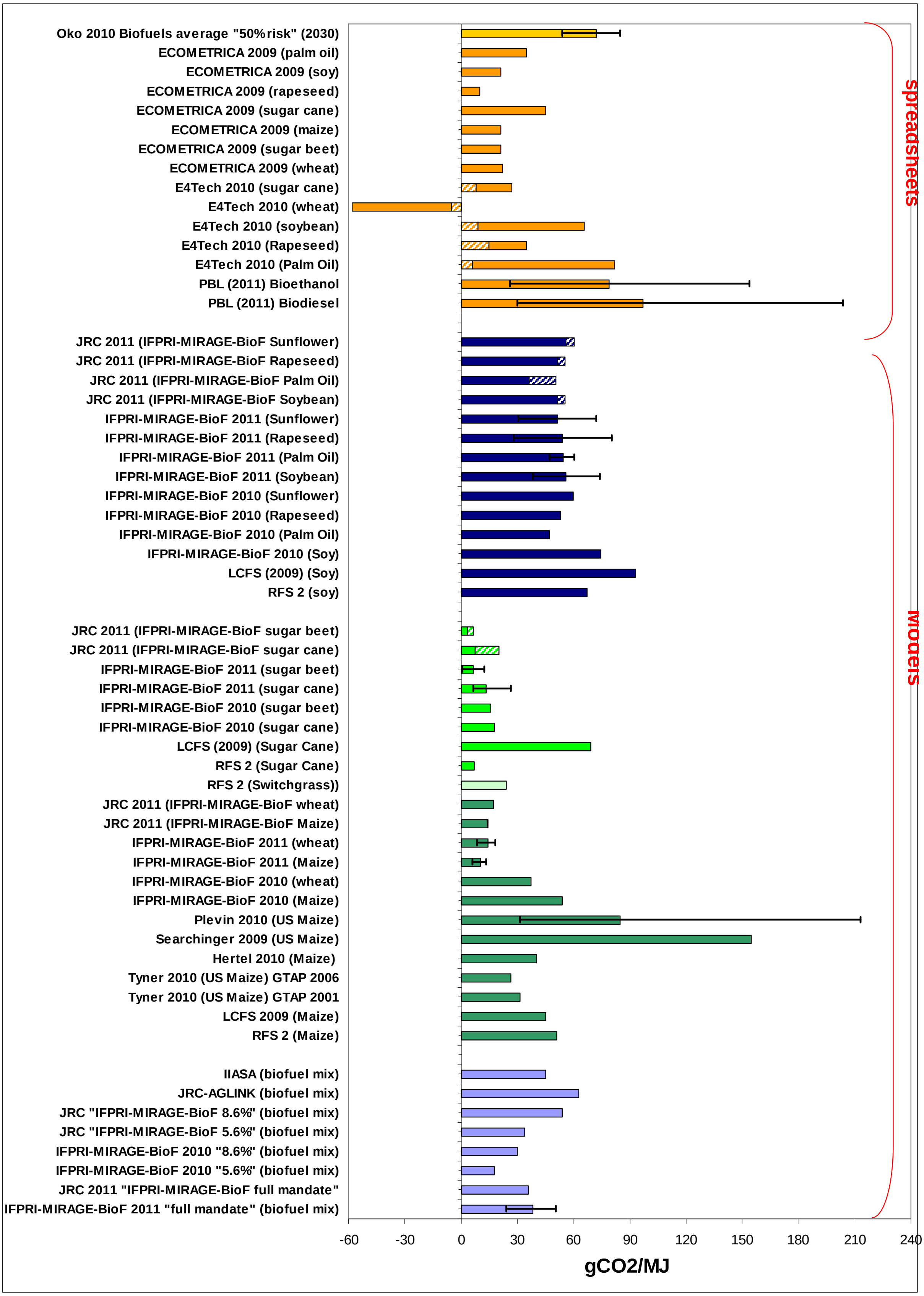

Figure 3: Summary of estimated (indirect) land-use change emissions. Source: various

2.4.2. *Short and long term developments to deal with limitations and uncertainties*

There are a range of key assumptions used in the indirect land-use change models that can have a substantial impact on the indirect land-use change estimates. A first step in dealing with this cause of uncertainty is to understand the parameters involved. The Commission's model comparison exercise and the literature review have provided an indication of a limited number of key factors that are of high importance. These include, but are not limited to: co-products, yield developments, carbon stocks and displacement/substitution of other commodities. These aspects have also been considered by the Low Carbon Fuel Standard Expert Workgroups established as part of California Air Resource Board's attempts to improve the modelling of indirect land-use change[27].

In relation to uncertainty in the model results due to data and assumptions, an approach that enables the parameters being considered to be varied randomly according to an expected probability function can be used. This so-called Monte Carlo analysis is a standard approach to dealing with uncertainty in modelling, and the method chosen by the US Environmental Protection Agency in their attempt to estimate indirect land-use change emissions.

2.4.3. *Overall greenhouse gas balance of using biofuels in the EU*

The emissions associated with the cultivation, processing and transport of biofuels have been extensively explored by the Commission making use of the JEC's Well to Wheel study[28], and form the basis for the greenhouse gas intensity values established in EU legislation. These values for land using first generation biofuels[29] vary from around 20 g/MJ to 60 g/MJ, and do not include emissions for either direct or indirect land-use change.

The Directives require that biofuels counted towards the targets need to save at least 35% greenhouse gas emissions compared to average fossil fuel emissions, using a fossil fuel comparator (FFC), which is currently set at 83.8g/MJ[30]. However, more recent research indicates that a higher number would be more accurate[31].

Different models assume different fossil fuels being substituted by biofuels. The literature review finds that to some degree higher production cost is linked with higher greenhouse gas emissions, but not systematically. For example, "deep water" and "artic" sources are more costly for other reasons than high energy consumption per barrel extracted crude. However, the general picture is that more expensive crudes are connected with higher emissions.

In the context of analysing indirect land-use change, a consequential lifecycle analysis is applied for the land resources, which implies that the *global net effect* is analysed. This is why land-use changes taking place in areas where no biofuel is produced still has an impact on the estimated indirect land-use change emissions of biofuels. Applying the same framework to fossil fuel, it is appropriate to compare overall emissions from biofuels to global marginal

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27 CARB Expert Workgroups: http://www.arb.ca.gov/fuels/lcfs/workgroups/ewg/expertworkgroup.htm.

28 Reports available here: http://ies.jrc.ec.europa.eu/jec-research-collaboration/downloads-jec.html.

29 A list of typical values for a range of most common biofuel pathways is discussed in table 4.

30 In addition, the fossil fuel comparators for bioliquids are 91, 77 and 85 g/MJ depending on whether they are used for electricity production, heat production or cogeneration.

31 JRC estimates on expected fossil fuel comparator in 2020 can be found in Annex VI.

emissions from fossil fuels not being extracted as a consequence of using biofuels. Set out below is a simplified figure depicting the application of the above approach[32].

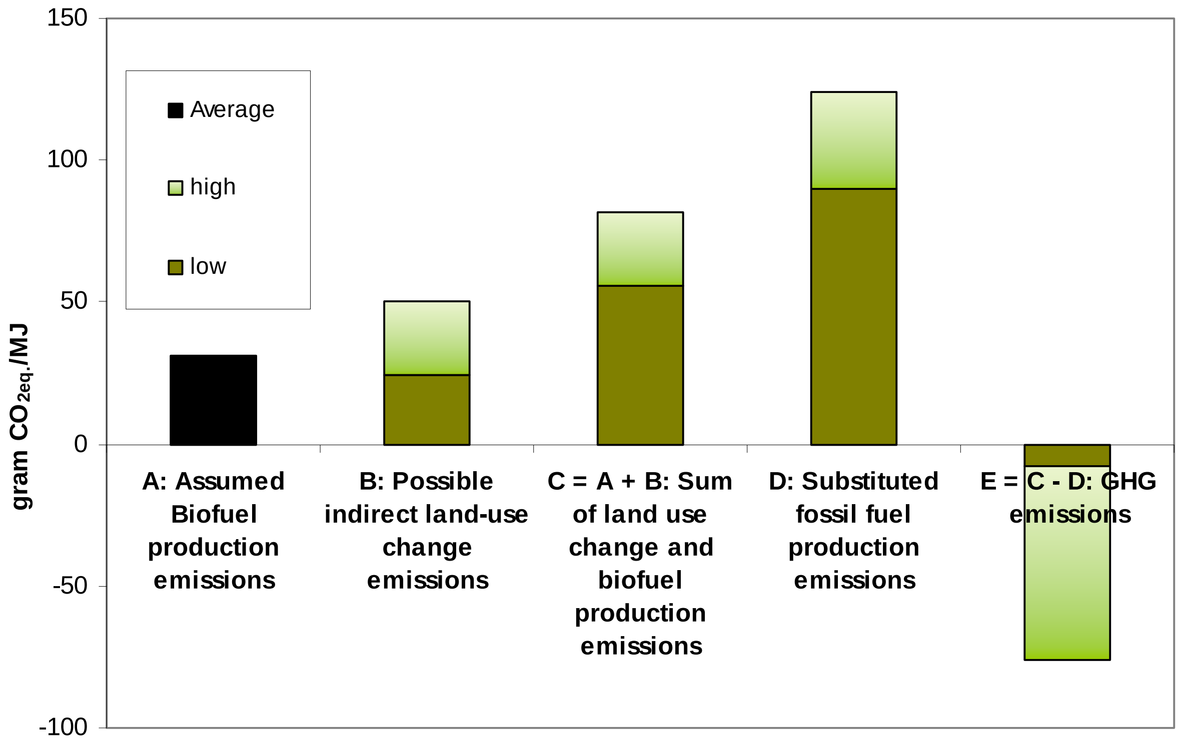

Figure 4: Emissions balance of biofuels in 2020, including estimated indirect land-use change emissions, compared to the emissions of fossil fuels not extracted.

The global marginal emissions from fossil fuels are expected to be higher than average emissions of fossil fuels used in the EU, the latter being reflected in the fossil fuel comparator (FFC), which in this assessment has been assumed to be 90.3 g/MJ in 2020. As can be seen from figure 4, the overall greenhouse gas emissions balance of the estimated biofuel mix compared to fossil fuels is expected to be positive in 2020, implying that the use of biofuels will save emissions also when the estimated indirect land-use change emissions are taken into account. Irrespective of the emissions from conventional sources of fossil fuels, if biofuels are to lower the overall greenhouse gas emissions from transport fuels significantly and to an increasing degree, the greenhouse gas intensity has to be reduced over time[33]. It is in this context that indirect land-use change emissions pose a challenge.

32 A: average direct emissions in 2020 based on the Member States National Renewable Energy Action Plans (NREAPs, 27.2Mtoe, ¾ of biodiesel vs ¼ bioethanol). All biofuels are assumed to meet the greenhouse gas emissions thresholds in the Directives - no changes to current sustainability scheme but fossil fuel comparator is set at 90..3g CO2/MJ. B: possible range (5th to 95th percentile) of estimated indirect land-use change emissions according to latest IFPRI-MIRAGE-BioF 2011 study based on NREAPs (27.2Mtoe, ¾ of biodiesel vs ¼ bioethanol). Averaged over 20 year period according to the Directive's greenhouse gas emissions methodology. C: Sum of average direct emissions in 2020 and estimated indirect land-use change emissions (A+B). D: marginal fossil fuel emissions from crudes not being extracted based on the assumed 2020 fossil fuel comparator (lower end) and high emitting oil sands from Brandt et al (upper end). E: overall greenhouse gas emissions balance of the expected biofuel mix in 2020 compared to fossil fuels; range comes from comparing high indirect land-use change emissions with low fossil fuel emissions and vice versa.

33 See the EU 2050 Roadmap for an indication of the required reduction in transport emissions.

2.5. Underlying drivers

The drivers behind indirect land-use change can be summarised as the increased demand for crops resulting from increased biofuel use, coupled with poor land-use governance in areas with high carbon stock land and lack of complete accounting rules and emission targets for land-use change globally.

2.5.1. Land availability globally

The basic driver for indirect land-use change is the increased demand for agricultural crops as a result of increasing biofuel production in a situation where potential yield increases are limited and demands (most notably for food and feed) are not fully elastic. Some other key factors, such as achieving maximum profit from the production and complying with relevant legislation, are also likely to play a role in determining how the increased demand is to be realised.

The extent to which land availability is limited in various regions of the world is much debated. Compared to 1981 the harvested land has significantly declined in Europe, CIS and North America, thus suggesting that there would be low carbon stock land available[34]. With regard to the EU, it is expected that the agricultural area will continue to reduce by around 0.5 million hectares each year. Further details on this can be found in Annex VII.

2.5.2. Where is agricultural land expanding?

Although it is clear that a significant amount of land is available in certain areas of the world, it is difficult to govern the proper use of these land areas. Recent studies suggest that tropical forests were the primary sources of new agricultural land in 1980-90s, with various studies highlighting a significant role for soy production and cattle ranging, as well as palm oil, as drivers behind the expansion of agricultural land into the Amazon and South East Asia respectively[35].

The lack of effective protection of forests and carbon rich areas is another factor that allows damaging indirect land-use change to take place. If conversion of carbon rich areas such as forests and wetlands were to be limited, the risk of damaging indirect land-use change would be lower. Further information, including international developments in this area, can be found in Annex VII.

2.5.3. Accounting for land-use, land-use change and forestry (LULUCF)

In national greenhouse gas inventories (which are the basis for countries' emission commitments, such as the EU's greenhouse gas target) emissions from the burning of biofuels are reported under the energy sector as zero. This means that emissions are not added to the total national emissions and that it is assumed that any greenhouse gas emissions from land

34 However, if it is the least fertile land that has been recently abandoned, then its future production could be expected to show typical yields below average, leading to either increased land requirements or increased use of fertilisers. In addition, if the land is under a process of managed reforestation, its reversion to agricultural production could result in the release of carbon emissions.

35 Tropical forests were the primary sources of new agricultural land in the 1980s and 1990s. H. K. Gibbs, A. S.Rueschb, F. Achardc, M. K. Claytond, P. Holmgrene, N. Ramankuttyf, and J. A. Foleyg 2010.

(including any direct and indirect land-use change) are captured under the "land-use, land-use change and forestry" (LULUCF) sector of the inventory[36].

So, while incentives exist to promote the use of bio-energy[37], a coherent approach to climate change mitigation in the LULUCF sector via measures in agriculture, forestry and related industries at the global level is only in the making. The LULUCF sector has a positive and significant impact on the EU's greenhouse gas emissions. The sector removes the equivalent of 9% of greenhouse gases emitted in other parts of the economy[38]. Although emissions and removals from LULUCF are reported under the UNFCCC and partially accounted under the Kyoto Protocol, the sector was left out of the EU's climate commitments for 2020 under the Climate and Energy Package[39] due to the recognition of serious deficiencies in international accounting rules of emissions from this sector (accounting for emissions and removals is only mandatory for some land use change activities including afforestation, deforestation and reforestation). Developing countries do not account at all.

Taken together, this means that emissions from land-use changes in developed countries due to agricultural expansion is unlikely to be fully reflected in the accounting, and that land-use change emissions in developing countries are not accounted for.

An international agreement on revised accounting rules for LULUCF for the second commitment period under the Kyoto Protocol post 2012 was achieved at the 17th Conference of the Parties to the UNFCCC ("COP17") in Durban in December 2011. In particular accounting for forest management activities, including harvested wood products, will be mandatory and definitions for natural disturbances and "wetland drainage and rewetting" have been established.

Following this agreement the Commission tabled a proposal on 12 March 2012 on how the LULUCF sector increasingly could be integrated in the EU's climate policy using a step-wise approach. As a first step, it proposes establishing robust, common accounting, monitoring and reporting rules mandatory for forests, forest management, croplands and grassing land as well as national LULUCF action plans (LAP). In view of the sector's specific emissions profile, the Commission proposed a dedicated legal framework, rather than including it in the EU Emissions Trading Scheme or the rules created by the Effort Sharing Decision.

The second step would be to formally include LULUCF in the EU's greenhouse gas reduction target. It is proposed to take this step when the Member States have implemented the accounting framework and it has proven to be robust.

Accounting for LULUCF would clarify the benefits of sustainable bio-energy by better reflecting related emissions, in particular resulting from the combustion of biomass, which is unaccounted for at the moment. This would strengthen the incentives provided by sustainability criteria in the context of renewable energy targets. However, implementing LULUCF accounting, monitoring and reporting in the EU is likely to have a limited effect on the estimated indirect land-use change emissions globally, as these take place mostly outside of the EU. An implementation of LULUCF accounting on a global scale, combined with

[36] 1996 IPCC Guidelines for National Greenhouse Gas Inventories (Vol. 3, Energy, p. 1.10).
[37] Directive 2009/28/EC.
[38] National total excluding the LULUCF sector.
[39] Unlike non-CO2 greenhouse gases from agricultural activities e.g. methane and nitrous oxide from ruminants and fertilisers.

commitments for reducing emissions, could significantly reduce the indirect land-use change emissions, as converting high carbon stock land would have a cost.

2.6. Who is affected by indirect land-use change?

Climate change is a global problem, while the socio-economic consequences of indirect land-use change have regional and national effects affecting the global population. Regulations to address indirect land-use change emissions in the field of biofuels may affect local communities, biofuel feedstock producers, the biofuel industry, Member States and third countries in various ways. These will be incorporated in the assessment of the policy options in section 5.

Although land-use change can have a wide range of positive and negative impacts (i.e. greenhouse gas emissions, biodiversity, economics, social issues, etc), this report focuses on the consequences for the greenhouse gas emissions of biofuels, as required by the Directives. The Commission will analyse wider sustainability impacts associated with the promotion of biofuels in the Renewable Energy Directive's biennial reports to the European Parliament and the Council from 2012 onwards.

2.7. How are existing policies and legislation affecting indirect land-use change?

Developments driven by existing legislation in a number of areas could have a significant impact on indirect land-use change. These include existing EU legislation relating to biofuels (the Renewable Energy and Fuel Quality Directives), as well as wider agricultural (i.e. Common Agricultural Policy), environmental (i.e. biodiversity, forestry, REDD+), trade (i.e. agricultural tariffs), developmental (i.e. investment into agriculture) and research (i.e. agricultural research and advanced biofuels) policies. Further details are found in Annex VIII.

2.8. Baseline scenario for the assessment of indirect land-use change

In order to be able to assess the full impacts of the policy options being considered in this assessment, this section aims to provide an overview of the EU biofuel and related industries, and the estimated indirect land-use change emissions associated with the increased feedstock demand for biofuels.

2.8.1. Overview of biofuels and related industries

The production of biofuels involves economic activity and employment all along the supply chain; in agriculture, logistics and at biofuels production facilities, but also in sectors that supply to or support biofuels supply chains, and is generally more labour intensive than fossil fuels. The expected employment related to biofuels in EU in 2020 could be around 400,000 jobs in total[40].

[40] EmployRES study (p. 133). http://ec.europa.eu/energy/renewables/studies/doc/renewables/2009_employ_res_report.pdf. This figure represents estimated gross effects and does neither take into account adjustments in other parts of the economy (i.e. reduced opportunities in fossil fuel industry) nor adjustments for tax incentives and subsidies given to the production of biofuels.

2.8.1.1. EU production and consumption - 2008 and 2020

Reported 2008 and estimated 2020 consumption figures for biofuels and other renewable energy sources (RES) in transport are shown in table 1 below. The 2020 figures are based on the National Renewable Energy Action Plans (NREAPS), which have been submitted by the Member States[41]. The NREAPs are also the basis for the baseline established in this Impact Assessment. Compared to the expected increase of biofuels, bioliquids are expected to play a small role in contributing towards the overall 20% RES target at around 5.5 Mtoe (4.4 Mtoe and 1.1 Mtoe going into the production of heat and power, and electricity generation respectively). This does not represent a significant increase compared to 2008 levels. The production of biofuels from waste feedstocks and advanced biofuel technologies is not expected to be significant and lower than anticipated, reaching 2.3 Mtoe (approximately 1.5 percentage point with double counting) in 2020. It appears that the current incentives, particularly,those set out in Article 21(2)[42] of the Renewable Energy Directive, are not enough to spur the desired level of investment in advanced 2nd generation biofuels.

	2008	2020
Total transport fuels (Mtoe)	239	312
1st generation biofuels (Mtoe)	10	26.5
of which biodiesel (Mtoe)	8.2	19.8
of which bioethanol (Mtoe)	1.8	6.7
1st generation biofuel (p.p of RES-T)	3.5	8.6
Biofuels from waste and 2nd generation share (p.p of RES-T)	0	1.5
Renewable electricity in transport (p.p of RES-T inc)	0.4	1.4

Table 1: RES in transport 2008 and 2020.

2.8.1.2. EU agricultural production

Biofuel feedstocks currently used are typically 'first generation' and include biodiesel and bioethanol derived mostly from crops, (i.e. cereals, sugars and oil crops) except those produced from waste feedstocks.

In the EU, the share of the cereal production[43,44] consumed in the bioethanol market was around 9.4 Mt during the 2009/10 marketing year (3.2% of a total EU cereal production at 292 Mt), with wheat being the most common feedstock used. Moreover, estimated consumption of sugarbeet in the EU bioethanol market is about 6 Mt (5.4% of the total EU

[41] All the plans, in both English and original language are available here: http://ec.europa.eu/energy/renewables/transparency_platform/action_plan_en.htm.

[42] Biofuels made from certain feedstocks (waste, residues and woody material) are counted double towards the 10% target of the Renewable Energy Directive.

[43] Data for cereals from: Prospects for agricultural markets and income 2010-2020, http://ec.europa.eu/agriculture/publi/caprep/prospects2010/fullrep_en.pdf.

[44] Bioethanol figures are for fuel use only. Data on cereals, sugar beet and oil crops divided by member states, data available at http://epp.eurostat.ec.europa.eu/cache/ITY_OFFPUB/KS-ED-10-001/EN/KS-ED-10-001EN.PDF.

sugar beet production at 110 Mt)[45]. Across the EU, the largest producers of cereals and sugar beet respectively were France (70Mt and 33 Mt), Germany (50 Mt and 25 Mt), Poland (30 Mt and 11 Mt) and the UK (18 Mt and 8 Mt).

With regard to biodiesel, the share of vegetable oils destined for this market represented around 9 Mt. This equals to 38% of the estimated EU consumption of vegetable oils 23.4Mt in 2010/11[46]. Of this oils market, around 41% is imported as oil, and around 10% is imported as beans (mainly soya)[47]. EU oil crops production concerns mainly rapeseed (20.4 Mt in 2010/2011), sunflower seed (6.7 Mt) and soya (1.1. Mt). Across the EU, the largest producers of rapeseed were Germany (6.3 Mt), France (5.6 Mt), Poland (2.5 Mt) and UK (2 Mt). For sunflower, these were France (1.6 Mt), Bulgaria (1.3 Mt), Hungary (1.3 Mt), Romania (1 Mt) and Spain (0.8 Mt).

The EU-27 is traditionally a net exporter of cereals, but a net importer of vegetable oils and oilseeds (despite recently achieving record production levels of oil crops), and to a lesser extent of sugar. Current forecasts predict that this trend, with regard to cereals and vegetable oils, will continue to 2020.

2.8.1.3. Trade in biofuels

The table below shows the current and estimated split of biofuels across feedstocks in 2020.

	2008 (%)	*Source 2008*	*2020 (%)*	*Source 2020**
Biodiesel	**83**		**72**	
Rapeseed	57	Europe	40	Europe and imports
Soya	20	Argentina, USA	11	Argentina, USA
Palm oil	4	South East Asia	17	South East Asia
Sunflower	2	Europe and imports	4	Europe and imports
Bioethanol	**17**		**28**	
Sugar cane	6	Brazil	13	Brazil
Wheat	5	Europe	6	Europe and imports
Sugar beet	3	Europe	5	Europe
Maize	3	Europe and imports	4	Europe and imports

Table 2: Land using biofuels currently used in the EU[48] and estimations for 2020[49].

With regard to imports vs. domestic production, IFPRI-MIRAGE-BioF estimates that biodiesel imports will grow from 0.75 Mtoe in 2008 to 2.5 Mtoe in 2020 (mostly from Indonesia, Malaysia and Latin America); whereas bioethanol imports will increase from under

45 Commission's calculations based on total bioethanol volumes from "The EU Beet and Sugar Sector: A model of environmental sustainability " available at http://www.cibe-europe.eu/Press/Brochure%20CIBE-CEFS%20Final_05.05.2010.pdf.

46 Oil World March 2011.

47 In comparison, global production of cereals reached 2240 million tons, vegetable oils at 141 million tons and sugars at 174 million tons in 2009. OECD-FAO Agricultural Outlook 2010-2019.

48 Source: Progress report on Renewable Energy and supporting material. The Communication and the accompanying staff working documents are available here: http://ec.europa.eu/energy/renewables/reports/reports_en.htm.

49 Source: IFPRI-MIRAGE-BioF simulations.

1 Mtoe in 2008 to around 3.5 Mtoe in 2020 (mostly from Brazil). In addition, a total of 14 Mt of feedstocks will also be imported into the EU (rapeseed, oil palm and maize having the largest share) as a result of the additional demand[50]. Therefore, it is expected that about half of the biofuels consumed in the EU in 2020 would be domestically produced, with rapeseed being the main feedstock.

2.8.1.4. Biofuel installed production capacity

Production capacity in the EU, both installed and under construction, currently stands at 24.5 Mtoe, of which 19.8 Mtoe is for biodiesel and 4.3 Mtoe for bioethanol. With regard to its distribution across Member States, most of the EU biodiesel capacity can be found in Germany (4.5 Mtoe), Spain (3.7 Mtoe), France (2.3 Mtoe), Italy (2.1 Mtoe) and the Netherlands (1.2 Mtoe)[51]. The smaller bioethanol capacity is distributed across France (0.9 Mtoe), Germany (0.7 Mtoe), UK (0.5 Mtoe), Spain (0.4 Mtoe) and Poland (0.4 Mtoe)[52]. Advanced biofuels installed capacity is currently negligible and limited to a few pilot plants.

Although the installed biodiesel production capacity in Europe increased rapidly from 2006-7 onwards, it seems to have slowed down in 2010. In some countries such as Germany, it has shown a slight decrease in 2010, where some biodiesel facilities have been closed down, decommissioned or retrofitted to other production processes. Moreover, it is worth noting that due to a slow market uptake, capacity utilisation is at around 50%, with total 2009 European production standing at 8.2 Mtoe and 1.9 Mtoe for biodiesel and bioethanol respectively. Germany and France alone accounted for over 50% of EU biofuel production in 2009.

Other related industries include those involved in the processing of the feedstocks, particularly oil crops into vegetable oils before they are chemically treated to produce the final biodiesel product. In this context, there are some 150 oil crops processing and vegetable oils and fats production facilities across Europe, for which the trade in biodiesel products will be one of their major markets. Of a total of 13Mt of vegetable oil being pressed in the EU in 2008, the main producing country was Germany (4Mt), followed by France (1.9Mt), the Netherlands (1Mt), Spain (1Mt) and UK (0.8Mt). The main vegetable oils being produced were rapeseed oil (8Mt), followed by soya oil (2.5Mt) and sunflower oil (2Mt)[53]. Full datasets for all Member States can be found in Annex IX.

2.8.1.5. Deployment of biofuels

There is some uncertainty regarding how much biofuel can be blended with petrol and diesel, while maintaining associated warrantees from car manufactures. Based on the biofuel volumes estimated by Member States for 2020, it seems that, in volume terms, blends beyond 10% for diesel (currently at 7%) and around 15% for petrol (currently at 10%) will be needed to achieve the Renewable Energy targets EU-wide[54]. This is an important issue due to the long lead-times both in changing specification of car engines, the slow turnover of cars, and the long lead-time needed for changing fuel specifications. The use of various fuels as

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50 Although the model does not differentiate between commodities according to their market uses, imports of these feedstocks are attributed to the additional demand from biofuels.

51 Source European Biodiesel Board. Units adjusted to Mtoe.

52 Source Epure. Part of the installed bioethanol capacity quoted here is not only destined to the biofuel markets.Units adjusted to Mtoe.

53 Statistics from Fediol's website at www.fediol.be.

54 JEC Reference scenario: http://ies.jrc.ec.europa.eu/uploads/jec/JEC%20Biofuels%20Programme.pdf.

estimated by JEC (JRC/EUCAR/Concawe) towards 2020, taking the turnover of vehicles into account, is shown in the figure below[55].

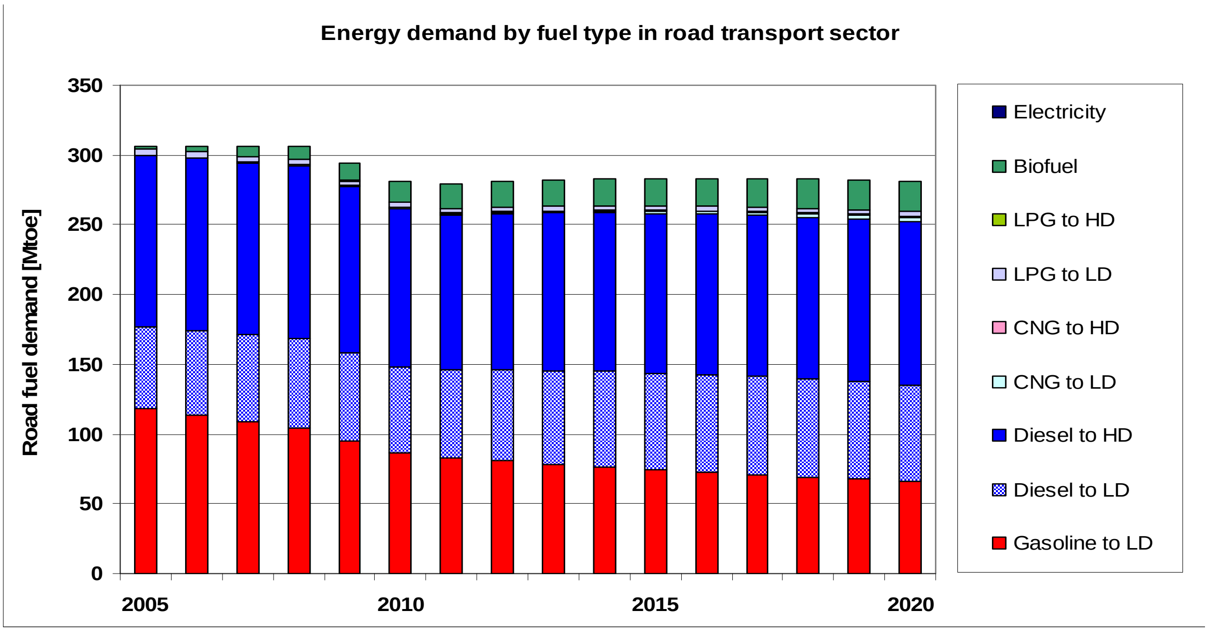

Figure 5: Energy demand by fuel type in road transport towards 2020 (source: JEC) Heavy duty and light duty vehicles are referred to as HD and LD

The use of petrol is expected to decline, while the use of diesel increases. With regard to biodiesel blends, work is currently underway to develop standards for B10 for cars and B30 for heavy duty engines. There are also a number of plants currently producing hydrotreated vegetable oils, which can be used at any blending levels. However, the latter fuel is likely to be in demand from the aviation sector, which may limit the supply available to the road transport sector.

In the case of bioethanol, the situation remains more challenging as the petrol/diesel split is estimated to increase in favour of diesel cars towards 2020, and in addition bioethanol has a lower energy content. Work on bioethanol blend standards is ongoing. While manufacturers can produce vehicles that are compliant with EU emission standards at petrol and bioethanol blends up to 95%, the sales of these vehicles are low in the EU. Certain countries such as Brazil and Sweden have shown that vehicles can readily be built to be compatible with higher levels of oxygenates and alcohols at a low additional cost (around 100€ per vehicle or lower). It is also possible to convert heavy duty vehicles to run on bioethanol.

In terms of current supply infrastructure available for E85 in the EU, total sales were estimated to be about 100 ktoe in 2008[56]. Sweden had by far the most selling points for E85, with 1300, followed by France with 320 and Germany (100). The UK, Ireland, Hungary, Norway, Spain and the Netherlands had fewer than 20 stations in 2008. The situation in Sweden seems to be driven by current incentives which include reduced registration charges and road taxes, free parking in some cities and waived congestion charges for flexi-fuel vehicles[57].

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55 The study can be found here: http://ies.jrc.ec.europa.eu/about-jec.

56 On the basis of extrapolation of the known sales in Germany (where the 100 filling stations selling E85 – 5% of the European total of such filling stations – sold about 5.5 ktoe of the fuel.

57 EC 2010 RES progress report available at http://ec.europa.eu/energy/renewables/reports/doc/sec_2011_0130.pdf.

Biofuels may also be employed in the shipping and aviation sectors. In terms of blending requirements, they have opposite features; most ships can run on most hydrocarbons, but the safety requirements for aviation are strict and only certain types of biofuels can be used. Three types of biofuels are favoured to be used in aviation engines, when blended with kerosene: Synthetic Fischer-Tropsch (FT) based kerosene, Hydrogenated Vegetable Oils (HVO) and Hydrogenated Pyrolysis Oils (HPO) produced from lignocellulosic biomass. At the moment only HVO is available, but the two other biofuels are expected to be available by 2020. So far no targets have been established for either the shipping or aviation sector. However, the aviation sector aims to use around 2Mtoe of biofuels by 2020.

2.8.2. Indirect land-use change greenhouse gas emissions assumed in the baseline

The evaluation of the policy options requires a baseline scenario that the policy options can be compared against. As discussed in section 2.3, indirect land-use change can only be estimated through modelling, and the Commission has taken the view that although a number of limitations and uncertainties remain, the IFPRI-MIRAGE-BioF is considered to be the best available estimation of the baseline. Further results as well as the key assumptions of the IFPRI-MIRAGE-BioF model are summarised in Annex V.

The ATLASS consortium has, since the publication of the Commission report on indirect land-use change last year, conducted more analysis. The latest results provide an estimate of overall land-use change emissions based on the additional 2020 biofuel volumes estimated by the Member States compared to 2008[58]. However, it is important to note that since the modelling assumes that the sustainability criteria have no effect, the baseline assumes consumption of some biofuels that might not meet the greenhouse gas savings and the land-use criteria in 2020.

It is also worth noting that no further implementation of LULUCF accounting in the run up to 2020 is assumed in the model. However, if complete accounting for land-use, land-use change and forestry, in the framework of a system of global emissions targets was implemented, this would send price signals providing disincentives for such conversions. As described in more detail in section 2.5.3 a move towards including LULUCF in the EU's GHG reduction target can only be considered once Member States have implemented the accounting framework and it has proven to be robust within the EU. Other initiatives, such as the moratorium for peatland and primary forests agreed between Norway and Indonesia, in the context of REDD+, might also impact on indirect land-use change emissions[59]. Such agreements are not reflected in the modelling.

2.8.2.1. Total estimated indirect land-use change impacts

IFPRI-MIRAGE-BioF estimates the indirect land-use change emissions from 2008 to 2020 to amount to around 500 Mt of CO_{2eq}. These emissions are equally divided between peatland emissions (in South East Asia), losses of biomass below ground, and changes in above ground biomass. Emissions from peat conversion have a larger impact on the overall emissions attributed to oil crops, particularly for palm oil, than for bioethanol crops. The range of

[58] In their modelling, it was assumed that half of those biofuels double counted under the RED were considered to come from waste and residues, having no ILUC impact, whereas the other half was modelled as increased bioethanol demand.

[59] See press release here: http://www.regjeringen.no/upload/MD/2011/vedlegg/klima/klima_skogprosjektet/Press_Release_Inpres_Mo_atorium_ENG.pdf.

estimated indirect land-use change emissions is 24 g/MJ to 50 g/MJ, with an average of 38 gram CO_{2eq}/MJ based on the assumed biofuel mix. This estimate of indirect land-use change emissions is based on conversion of around 1.7 Mha of land, which is taking place in a range of regions globally, mostly in Brazil and the Commonwealth of Independent States (CIS).

With regard to the estimated biodiversity impacts, IFPRI-MIRAGE-BioF study showed that this new cropland is taken from pasture (42%), managed forest (39%), primary forest (3%) and savannah and grassland (16%), which will have biodiversity and wider environmental impacts. A qualitative estimation of these impacts made by the JRC using the Mean Species Abundance (MSA) values provided by the Global Biodiversity Model (GLOBIO 3)[60,61], shows that the largest biodiversity losses will be associated with the conversion of primary forest, and savannah and grassland (both at 100% MSA), pasture land (70% MSA) and managed forest (50% MSA) in order of decreasing significance. Cultivated and managed areas receive a score of 10% MSA under the same classification[62]. Please see Annex X for more detail.

	Forest managed	Forest primary	Pasture	Savannah Grassland	Other	**TOTAL**
Brazil	3%	1%	10%	3%	0%	**18%**
Central America and Caribbean	0%	0%	1%	0%	0%	**1%**
China	6%	0%	2%	0%	0%	**8%**
CIS	11%	0%	9%	3%	0%	**23%**
EU27	4%	0%	1%	2%	0%	**7%**
Indonesia and Malaysia	5%	0%	2%	0%	0%	**7%**
Latin America	3%	1%	1%	4%	0%	**9%**
Rest of the OECD	1%	0%	1%	1%	0%	**3%**
Rest of the World	4%	0%	4%	1%	0%	**9%**

60 GLOBIO 3 is developed by a consortium made up of UNEP world Conservation Monitoring Centre (WCMC), UNEP/GRID-Arendal and the Netherlands Environmental Agency (PBL). [Alkemade et al, 2009].

61 Biodiversity is described in GLOBIO3 on the basis of the remaining mean species abundance (MSA) of original species, relative to their abundance in pristine or primary vegetation, which are assumed to be not disturbed by human activities for a prolonged period. MSA is therefore considered as the indicator for biodiversity.

62 For example, according to the MSA values in the table, a transition from pastureland (MSA 70%) to cropland (MSA 10%) will cause a loss of 60% of MSA on top of the 30% already lost from the conversion from natural land to pastureland.

Sub-Saharan Africa	1%	0%	11%	1%	0%	**13%**
USA	1%	0%	0%	1%	0%	**2%**
TOTAL	**39%**	**3%**	**42%**	**17%**	**0%**	**100%**

Table 3: Percentage land converted by type and world region. Source: IFPRI-MIRAGE-BioF

2.8.2.2. Estimated indirect land-use change impacts by feedstock

The overall estimated indirect land-use change emission impact is the aggregate of a set of sub-results, such as country of origin and feedstock. It is therefore relevant to present the crop-specific indirect land-use change emission estimates, as these are components of the overall baseline impact. The IFPRI-MIRAGE-BioF model has recently been combined with a Monte Carlo simulation, to provide a better description of the probability distribution of the uncertainty associated with the variables. More information on this analysis can be found in Annex XI.

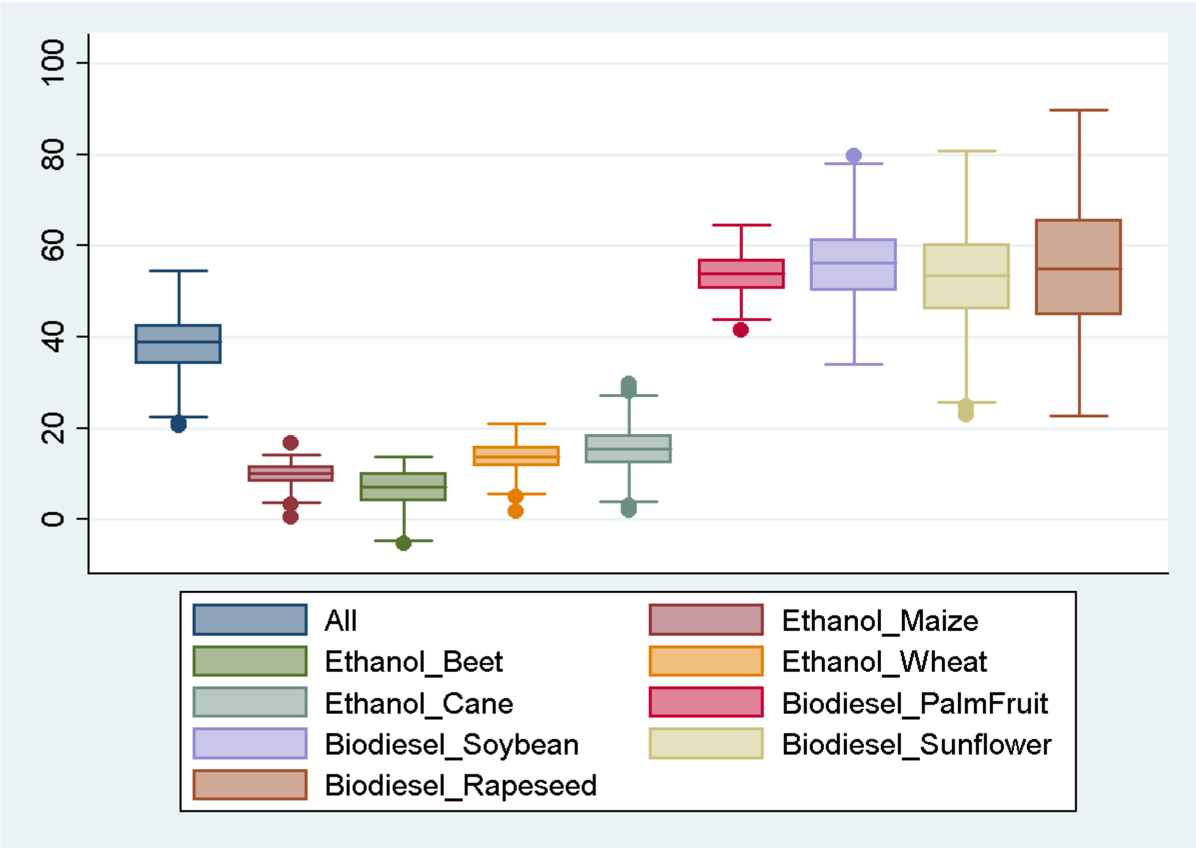

Figure 6: Results of the Monte-Carlo analysis: estimated indirect land-use change emissions (gCO2/MJ)- under scenario of current trade policy. The bars indicate 1st and 99th percentile, while the boxes are 25th and 75th percentiles.

It is important to note that these crop specific values are estimated based on the increase of biofuel consumption towards 2020 compared to the existing consumption in 2008. They are therefore not representative for the around 10 Mtoe already consumed in 2008. Indeed, it is pointed out that for rapeseed, which is the most important feedstock used in 2008 (5.7 Mtoe out of a total of 10 Mtoe), the average land-use change is significantly lower in the baseline.

With regard to the values for cereal crops, it should also be born in mind that some of the assumptions on the yields of EU wheat and US/Brazil maize are considered strongly optimistic. Although these assumptions can significantly influence the estimated indirect land-use change emissions for these crops, they have not been included in the Monte Carlo analysis.

2.8.2.3. Establishing a greenhouse gas emissions baseline for biofuels in 2020

In order to establish a greenhouse gas emissions baseline for biofuels, it is necessary to compare the estimated indirect land-use change emissions to the expected direct greenhouse gas savings from substituting fossil fuels in 2020. In this context, assumptions regarding the expected improvements in greenhouse gas emissions performance of biofuels, as well as changes in the carbon intensity of fossil fuels to 2020 need to be made.

With regard to the expected improvements in greenhouse gas emissions performance of biofuels towards 2020, COWI[63] estimated how various feedstocks would develop. However, those values do not take into account more recent developments (such as the ETS proposals for ammonia and nitric acid plants in EU), and do not cover improvements for all feedstocks. As such, these have been adjusted by JRC to allow for comparison across all biofuels[64]. The results combined with the estimated indirect land-use change emissions are summarised in the table below[65].

	Average estimated ILUC emissions	Direct emission savings	Total emissions
Maize	10	-57	-47
Sugar beet	7	-63	-56
Sugar cane	15	-70	-54
Wheat - Not specified	14	-40	-26
Wheat - Natural gas/CHP	14	-56	-43
Wheat - Straw/CHP	14	-68	-55
Waste/2nd generation bioethanol - land using	15	-73	-58
Waste/2nd generation bioethanol - non-land	0	-81	-81
Waste/2nd generation biodiesel - land using	15	-85	-69
Waste/2nd generation biodiesel- non-land using	0	-81	-81
Palm oil	54	-39	15

63 See details on assumptions in chapter 2.2 of the report: Technical assistance for an evaluation of international schemes to promote biomass sustainability (2009) http://ec.europa.eu/energy/renewables/bioenergy/sustainability_criteria_en.htm.

64 The fossil fuel comparator for biofuels in 2020 has also been estimated. Please see Annex VI.

65 Values that were not included in the COWI set are based on the typical values in the Directives, however, improved with the same percentage as other bioethanol fuels or biodiesel fuels respectively. Although the specific indirect land-use change emissions associated with typical land using second generation biofuels were not modelled, these are assumed to be at the same level as for sugarcane in the assessment of the options (i.e. high yielding crops with no land saving co-products).

Palm oil with methane capture	54	-61	-7
Rapeseed	55	-50	5
Soybean	56	-43	13
Sunflower	54	-58	-4

Table 4: Typical annual direct savings compared to estimated indirect land-use change emissions per crop (gCO_2/MJ). Source: ATLASS (2011), COWI and Commission's calculations

2.8.2.4. Sensitivity of the baseline scenario

The uncertainty of estimating indirect land-use change implies that several sensitivities should be investigated. In the assessment of the options, sensitivity analysis is limited to the changes of the assessment of the efficiency of the different options by the range of estimated indirect land-use change impacts (5^{th} and 95^{th} percentiles) from the Monte Carlo analysis (see figure 6). With regard to the average estimated indirect land-use change emissions at 38 g/MJ respectively, the 5^{th} and the 95^{th} percentile values of the distribution are a range of 24 g/MJ to 50 g/MJ[66].

2.9. The right to act

Articles 19(6) and 7d(6) of the Directives particularly require the Commission to address the issue of indirect land-use change, as explained in Chapter 1. The overall objective of the Fuel Quality and Renewable Energy Directives is to contribute to the goal of reducing economy-wide greenhouse gas emissions through the promotion of renewable energy sources. As a way to achieve that, they create an EU-wide fuel market and market for renewable energy, the Member States per se are not able to meet these challenges individually for the following reasons:

- the sustainability criteria of the Directives have their legal basis in Article 114 of the Treaty: internal market. The indirect land-use change impacts necessarily have transnational aspects which cannot be dealt with satisfactorily by Member States, when the EU wants to establish a functional EU-wide market for biofuels. Since there will also be international trade in biofuels with countries outside the EU, this can also not be properly regulated at Member State level.

- it has to be considered whether and how the objectives could be better achieved by action on the part of the EU: the “test of European added value”. The rationale for European action in the field of biofuels has already been decided with the adoption of the Fuel Quality and Renewable Energy Directives. This stems from the transnational nature of the identified problem and the desire to create a single market in renewable and lower greenhouse gas intensity energies for transport.

For these reasons, the policy objectives set out in section 3 of the present Impact Assessment report cannot be sufficiently achieved by actions of the Member States alone, but have to be coordinated and harmonised across the EU.

[66] It is also worth noting that average emissions reached 116g/MJ under an extreme scenario not included in the sensitivity analysis where the increased demand for biofuels did not lead to either yield increases, food consumption reductions or intermediate consumption of agro-foods compared to the baseline.

2.9.1. Precautionary principle

Article 191(2) of the Treaty states that EU policy on the environment shall be based on the precautionary principle. In view of this, the Commission noted in its December 2010 report on indirect land-use change that action should be based on the precautionary approach.

3. SECTION: POLICY OBJECTIVES

As explained in more detail in section 2.1, the Directives contain a number of sustainability criteria which are aimed at preventing direct land-use change of areas of high carbon stock and high biodiversity value for the production of biofuels, as well as setting minimum greenhouse gas emission savings compared to fossil fuels[67]. Although the current greenhouse gas emissions performance methodology takes account of emissions associated with direct land-use change, as well as emissions coming from the production of biofuels, it does not include emissions from indirect land-use change.

In response to the requirement for the Commission to review the impact of indirect land-use change on greenhouse gas emissions and to propose ways to minimise them if appropriate[68], the Commission published a report[69] in December 2010 which (i) identified a number of uncertainties and limitations associated with the available numerical models used to quantify indirect land-use change; (ii) acknowledged that indirect land-use change can reduce greenhouse gas emissions savings associated with biofuels; and (iii) indicated that if action is required, indirect land-use change should be addressed under a precautionary approach. In view of the above, the fundamental policy objective for the Commission's continued work on indirect land-use change is to provide a full response to the request laid down in the Directives[70]:

The Commission shall, by 31 December 2010, submit a report to the European Parliament and to the Council reviewing the impact of indirect land-use change on greenhouse gas emissions and addressing ways to minimise that impact. The report shall, if appropriate, be accompanied, by a proposal, based on the best available scientific evidence, containing a concrete methodology for emissions from carbon stock changes caused by indirect land-use changes, ensuring compliance with this Directive, in particular Article 17(2).

Such a proposal shall include the necessary safeguards to provide certainty for investment undertaken before that methodology is applied. With respect to installations that produced biofuels before the end of 2013, the application of the measures referred to in the first subparagraph shall not, until 31 December 2017, lead to biofuels produced by those installations being deemed to have failed to comply with the sustainability requirements of this Directive if they would otherwise have done so, provided that those biofuels achieve a greenhouse gas emission saving of at least 45 %. This shall apply to the capacities of the installations of biofuels at the end of 2012.

The Articles and the corresponding recitals[71] allude to the development of a calculation methodology for capturing indirect land-use change emissions. However, due to the right of initiative, the Commission wishes to consider other options which the Commission believes can also meet the policy objectives in a suitable way. The Commission evaluates four different options in this Impact Assessment, as laid down in chapter 4; "Policy Options".

To enable the assessment of the options, it is desirable to understand the general policy objectives and narrow these down to a description of more specific, operational objectives.

67 This requirement is progressive as it increases to 50% in 2017 and 60% in 2018 for new installations.
68 Article 7d(6) of Directive 2009/30/EC and Article 19(6) of Directive 2009/28/EC.
69 COM(2010) 811.
70 Article 19(6) of the Renewable Energy Directive and Article 7(d)6 of the Fuel Quality Directive.
71 Recital 85 of the Renewable Energy Directive and Recital 22 of the Fuel Quality Directive.

3.1. Treaty based general objectives

The EU's policies on the promotion of the use of biofuels have always been developed in the context of EU energy policy and EU policy aimed at protection of the environment. The development of new and renewable forms of energy is specifically foreseen as an objective in the Treaty and it is clear that this goal is pursued with regard to the need to enhance security of energy supply and that of preserving and improving the environment. The Treaty foresees that environmental protection must be built into all policy areas and action to reduce climate change is specifically foreseen within the Treaty as an environmental objective.

The provisions on sustainability criteria, including the requirement to analyse indirect land-use change emissions, are based on the functioning of the internal market provisions of the Treaty. Any legislative proposal that addresses indirect land-use change emissions must therefore also be based on these provisions.

3.2. General objectives

The general objectives are those of the Directives. In context of the Renewable Energy Directive, Recital 65 summarises the general environmental objective related to the use of biofuels:

> *Biofuel production should be sustainable. Biofuels used for compliance with the targets laid down in this Directive, and those that benefit from national support schemes, should therefore be required to fulfil sustainability criteria.*

The content of Recital 65 is reflected in Article 17 of the Directive, which requires biofuels to be sustainable, and in particular Article 17(2) thereof, which in context of greenhouse gas savings requires biofuels to save at least 35% compared to fossil fuels, increasing to 50% in 2017 and 60% in 2018 for new installations.

The objectives of the Fuel Quality Directive in relation to the use of biofuels are reflected in Recitals 9 and 10:

> *Biofuel production should be sustainable. Biofuels used for compliance with the greenhouse gas reduction targets laid down in this Directive should therefore be required to fulfil sustainability criteria.(…).*
>
> *Suppliers should, by 31 December 2020, gradually reduce life cycle greenhouse gas emissions by up to 10 % per unit of energy from fuel and energy supplied. This reduction should amount to at least 6 % by 31 December 2020, compared to the EU-average level of life cycle greenhouse gas emissions per unit of energy from fossil fuels in 2010, obtained through the use of biofuels, alternative fuels and reductions in flaring and venting at production sites.(…).*

Recital 4 is reflected in Article 7b, which sets identical sustainability requirements as Article 17 of the Renewable Energy Directive. Recital 10 is reflected in article 7a which states that Member States shall require fuel suppliers to reduce as gradually as possible life cycle[72]

[72] The Fuel Quality Directive defines "life cycle greenhouse gas emissions" as the net emissions of CO2, CH4 and N2O that can be assigned to the fuel, included any blended components, or energy supplied. This includes all relevant stages from extraction or cultivation, including land-use changes, transport and distribution, processing and combustion, irrespective where those emissions occur (Article 1.2 of the Fuel Quality Directive).

greenhouse gas emissions per unit of energy from fuel and energy supplied by up to 10 % by 31 December 2020, compared with the fossil fuel baseline representing 2010.

3.3. Specific and operational objectives

As described in section 2.1, this impact assessment is focused on the specific requirement in the Directives related to greenhouse gas emissions from indirect land-use change and does not consider any wider environmental and social impacts associated with the use of biofuels. As such, the general objectives presented above translate into the following specific/operational objective to:

> *Minimise the impact of indirect land-use change on greenhouse gas emissions of biofuels, within the wider policy objectives of the targets that by 2020 at least 10% of transport fuels are renewable and that greenhouse gas intensity in road transport fuels is reduced by at least 6% compared to 2010.*

The policy options will be evaluated in context of the extent to which the options fulfil this specific objective.

4. SECTION - POLICY OPTIONS

4.1. What are the possible options for achieving the policy objectives?

Further to the option referred to in the Directives, the development of a concrete methodology for emissions from carbon stock changes caused by indirect land-use change from biofuels that could be included in the greenhouse gas calculation, the Commission wishes to consider the effectiveness of a number of options aimed at minimising indirect land-use change impacts. The policy options, including those initially set out in the Commission's report on this topic adopted in December 2010, are:

A. take no action for the time being, while continuing to monitor,

B. increase the minimum greenhouse gas saving threshold for biofuels,

C. introduce additional sustainability requirements on certain categories of biofuels,

D. attribute a quantity of greenhouse gas emissions to biofuels reflecting the estimated indirect land-use impact.

E. limit the contribution from conventional biofuels to the Renewable Energy Directive targets to current production levels.

4.2. Option A – take no action for the time being; while continuing to monitor

This option refers to the Commission's bi-annual monitoring and reporting of impacts, including indirect land-use change, as required by the Renewable Energy Directive[73], the first of which is due in 2012. The option also implies continued monitoring of the scientific developments related to estimating indirect land-use change emissions.

During the latest consultation on policy options, option A was preferred by those stakeholders who believed that the current state of development of the models was not appropriate to base policy approaches upon. This included most of the industry, farmers' associations and biofuel producing third countries.

4.3. Option B - increase the minimum greenhouse gas saving threshold for biofuels

This option consists of increasing the current minimum greenhouse gas savings thresholds provided in the Directives[74], currently at 35% compared to average fossil fuels. According to the Directives, this requirement is increased to 50% in 2017, and 60% in 2018 for installations that started production in 2017.

Option B aims at a) *compensating* for the estimated indirect land-use change emissions through requiring higher *direct* savings, and thereby improving the overall greenhouse gas performance of the biofuels consumed and; b) *reducing* indirect land-use change emissions through raising the threshold to such a level that many of the biofuels with estimated large indirect land-use change emissions are excluded.

73 Article 23 of 2009/28/EC.
74 Article 17.2 of 2009/28/EC and Article 7b.2 of 2009/30/EC.

The increased level of the threshold should be achievable for a set of feedstocks, while at the same time maximizing the direct greenhouse gas savings. The level must be technically feasible for a range of feedstocks, but require improvements beyond what is required by the Directives today. A discussion of the exact level of the threshold is set out in chapter 5.

This option implies changing Article 17 of the Renewable Energy Directive and Article 7b of the Fuel Quality Directive.

Option B was not supported by any particular stakeholder group during the last consultation exercise, as stakeholders generally favoured option A or option D.

4.4. Option C - introduce additional sustainability requirements on certain categories of biofuels

This policy option consists of introducing additional sustainability requirements aimed at mitigating the risk of indirect land-use change emissions. As such, compliance with a number of additional criteria could be required at national (country) level or at project/farm level as detailed in sub-options C1 and C2 below. These options are very different in their approach and are therefore, being treated as two separate sub-options. Both these options require changing Article 17 of the Renewable Energy Directive and Article 7b of the Fuel Quality Directive.

4.4.1. Option C1- country level actions

Given that indirect land-use change emission impacts associated with biofuels manifest themselves through unwanted direct land-use change across countries, and often as a result of inadequate land governance, option C1 is aimed at addressing such negative effects by improving land-use governance and protection of high carbon stock lands. More specifically, under option C1 biofuel producing countries including Member States, are requested to implement LULUCF methodology based (see chapter 2.5.3 for description) reporting (if not already in place) and protection of high carbon stock land. Simultaneously, efforts to increase the supply of biofuels with low risk of indirect land-use change emissions at a national level could be implemented.

To guarantee that option C1 reduces indirect land-use change emissions completely the option would need to be implemented globally, thus preventing any leakage. However, indirect land-use change emissions could be reduced and even over-compensated if the implementation of option C1 is successful, as it may reduce indirect land-use change emissions from *other* commodities. An example of this is provided below, where peatland emissions in Indonesia are halved.

Stopping conversion of peatlands in Indonesia would have a considerable impact on the estimated indirect land-use change emissions from all oil crops, as their production is assumed by the models to cause indirect conversion of peatland (i.e. more than the third of the estimated indirect land-use change emissions are from peatland). Moreover, the protection of peatland would also limit the land-use change emissions from other agricultural commodities (both directly and indirectly), as demand for biofuels is only one of many drivers for increased production of vegetable oils globally. Wetlands International[75] reports that emissions from peatlands in Indonesia alone in 2008 amounted to 500 Mt. This implies that *one* year of emissions from peatland in Indonesia is ten times higher than the estimated annual

75 Wetlands International (2010).

indirect land-use change emissions in 2020. However, the overall effectiveness of this option relies on whether countries choose to comply or not, which is outside the control of the EU and therefore it is not possible to guarantee that the results will develop in a certain way. This is further analysed in chapter 5.

During the latest consultation on policy options, most of the industry and farmers' associations supported the use of international action to address indirect land-use change emissions, although not necessarily in the same terms as outlined in this sub-option.

4.4.2. Option C2- project level actions

This sub-option refers to practices that could prevent indirect land-use change by producing feedstocks without the need for *additional* land. Potential mitigation measures would include:

(a) Using land without provisioning services[76] that would be unlikely to be taken into production in the absence of biofuel demand (i.e. typically land that either requires some form of remediation prior to being used or where significant barriers exist). Expanding production on unused land may lead to direct land-use change, but the latter would be addressed by the current sustainability criteria and therefore directed to those areas where effects are acceptable.

(b) Increasing yields above projected future trends which would not have happened in the absence of biofuel demand. This could lead to the production of biofuel feedstocks without increasing the pressure on land and therefore limiting indirect land-use change emissions. In this case, only the additional feedstock production should be considered as meeting this requirement.

(c) Integrating biofuels and non-bioenergy production systems (i.e. land-used for cattle farming) in ways that lead to a higher overall land productivity. Again this integration would be additional to what would have happened in the absence of the biofuel demand.

In order for indirect land-use change to be prevented, it would also be necessary to ensure that the actions put in place are additional and that would not have been implemented in the absence of these criteria. Both the reporting and verification processes could be foreseen to be incorporated into the existing reporting and verification systems established under the sustainability scheme, which already requires the collection of detailed information across the supply chain by economic operators or managers of sustainability schemes on land-use and cultivation practices in order to demonstrate compliance[77]. In addition, the process for verification would require that an assessment at project level is carried out before the project is approved, although it would seem reasonable to assume that *additionality* would only need to be proven once within the legislative period.

The literature[78] indicates that the potential for producing biofuels in this way is significant, and that the share of non-EU crops would increase if this option was to be implemented (i.e.

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76 The Millennium Ecosystem Assessment distinguishes four categories of ecosystem services: provisioning services, regulation services, cultural services and supporting services. Provisioning services are defined as harvestable goods such as fish, timber, bush meat, genetic material, etc.

77 Further detail can be found at http://eurlex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:C:2010:160:0008:0016:EN:PDF.

78 Please see description of this option under Annex XII for further detail.

sugarcane, soy and palm oil) as opportunities for intensification seem to be greater in certain world regions (i.e. Brazil, South East Asia).

The full details for implementing these criteria would need to be developed at a later date. A more detailed description of these measures as well as a summary of their potential can be found in Annex XII.

Most NGOs supported sub-option C2 during the last consultation in combination with option D. The rationale behind this approach is that biofuels produced under the conditions outlined above, would in theory mitigate the risk that their production would trigger indirect land-use change. Option D was by these stakeholders believed to be a strong incentive for the actions described under sub-option C2 to be implemented, which in some cases would require significant changes in current production practices.

4.5. Option D - attribute a quantity of greenhouse gas emissions to biofuels reflecting the estimated indirect land-use impact.

This is the option referred to in the Directives, which would require incorporating estimated indirect land-use change emissions values in the reporting of existing greenhouse gas methodology[79,80], including ensuring compliance with minimum greenhouse gas thresholds[81]. A new Annex VIII would need to be added to the Renewable Energy Directive and a new Annex V to the Fuel Quality Directive.

This option implies incorporating the estimated indirect land-use change emissions of biofuels into the emission calculation. However, there are a number of issues that need to be described, as the use of a factor may not be appropriate in some circumstances (i.e. non-land using feedstocks such as algae).

These various elements are set out below:

- Evaluate the introduction of different estimates of factors (***eiluc***) into the greenhouse gas calculation representing the estimated indirect land-use change greenhouse gas emissions and taking into account the results of the Monte Carlo analysis from the IFPRI-MIRAGE-BioF.

- Define the situations where ***eiluc*** should have a value of zero because there is no displacement of agricultural activity. This is likely to be appropriate for the following circumstances,

  i.) Waste and residual materials are used as feedstocks.

  ii.) The feedstock does not require land for its production (i.e. algae).

  iii.) The production of the feedstock has led to 'direct land-use change', and as such an el value has been calculated in accordance to greenhouse gas emissions methodology.

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79 Annex V C of 2009/28/EC and Annex IV C of 2009/30/EC.

80 Member States are required to report the greenhouse gas emissions savings from biofuels under the general reporting requirements set by Article 22 of the Renewable Energy Directive and for demonstrating compliance with the greenhouse gas emissions reduction target set by Article 7a of the Fuel Quality Directive.

81 The minimum greenhouse gas savings threshold is 35%, raising to 50% in 2017.

When assessing this option, consideration will be given at setting the indirect land-use change emission factors ***eiluc*** at levels which mitigate/anticipate the risk of a possible model i) overestimation (50%, 25%, 5% percentiles) and ii) underestimation (50%, 75%, 95% percentiles) of crop-specific indirect land-use change factors. In addition, consideration will be given to the degree of disaggregation these factors should be set at (i.e. feedstock specific or crop group level i.e. oil crops, sugars and cereals).

As with the current methodology for default greenhouse gas emissions values, it would be required to consider whether a review process[82] needs to be established within the Directives for updating these values. Consideration will be given as to whether safeguards for investment from the introduction of this particular option, as stated in the Directives[83], should be introduced.

Most NGOs and a few industrial stakeholders from the non-biofuel sectors supported this option during the last consultation. This was also the most supported option during the international scientific expert workshop with academics and experts organised by the JRC in November 2010.

4.6. Option E - Limit the contribution from conventional biofuels to the Renewable Energy Directive targets.

This option aims at minimising the indirect land use change impacts of biofuels by limiting the amount of conventional biofuels that can be counted towards the Renewable Energy Directive targets to current production levels. The risk of indirect land use change is mostly associated with conventional biofuel feedstocks grown on high yielding agricultural land. To limit the consumption of such biofuels therefore also limits the risk of indirect land-use change emissions. Moreover, such a limit will require that the remaining amount of biofuels needed to achieve the 10% Renewable Energy Directive transport target would need to come from advanced biofuels with lower indirect land use change risks, which will significantly improve the biofuel mix that can be expected in 2020.

This option implies changing Article 3 of the Renewable Energy Directive.

Although Option E was not included as one of the shortlisted options by the Commission in the last consultation exercises, options aimed at limiting the amount of conventional biofuels while increasing the incentives for advanced biofuels were favoured by NGOs and certain industrial stakeholders.

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[82] Article 19.7 of 2009/28/EC and Article 7d. 6 of 2009/30/EC.

[83] The Directives include a clause that would mean that biofuels should not be regarded as failing to comply with the sustainability criteria until 2018 (as long as they achieve 45% minimum savings when direct savings are looked at and are produced in a plant installed prior to 2013), should such methodology be introduced.

5. ANALYSIS OF IMPACTS

5.1. Assessment methodology

5.1.1. Introduction

The baseline estimated indirect land-use change greenhouse gas emissions impacts are outlined in chapter 2. Consequently, the different policy options assessed here focus on potential ways of minimising these impacts. The assessment focuses on the impacts resulting from the potential changes in feedstock availability[84] following intervention.

The assessment of the policy options has been carried out according to their *effectiveness*, in achieving the policy objectives in chapter 3[85] and their likely wider environmental, economic[86] and social impacts, as well as their consistency with other EU policies. Further detail can be found in Annex XIII.

The particular question of administrative burden and associated costs is addressed to the extent possible for options B and C2. In the case of option B, this is because it is not possible to know precisely to what extent certain feedstocks will be excluded (in which case there would be economic impacts but no administrative costs) or the extent to which economic operators would need to report actual greenhouse gas emissions values to meet increased requirements. With regard to option C2, the potential certification system is still being developed and therefore some costs from current pilots are presented as an indication only. Option C1 has administrative costs related to the verification of LULUCF reporting. All other options are considered to have insignificant additional administrative costs because they are all based on the current framework for verifying compliance with existing sustainability criteria under the Directives[87].

5.1.2. Development of scenarios

In most cases, it is expected that options will limit the availability of qualifying biodiesel feedstocks as these typically present both higher direct and estimated indirect land-use change emissions. In order to compensate for the reduced availability of biodiesel and so to still achieve the targets of the Directives, the contribution from all the available Renewable Energy transport technologies (i.e. bioethanol, advanced biodiesel and electric cars) is increased by similar amounts to maintain the 5.4% reductions in greenhouse gas intensity towards the Fuel Quality Directive found in the baseline. It should be stressed that this is a

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84 Note that "availability" refers to whether the feedstock meets the greenhouse gas saving threshold, and is not related to physical availability of the feedstock.

85 The effectiveness criteria assesses whether policy options are minimising the greenhouse gas impact of biofuels, while ensuring that emissions from biofuels are below the required thresholds set out in the Directives, as well as respecting the greenhouse gas emissions reduction target set out in the Fuel Quality Directive.

86 As the level of uncertainty of the indirect land-use change emission estimates included in the baseline is already high, the introduction of further uncertain results through assumptions on costs gives rise to counterintuitive results, and risks of misinformed assessment. The assessment of costs is therefore limited to a qualitative level.

87 Please see article 7b of 2009/30/EC, Article 18 of 2009/28/EC and related guidance (http://eurlex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:C:2010:160:0001:0007:EN:PDF). An assessment of the administrative burden associated with the current verification framework can be found in the impact assessment of the energy and climate package (Chapter 6.7.1.5. How should performance be verified? – page 149).

purely theoretical exercise which does not necessarily lead to realistic results. Alternatively, but not assessed here, a higher contribution from the use of LPG and venting and flaring reductions could contribute towards the carbon intensity reduction targets in the Fuel Quality Directive[88].

With regard to the final biofuel mix, key factors are expected to include the ability of the biofuel industry to improve the greenhouse gas emissions performance of pathways associated with conventional feedstocks (i.e. particularly oil crops) in order to comply with higher greenhouse gas emissions standards, and the ability of technologies using alternative feedstocks (i.e. non-land using feedstocks) to come to market within given timescales. In those cases where the availability of conventional biodiesel feedstocks is severely restricted, a number of car fleet compatibility issues associated with higher bioethanol blends or higher shares of certain feedstocks, such as palm oil, may arise. Further information on the current situation can be found in Annex XIV.

5.1.3. Assessment limitations

In order to appropriately interpret this assessment, the following limitations/simplifications should be born in mind;

- in reality, the indirect land-use change emissions could be higher or lower. As discussed in chapter 2 and particularly Annex III, there are still, and will possibly always remain, considerable limitations and uncertainties related to estimating indirect land-use change emissions. However, given the need to analyse the issue in a quantitative manner, it has been necessary to use the latest results from IFPRI-MIRAGE-BioF as the baseline.

- the modelling of indirect land-use change emissions assumes that the sustainability scheme has no effect. Still, in this assessment it is assumed that it actually reduces both direct emissions and indirect land-use change emissions through a reduction in consumption in the EU of biofuels from a particular feedstock, according to the estimates made by IFPRI-MIRAGE-BioF.

- although measures considered here for biofuels are also applicable to bioliquids, no calculations have been specifically made using their fossil fuel comparators[89]. This is not likely to give rise to any leakage issues (i.e. where excluded biofuels may be diverted to bioliquid market), as the assumed fossil fuel comparator value for 2020 here (90.3 g/MJ) is very close to the highest value provided for bioliquids.

- the question of whether a particular feedstock passes or not is a simple yes or no question. However, there are several conditions that determine the greenhouse gas emissions performance associated with different feedstocks, including potential improvements in greenhouse gas emissions performance, and hence whether they can ultimately meet the minimum thresholds set out in the Directives. Moreover, the

[88] In the baseline, which is based on how the MS are planning to meet the RED targets, the fulfilment of the Fuel Quality Directive is -5.4%. As such, it is therefore assumed that the remaining contribution percentage point will be achieved through non-RES technologies qualifying for the FQD such as flaring and venting. This is uncertain and should this not be the case, even more biofuels or electric vehicles would be needed to meet the Fuel Quality Directive.

[89] See footnote 31.

potentially increased attractiveness of e.g. the severely degraded/heavily contaminated land greenhouse gas bonus[90] is not assessed.

- the analysis is based on the year 2020 (i.e. for analytical purposes, as all the assumptions made are related to that year). All indirect land-use change emissions are assumed to be mitigated when action is taken in 2020. This is an oversimplification, as indirect land-use change impacts are of cumulative nature and irreversible in the period to 2020[91]. Moreover, it should be noted that although the assessment is done for only one year, the indirect land-use change emissions included in the greenhouse gas emissions balance of biofuels are averaged over a 20 year period in accordance with the existing methodology in the Directives.

- some of the options result in biofuels made from certain feedstocks being unable to meet the sustainability criteria of the Directives. The deficit that this might lead to would need to be covered by other feedstocks or means to comply with the targets. A range of factors, such as costs, technical blending possibilities, technical vehicle specifications and infrastructure developments influence how the deficit can or cannot be covered. None of these factors have been assessed in detail in this Impact Assessment.

Given all these uncertainties, it is important to bear in mind that the results presented in this section should be used with the utmost caution.

5.2. Option A - Take no action for the time being, while continuing to monitor

Option A is the "no policy change" option, which implies that no further action to mitigate indirect land-use change emissions is taken, while continuing to monitor the development of key factors determining the indirect land-use change impact and the science needed to assess the scale and nature of the phenomenon.

5.2.1. Effectiveness in reducing greenhouse gas emissions

The main results in terms of reducing greenhouse gas emissions are shown in the table below.

Direct emissions only- biofuels only	Average emissions 2020 (g/MJ)	35
	Average emission savings 2020 [%]	61%
	Total direct emissions 2020 (Mt)	42
Indirect land-use change emissions- biofuels only	Average ILUC emissions 2020 [g/MJ]	42
	Total ILUC emissions 2020 [Mt]	48
Total emissions- direct and indirect- biofuels only	Average emissions 2020 [g/MJ]	77
	Average savings 2020 [%]	15%
Change against baseline	Indirect land-use change emissions	0
	Total emissions (Mt)	0

Table 5: Effectiveness analysis of option A

[90] See Annex V and Annex IV of the Renewable Energy Directive and Fuel Quality Directive respectively.

[91] It is important to consider the date of adoption and the date by which it enters into force, as both influence the response of economic actors. This is not taken into account.

Both direct and indirect land-use change emissions are as described in the baseline in section 2.8, as no action is taken. Estimated indirect land-use change emissions are not reported, but even if they were to be included in the methodology, the average reported savings for biofuels compared to fossil fuels would be at 15%[92]. Similarly, with regard to the Fuel Quality Directive target, the total emission savings offered by biofuels would be at 1.1%.

5.2.2. *Impacts on achieving the Renewable Energy Directive transport target*

The fulfilment of the 10% renewable energy in transport target can be met, as envisaged in the NREAPs, as neither the emission reduction thresholds nor the GHG methodology are changed.

5.2.3. *Economic impacts*

Option A continues the existing policy framework, leaving the sustainability scheme as currently laid down in the Directives unchanged. The biofuel and related industries, as well as farmers are thus ensured a stable policy framework, which enables investor certainty. This also implies that Member States and industry can continue to follow the submitted National Renewable Action Plans[93] (NREAPs), and the EU installed biofuel production capacity can be utilised.

Security of supply is maintained as foreseen, with 10% of the energy used in the transport sector being renewable, from diversified energy sources, with about half of the total demand being met by domestic production and half by imported.

Option A has no specific implications for trade policies and trade relations. Imports of biofuels and biofuel feedstocks, particularly biodiesel, are expected to increase significantly. This option has no additional implications for technological development and innovation as both developments in greenhouse gas emissions performance and advanced biofuel production remain as planned. No additional impacts on car manufacturers with regard to the levels of biofuel blending required other than those described in the baseline.

5.2.4. *Social impacts*

EU rural development and employment opportunities are not affected under this option, as activities in the agricultural and industrial sectors associated with the production of biofuels in the EU are not affected and continue to develop as planned. An estimated 400 000 jobs could thus be maintained in the sector.

The expected increase in demand for biodiesel and bioethanol to 2020 will increase the pressure on global commodity markets, particularly for vegetable oil as the EU demand for biodiesel represents a more significant share of the total production. As biofuel demand is inelastic, this increased demand could impact on certain manufacturers of food, cosmetics and daily care products who rely on the same raw materials, particularly vegetable oils.

Development objectives in third countries are difficult to assess, as such impacts are dependent on local factors. However, the current framework, which is continued under option

[92] If the sustainability criteria were assumed to have an effect (by eliminating certain feedstocks with high direct emissions), the emissions balance in the baseline is improved to 22%.

[93] All NREAPs are available here: http://ec.europa.eu/energy/renewables/transparency_platform/action_plan_en.htm.

A allows for a range of crops typically grown in developing countries to be supplied to the EU, as they typically fulfil the sustainability criteria.

5.2.5. Environmental impacts

According to the models, the estimated additional cropland requirements globally amount to 1.7 Mha, mainly in regions of the Commonwealth of Independent States, Sub-Saharan Africa and Brazil, and would be taken from pasture (42%), managed forest (39%), primary forest (3%) and savannah and grassland (16%). The JRC analysis of the land cover classification used by IFPRI-MIRAGE-BioF, suggests that the largest biodiversity losses would be associated with the conversion of primary forest, and savannah and grassland, pasture land and managed forest to cropland in order of decreasing biodiversity value[94].

Although it is not possible to provide any specific information on wider environmental impacts based on the model results, adverse water, soil and air impacts would be expected from the conversion of primary and managed forests, as well as the conversion of grassland.

5.2.6. Other impacts

As emission savings offered by biofuels would not reflect indirect land-use change, biofuels would contribute less to the integrated approach for CO_2 in cars[95].

5.3. Option B - Increase the minimum greenhouse gas saving threshold for biofuels

Option B follows the principles of the already existing sustainability criteria which contain thresholds for minimum greenhouse gas savings from biofuels compared to fossil fuels. To raise the threshold further would exclude certain feedstocks with higher direct emissions. The table below illustrates how increasing the threshold affects compliance for various feedstocks. As shown in table 4 in chapter 2.8, vegetable oils have high estimated indirect land-use change emissions; these are highlighted in red colour and bold letters in the table below.

	Feedstock	Direct greenhouse gas emissions (2020)	Allowed with **50%** threshold	Allowed with **55%** threshold	Allowed with **60%** threshold	Allowed with **65%** threshold	Allowed with **70%** threshold
		(g/MJ)	**45,4**	**40,8**	**36,3**	**31,7**	**27,2**
Biodiesel	**Palm oil**	51,1					
	Soybean	46,9					
	Rapeseed	40,2					
	Sunflower	32,4					

94 Please see Annex X for more detail.

95 Commission Communication of 7.2.2007 on Results of the review of the Community Strategy to reduce CO2 emissions from passenger cars and light-commercial vehicles COM(2007)19, proposed a CO2 goal of 130g/km for passenger cars, together with a "further reduction of 10g CO2/km, or equivalent if technically necessary, by other technological improvements and by an increased use of biofuels. This would need to be measurable, monitorable, accountable and non-double-counting the reductions of CO2."

	Palm oil with methane capture	29,3					
	2G biodiesel - non-land using	9,3					
	2G biodiesel - land using	5,4					
Bioethanol	Wheat - Process fuel not specified	50,3					
	Wheat - Natural gas as process fuel in	33,5					
	Corn (maize)	32,7					
	Sugar beet	27,1					
	Sugar cane	20,2					
	Wheat - Straw as process fuel in CHP plant	21,6					
	2G bioethanol - land using	16,7					
	2G bioethanol - non-land using	9,0					

Table 6: Direct emissions are shown in the first column, the allowed direct emissions as a function of the threshold is shown in the second row (in bold). The colouring is indicating whether the feedstock named in the left column achieves the threshold indicated in first row. Grey colour indicates that the feedstock is not reaching the threshold (however, the feedstock could be in compliance by improving performance by less than 5 g/MJ), while red/dark grey colour means that the feedstock is below the threshold by more than 5 g/MJ.

5.3.1. *Level of threshold*

It should be noted that these figures are estimates for 2020, and represent typical values, and not default values[96]. From the table it can be observed that certain types of wheat bioethanol, palm oil biodiesel and soy bean biodiesel have difficulties achieving 50% savings. No further changes are occurring when the threshold is raised from 50% to 55%, but rapeseed[97] is likely to be excluded when the threshold reaches 60%. At 65% corn bioethanol, wheat bioethanol produced with natural gas and sunflower biodiesel are unable to achieve the threshold, where only the latter has estimated high indirect land-use change emissions.

At 70%, all vegetable oils are below the threshold of required savings, while only bioethanol from sugar cane and efficient wheat can be produced with sufficiently savings to be above the threshold. A 70% threshold thus appears to be too ambitious, if a certain variety of feedstocks for both bioethanol and biodiesel should be available, whereas 60% savings could be achieved with several feedstocks, especially if improvements and more efficient production techniques are implemented.

To increase the threshold to 60% lowers the direct emissions by almost 10 g/MJ, thus compensating for a certain amount of indirect land-use change emissions. But more importantly it is expected to exclude palm oil without methane capture, rapeseed oil and soybean oil from being used, all of which the IFPRI-MIRAGE-BioF model estimate to have large indirect land-use change impacts. To ensure a smooth transition to higher thresholds,

96 See definitions of default and typical values laid down in Article 2 of the Renewable Energy Directive.

97 The crop specific values are estimated based on the increase of biofuel consumption towards 2020 compared to the existing consumption in 2008, and not necessarily representative for those in the baseline. Indeed, IFPRI-MIRAGE-BioF points out that for rapeseed, which is the most important feedstock used in 2008 (5.7 Mtoe out of a total of 12 Mtoe in 2020), the estimated indirect land-use change emissions in the baseline should be significantly lower.

option B entails that the required minimum savings are raised already in 2013, to 60% up from 35% today[98].

It should be noted that in accordance with the intention of the Directives to safeguard investments[99] and allow time for industry to adjust, biofuels produced at plants that were in operation by the end of 2012 would only need to comply with a threshold of 45% until the end of 2017, at which point the 60% threshold would apply also to those installations. The proposed level of threshold increase would exclude certain feedstocks, which will need to be substituted. For the purpose of the analysis of impacts certain assumptions as to how this could take place need to be made. The following section explains this in more detail. Again, it should be noted that the analysis has several shortcomings as explained in chapter 5.1.

5.3.2. Potential scenario – meeting the targets of the Directives

A range of possible scenarios for how to achieve the targets under option B, can be developed. Essentially they imply increasing the use of bioethanol, advanced biodiesel or electric vehicles. A set of theoretical and extreme scenarios exploring the use of these options are found in Annex XIV. The least unrealistic based on contributions from other technologies (electric vehicles) is set out below.

	Bioethanol [Mtoe]	**Double counted biodiesel [Mtoe]**	**Electricity in road [Mtoe]**
Baseline	6.7	1.8	2.1
Option B	13.6	3.8	2.7

This would require both more (a doubling of) bioethanol blended into the vehicle fleet, and more than doubling the amount of 'double-counted' biodiesel produced (both are doubled compared to the baseline – which means twice the amount of what is estimated in the NREAPs).

The increased consumption of ethanol is a question of blending possibilities, as the share of petrol consumption in the EU is decreasing, and expected to continue to decline. It implies that the average bioethanol blends in petrol cars would be needed to increase from 11% to 22%. The JEC Analysis of scenarios for transport in the EU towards 2020[100], finds that in a scenario with an E85 grade (flexi-vehicles) introduced now, and E20 in 2017, the EU would consume 8-9 Mtoe of ethanol. If E20 is introduced in 2015 rather than in 2017 (2 years earlier), it leads to additional 0.7 Mtoe of ethanol being consumed in 2020. This indicates how challenging the consumption of 13.6 Mtoe of ethanol would be.

The availability of double-counted biodiesel is a question of supply, both in terms of availability of raw-material e.g. waste oil, but also a technical question whether enough production capacity can be cost-efficiently installed by 2020. Achieving a supply of 3.8 Mtoe of double counted biodiesel would therefore be challenging.

[98] To ensure a consistent increase of the level of ambition, also the threshold for new installations is increased. New installations after 2018 would be required to save at least 65%, instead of currently planned requirement of 60%.

[99] Article 19(6) and Article 7d(6) of the Renewable Energy Directive and Fuel Quality Directive respectively.

[100] EU renewable energy targets in 2020: Analysis of scenarios for transport – JEC biofuels programme http://ies.jrc.ec.europa.eu/uploads/jec/JECBiofuels%20Report_2011_PRINT.pdf.

The scenario also needs 0.6 Mtoe of additional electricity in road transport by 2020. This would be equivalent to deploying an additional 2.3 million electric cars[101] by 2020 on top of what is foreseen in the NREAPS. The NREAPs estimate that around 2.1 Mtoe of electricity[102] is consumed in electric vehicles in 2020, which implies around 8 million electric cars. It should be noted that 2.1 Mtoe includes plug-in hybrids, as well as other road vehicles using electricity. Again, this means that this scenario is not very likely and these figures are included here for illustrative purposes only.

It is also possible that the increased threshold would lead to additional contributions from other available technologies in meeting the Fuel Quality Directive target (i.e. flaring and venting reductions). An additional 0.5 percentage points reduction through such means, would reduce the contribution illustrated in the table above by 0.7 Mtoe of electricity in road transport (back to baseline levels) or with almost 2 Mtoe of double counting biodiesel.

The shortfall could also be met by increased use of sunflower and palm oil with methane capture, as both meet the threshold at 60%. However, there are technical constraints as to how much palm oil can be used, due to high CFPP (cold filter plugging point) properties, which makes it inappropriate in colder climates. While this is true for FAME and pure vegetable oils, palm oil that has been hydro-treated into HVO (hydro-treated vegetable oil), does not give rise to issues with CFPP in colder climates, but such fuels are also expected to be in demand from the aviation sector, as it is one of the few available biofuels that jet engines can use. Having regard to the expected capacity of HVO plants and the assumed amount of palm oil with methane capture in the baseline, it is assumed that 2.3 Mtoe of palm oil with methane capture is used in the EU in 2020. Although there are no technical constraints associated with blending in more sunflower oil, its volume is assumed not to increase and is maintained at baseline levels of 1.1 Mtoe. A total of 3.4 Mtoe of oil crops derived biodiesel is therefore consumed under option B. Alternative levels of consumption of oil crops derived biodiesel is analysed in the sensitivity section.

5.3.3. Effectiveness in reducing greenhouse gas emissions

Increasing the threshold to 60% implies that overall emissions are reduced by 56 Mt compared to the baseline. 33 Mt (70%) of the estimated indirect land-use change emissions occurring in the baseline would be avoided in 2020. The biofuels used are on average saving 56% compared to fossil fuels when indirect land-use change emissions are considered. The emissions reported towards the Fuel Quality Directive target will not reflect estimated indirect land-use change emissions.

The main results are shown in the table below.

Direct emissions- biofuels	Direct emissions 2020 (g/MJ)	22
	Direct emission savings 2020 [%]	76%

[101] Assumptions: Electricity consumption of an electric car can be assumed to be approximately 0.20 kWh/km. Average annual electric distance travelled is assumed to be 15.000km. Annual electricity consumption of one electric car will be roughly 3000 kWh. Expressed in toe, this is 3 * 8.6 * 10-5 which gives 0.258 toe. Therefore 1 Mtoe electricity consumption by cars implies 3.9 million cars on the road.

[102] The NREAPs estimate a total of 0.7 Mtoe of renewable electricity in road vehicles by 2020. In order to convert this figure to overall electricity it has to be divided by the fraction of renewable energy in the electricity mix of 2020, assumed to be 34% for the EU in the NREAPs. This gives 2.1 Mtoe of electricity. The real figure is likely to be lower, as countries with higher than average share of renewable energy in the electricity mix, will use national values rather than the EU-average.

	Total direct emissions 2020 (Mt)	19
Indirect land-use change emissions – biofuels	Average ILUC emissions 2020 [g/MJ]	18
	Total ILUC emissions 2020 [Mt]	14
Total emissions- direct and indirect- biofuels	Average emissions 2020 [g/MJ]	40
	Overall savings 2020 [%]	56%
Change against baseline	Indirect land-use change emissions (Mt)	-33
	Total emissions (Mt)	-56

Table 7: Effectiveness analysis of option B

It should be noted that if rapeseed was to improve performance sufficiently, or the deficit of rapeseed was to be filled with other oil crops that pass the increased threshold (sunflower and palm oil with methane capture), the reductions in estimated indirect land-use change emissions would be reduced accordingly. This analysed in the sensitivity section of option B.

5.3.4. Impacts on achieving the Renewable Energy Directive transport target

There is a risk that the transport target of the Renewable Energy Directive is not achieved, if industry does not manage to produce sufficient amounts of biofuels with at least 60% direct greenhouse gas savings or the technological developments needed to achieve required increased bioethanol blends and electric vehicles do not take place.

5.3.5. Economic impacts

The change in cost compared to the baseline is expected to be moderate as a range of feedstocks is still available. The increased use of electricity in road transport, and 2nd generation biofuels will increase aggregate costs, depending on how the costs of these technologies develop.

Financial investment stability is affected, as the use of conventional biodiesel feedstocks would be significantly reduced, as well as less efficient bioethanol production pathways. This would have significant implications for the existing EU biofuel industry that is not able to increase its efficiency. In that case, considerable stranded investment would result. It also implies that Member States and industry cannot continue to follow the submitted National Renewable Action Plans (NREAPs), which may have political implications.

The raising of the threshold to 60% would thus require industrial adjustment, and those countries with the largest biodiesel installed capacity (i.e. Germany, Spain, France, Italy and the Netherlands) would be most affected. Moreover, activity will be reduced in related industries such as those involved in the production of vegetable oils/crushing of oil crops for all food/feed/biofuels markets (mainly being present in Germany, France, Spain, the Netherlands and the UK).

The increased threshold is likely to require more producers to report actual values, rather than default values, as the default values are below the threshold[103]. This is more burdensome, as more data needs to be submitted and verified. In the Impact Assessment on biomass sustainability[104] it was estimated that the increased cost of using actual values rather then

103 Annex V of the Renewable Energy Directive and Annex IV of the Fuel Quality Directive.

104 Impact Assessment - Report from the Commission to the Council and the European Parliament on sustainability requirements for the use of solid and gaseous biomass sources in electricity, heating and

default values would be 10-20 % higher, i.e. not substantially more than in the baseline, particularly since only a share of the market will need to use actual values.

Impacts on security of supply can be adversely affected if the necessary bioethanol blend levels are not available in terms of specification of the vehicle fleet, or the required high-saving biodiesel volumes are not supplied.

Option B would also have a number of trade impacts. Imports of conventional biodiesel feedstocks into the EU would be limited, while the feedstocks and biofuels with higher savings are expected to increase.

5.3.6. Social impacts

With regard to EU employment, the resulting impacts would depend on whether the opportunities created through the increase in the bioethanol and advanced biodiesel industry are able to make up for the reduction in activity in the conventional biodiesel industry. The foreseen grandfathering of installed capacity would be expected to help with the transition.

While rapeseed is likely to be excluded, the adverse employment effects within the EU for famers are likely to be limited, as farmers would respond to the shift in demand from rapeseed to cereals. Rural development is dependent on the same set of variables, and thus difficult to assess.

The reduction in vegetable oil demand will lower the pressure on global vegetable oil markets. Conversely, pressure on coarse grains and sugar prices is likely to increase, although the impacts are expected to be moderate as the demand for biofuels of these commodity groups represents a lower share of the global markets than for oil crops.

5.3.7. Environmental impacts

Adverse biodiversity impacts are reduced as it is expected that reduced indirect land-use change emissions are correlated with reduced conversion of bio-diverse areas. Certain crops such as sunflower and palm oil with methane capture which have associated high estimated indirect land-use change impacts would continue to qualify, but the quantities are assumed to be limited. This option would also contribute towards avoiding other environmental impacts associated with land conversion (i.e. adverse water, soil and air impacts).

5.3.8. Other impacts

As option B follows the principles of the already existing sustainability criteria which already contain thresholds for minimum greenhouse gas savings, the option is simple in design and implementation.

This option would be expected to motivate technological development. Firstly, it would provide incentives for accelerating the introduction of advanced biodiesel. Moreover, the increased greenhouse gas emissions requirements should encourage improvements in the performance of 1st generation feedstocks.

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cooling. Available here: http://ec.europa.eu/energy/renewables/transparency_platform/doc/2010_report/sec_2010_0065_1_impact_assessment_en.pdf.

This option does not change the existing calculation methodology and thus it is not likely to be challenged by the WTO. Moreover, this option does not depend on modelling for the design of the policy measure. However, it does not distinguish between feedstocks according to their estimated indirect land-use change impacts.

The greenhouse gas performance of the different biofuel pathways is only dependent on the actions taken by the biofuel producers themselves. As such the option B follows the existing methodology.

As emission savings offered by biofuels would not reflect indirect land-use change, biofuels would contribute less to the integrated approach for CO_2 in cars. As such, larger contributions towards achieving greenhouse gas emissions savings will be needed from energy efficiency and other available technologies.

5.3.9. Sensitivity of option B

5.3.9.1. Uncertainty related to the use of oil crops under option B

Three uncertainties are dominant regarding the effectiveness of option B.

Firstly, the direct emissions from the various feedstocks might change due to technological progress beyond what is assumed in this impact assessment, leading to changes in which feedstocks are used and thus changes in the estimated indirect land-use change emissions. This is particularly important aspect for rapeseed, which can comply if sufficient improvements in performance are made. Rapeseed has assumed direct emissions of around 41 g/MJ, while the threshold of 60% is allowing maximum 36 g/MJ, i.e. 5 g/MJ lower. In the production of rapeseed, cultivation is particularly important, although around 5 g/MJ can be saved by using bio-methanol instead of fossil derived methanol for the processing of vegetable oil into FAME. Reductions of up to 10-15 g/MJ compared to the 29 g/MJ of cultivation emissions reported under the default values in the Directives can be found in the literature[105]. In total is would therefore be theoretically possible to reduce emissions by around 20 g/MJ.

Secondly, there is uncertainty related to the replacement feedstocks of rapeseed. Substitution could take place, using more oil crops based biodiesel (rapeseed with improved efficiency and/or sunflower and palm oil with methane capture which would still be expected to pass the threshold) than what is assumed in B. Assuming that e.g. all rapeseed passes the increased threshold, the effectiveness of option B would be reduced; with overall emission savings being halved, from 56% to 28%. Moreover, the annual estimated indirect land-use change emissions in 2020 would be reduced by 11Mt (23%) instead of 33Mt (69%). The uncertainty related to these aspects could be reduced by further increasing the threshold.

While estimated indirect land-use change emissions would increase significantly, as well as the adverse environmental impacts such as biodiversity loss associated with them. However, the negative effect on European biodiesel industry would be considerably limited. The targets under the Fuel Quality Directive and the Renewable Energy Directive would be easier to meet, as more conventional biodiesel would be available for blending.

[105] IEA Task 39 – Don O'Connor, Biodiesel GHG emissions, past, present and future January 2011.

Thirdly, the increase in demand for double counted biodiesel such as that made from waste and residues would most likely increase the price for such oils, which in turn could lead indirectly to increased use of virgin vegetable oils, as the relative price[106] for virgin oils would decrease.

5.3.9.2. Sensitivity related to the estimated indirect land-use change emissions

If the indirect land-use change emissions are smaller or larger than the estimated central value, the resulting changes in emissions in response to option B are set out in the table below:

		Low	Central	High
Indirect land-use change emissions only- biofuels	Average ILUC emissions 2020 [g/MJ]	11	18	26
	Total ILUC emissions 2020 [Mt]	9	14	20
Total emissions- direct and indirect- biofuels only	Average emissions 2020 [g/MJ]	33	40	48
	Overall savings 2020 [%]	64%	56%	47%
Change against baseline	Indirect land-use change emissions (Mt)	-21	-33	-46
	Total emissions (Mt)	-43	-56	-68

Option B gives significant emission savings across the whole range of sensitivity. The baseline has 29 Mt and 66 Mt of estimated indirect land-use change emissions for low and high estimates respectively. For both extremes, B is reducing indirect land-use change emissions with around 70%. Looking at the "high" scenario, it leads to overall savings of using biofuels of 47%, which is not significantly different than 56% as is the result in the central case[107].

5.4. Option C – introduce additional sustainability requirements on certain categories of biofuels

Option C involves introducing additional sustainability requirements for biofuels. As explained in section 4, option C1 builds on LULUCF reporting and on taking measures to reduce deforestation. This operates on a national level. Option C2 places additional requirements on producers. That option thus operates at the level of economic operators (project level).

Option C1, the requirement of LULUCF reporting and reducing deforestation in biofuel producing countries would need to be implemented globally to ensure optimal effectiveness by avoiding "leakage". However, this risk could be mitigated against by ensuring that additional measures aimed at increasing the availability of overall agricultural production are put in place simultaneously.

In addition, it would seem appropriate to allow for the provision of exemptions from increased requirements resulting from the combination of B and C1 for producers in countries that may not be in compliance if they can demonstrate that their biofuels present a low risk of

[106] If the price of waste and residual oil increases, the total cost of using virgin oil goes down, as the cost of using virgin oils is the difference in price between virgin oil and waste/residual oil.

[107] If estimated indirect land-use change emissions were to be considered in the calculation of emissions, the reported savings to the Fuel Quality Directive target would be -4.5% and -3.4% for overestimating and underestimating indirect land-use change emissions respectively.

indirect land-use change emissions under C2. Although preliminary work suggests that large quantities of biofuels could be produced in this way and this option has therefore significant potential to reduce indirect land-use change emissions, a methodology for certification of biofuels produced under these conditions is not yet available. As such, this option is only assessed in combination with other options in chapter 5.6.

Option C1 Measures aimed at reducing deforestation in biofuel producing countries

Severe indirect land-use change emissions takes place as a result of cropland expanding into forests. A global reduction in deforestation and improved land planning would therefore significantly reduce indirect land-use change emissions. Option C1 requires governments supplying biofuels to the EU market to reduce deforestation, by means of implementing the following:

- Member States and Third countries should report emissions by sources and removals by sinks of greenhouse gases resulting from LULUCF activities, in accordance with rules laid down for Annex I parties in Article 4 of the UNFCCC, and following the IPCC Good practice guidance for LULUCF reporting[108]. This should start as soon as possible, preferably by 2015.

- Member States and Third countries should limit the rate of greenhouse gas emissions from losses of wetlands and forests (as defined in the Directives). This should start as soon as possible, preferably by 2015.

- Member States and Third countries should in parallel undertake appropriate measures aimed at increasing the availability of feedstocks that are suitable for biofuel production without increasing pressure on agricultural land through putting in place additional[109] measures in line with their national circumstances. Such measures would for example include increasing yields in a sustainable manner and intensification of pasture land; encouraging the remediation of degraded and contaminated land; reduction of waste of agricultural products at farm level and post harvest (particularly for developing countries), and post consumer level (in the case of developed countries). The assessment should be finalised by 2015, and published in an appropriate manner. This provision shall not apply if similar practices are already in place.

The paragraph on LULUCF reporting is necessary in order to establish the statistics of sufficient quality to assess the fulfilment of second paragraph[110]. It is thus not requiring third countries taking on commitments under the Kyoto Protocol.

The year 2015 as year of implementing LULUCF reporting is necessary to allow third countries to build the necessary capacity to comply. The advantage of linking it to the methodology required from Annex I countries, is that methodology and verification is catered for by a competent international body, where due considerations to both practical and political

[108] Available here: http://www.ipcc-nggip.iges.or.jp/public/gpglulucf/gpglulucf.html.

[109] As in the description of C2, the word "additional" makes reference to measures and developments beyond progress under a likely business as usual scenario.

[110] The dissemination of the accounting rules of LULUCF is beneficial in itself: improved data, more awareness in the countries in question, and possible easier transition to commitments under a new agreement.

limitations needs to be taken into account. Moreover, review and verification of data is qualified by existing institutions.

5.4.1. Effectiveness in reducing greenhouse gas emissions

Adding a requirement on all Member States and Third countries to reduce deforestation and put measures in place to increase the availability of agricultural commodities, could reduce emissions considerably. However there are three uncertainties:

(1) The effectiveness of this option relies on whether countries are choosing to be in compliance or not, something that is outside of the control of the EU;

(2) The mitigation in terms of greenhouse gas emissions depends on the level of implementation in each country (i.e. if implementation goes beyond minimum requirements), and finally;

(3) To what extent will leakages take place, i.e. biofuels exporting countries comply, while indirect effects are displaced to other countries. This can be mitigated depending on the extent that measures put in place to increase production are successful.

In order to understand the possible magnitude of potential impacts, additional estimations have been done using IFPRI-MIRAGE-BioF. Assuming compliance by Indonesia, Malaysia, Brazil and Central American countries, the overall land-use change emissions would be reduced considerably more than the baseline indirect land-use change emissions, i.e. not only those related to biofuels. For example, a reduction of deforestation rate to below 0.5% of land area would lead to 730 Mt of land-use change emissions being avoided each year according to the model. By comparison, the total estimated annual indirect land-use change emissions in 2020 are likely to reach 48 Mt.

However, reducing the deforestation has economic costs for these countries and access to a relatively small (in global terms) biofuel EU market might not represent a rational choice for all third countries. Therefore in some particular cases, if imports from certain countries (Brazil, Indonesia, Malaysia and Central America) are not allowed, resulting in trade distortions and potential transmittance of impacts to other countries, IFPRI-MIRAGE-BioF estimates that the total land-use change emissions may actually increase by 3 Mt compared to the baseline land-use change emissions. However, this risk could be mitigated by ensuring that additional measures aimed at increasing the availability of overall agricultural production put in place simultaneously are successful.

To combine option C1 with other incentives through trade agreements could prove effective in persuading countries to comply with option C1. Examples of such preferential treatment is explained below in context of the GSP+ (Generalised System of Preferences).

5.4.2. Impacts on achieving the Renewable Energy Directive transport target

The impacts on meeting the Renewable Energy Directive transport target would depend on the number of countries that would qualify with the above criteria as well as the ability of others to increase their production should any of the major suppliers to the EU market be disqualified.

5.4.3. *Economic impacts*

The economic impacts of option C1 would be moderate, although feedstock costs would be expected to increase as trade in biofuels and biofuel feedstocks with countries that are not implementing the necessary measures would be halted.

The option might pose a risk in the context of WTO compliance, as the measure is country wide. However, country wide trade arrangements are not new. The FLEGT and GSP+ (Generalised System of Preferences)[111] have several similarities to the proposed option C1. Access to EU markets for timber is dependent on bilateral trade agreements in the context of FLEGT, and additional trade preferences to countries committed to sustainable development and good governance[112] is given to countries in compliance with GSP+.

Administrative costs are limited to those related to reviewing the submitted LULUCF reports, which is done by the UNFCCC. Review of all Annex I countries' reports is already implemented.

5.4.4. *Social impacts*

Social impacts of option C1 depends on how effective the measures are, as discussed above. Employment in the EU is expected to increase if few third countries comply, since more production must take place within the EU. If most exporting countries are in compliance, employment will be as in the baseline. Reducing deforestation may also have positive impacts on the short term economic and social growth of developing countries.

5.4.5. *Environmental impacts*

Also environmental impacts of option C1 are dependent on its effectiveness. Deforestation is one of the major reasons for loss of biodiversity. The reduction of deforestation in biofuel producing countries could therefore reduce such losses, with additional positive impacts related to soil, water and air. In this context, it is important that the risk of indirect land-use change emissions transmission to other countries is appropriately mitigated.

5.4.6. *Other impacts*

If option C1 was to result in increased implementation of LULUCF reporting it could have wider positive impacts, as this would be likely to improve awareness of carbon losses related to land-use and land governance. The implementation of this option could add some countries to the group of 42 Annex I countries[113].

As emission savings offered by biofuels would not reflect indirect land-use change, biofuels would contribute less to the integrated approach for CO2 in cars. As such, larger contributions towards achieving greenhouse gas emissions savings will be needed from energy efficiency and other available technologies.

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111 For ACP countries: African, Caribbean and Pacific Group of States. Secretariat: http://www.acpsec.org/.

112 To benefit from GSP+ conditions, countries have to ratify and implement 27 international conventions and undergo a rigorous vetting and application process. GSP+ eligibility is reviewed every 3 years. Further explanation can be found here: http://trade.ec.europa.eu/doclib/docs/2007/september/tradoc_136097.pdf.

113 List of Annex I countries available here: http://unfccc.int/parties_and_observers/parties/annex_i/items/2774.php.

5.5. Option D - Attribute a quantity of greenhouse gas emissions to biofuels reflecting the estimated indirect land-use impact.

This option builds in the estimated indirect land-use change emissions into the greenhouse gas emissions accounting methodology for biofuels. According to the assumptions made in this impact assessment, these estimates (factors) are added to the expected 2020 baseline direct emissions (cultivation, processing and transport) as described in table 4 of chapter 2[114]. This would require incorporating the estimated indirect land-use change emissions values in both the reporting of greenhouse gases, as well as ensuring compliance with the minimum greenhouse gas thresholds of the sustainability criteria.

The initial assessment of this option focuses on the impacts in terms of exclusion of certain feedstocks. This depends on whether ***eiluc*** (the indirect land-use change emission factors) are set at a level which mitigates/anticipates the risk of a possible model overestimation (50%, 25% and 5% percentiles) and underestimation (95%, 75% and 50% percentiles) of crop-specific indirect land-use change emission factors based on the latest IFPRI-MIRAGE-BioF report. At the end of this section, the impacts from setting these levels based on crop group (i.e. starch, oil crops and sugar crops) are also explored.

5.5.1. Level of indirect land-use change emission factors per feedstock

The results in table 8 below show whether feedstocks would comply with the thresholds set out in the Directives respectively when the range of estimated indirect land-use change emissions resulting from the Monte-Carlo analysis are considered. Table 8 is thus the crop specific values in Annex XV added to the direct emissions. All values are shown in grams of $CO_{2\text{-eq.}}$/MJ.

	Feedstocks	5th	25th percentile	Central	75th percentile	95th
Biodiesel	Palm oil	98	102	105	108	111
	Palm oil with methane capture	76	80	83	86	90
	Soybean	85	97	103	108	121
	Rapeseed	68	85	95	106	121
	Sunflower	63	79	86	93	104
	2G biodiesel - land using	12	18	21	24	32
	2G biodiesel - non-land using	9	9	9	9	9
Bi	Wheat Process fuel not specified	59	62	64	66	69

[114] In this context, it is important to note that the crop specific values are estimated based on the increase of biofuel consumption towards 2020 compared to the existing consumption in 2008. IFPRI-MIRAGE-BioF reports that for those feedstocks that display a strong non-linearity effect (i.e. rapeseed), the indirect land-use change emissions in 2020 would be higher than those observed at lower consumption levels. Due to the limitations of this assessment (i.e. snapshot at 2020), this effect is not considered further in this document.

	Wheat Natural- gas process fuel CHP plant	42	45	47	49	52
	Corn (maize)	39	41	43	44	46
	Sugar cane	27	33	36	39	47
	Wheat Straw as process fuel in CHP plant	30	33	35	37	40
	Sugar beet	28	31	34	37	40
	2G bioethanol - land using	23	29	32	35	43
	2G bioethanol - non-land using	9	9	9	9	9

Table 8: impacts on the availability of feedstocks when different ILUC factors based on feedstock specific values are computed with expected typical direct emissions in 2020. Feedstocks in red/dark grey fail to achieve required levels of savings at 50% by more than 5g; in grey the fail by less than 5g, and; in green/light grey those than meet the 50% threshold.

From the table above, it is possible to draw a number of preliminary conclusions.

- Firstly, when the estimated indirect land-use change emissions are added to the expected direct emissions in 2020, none of the oil crops feedstocks would be able to meet the 50% greenhouse gas emissions savings as required by the Directives, regardless of the range of indirect land-use change estimates used. This is because these feedstocks present relatively high direct emissions (e.g. soybean fails even when the 50% threshold is applied to the direct emissions, before the estimated indirect land-use change emissions are included), and are attributed relatively high estimated indirect land-use change emissions.

- The contrary is true for bioethanol feedstocks. There only the least efficient wheat to bioethanol pathway is estimated not to achieve the required minimum savings, unless the most conservative indirect land-use change emission values (95^{th}) are applied, in which case corn and sugarcane also marginally fail to pass. All other bioethanol pathways would otherwise be expected to achieve the required savings in 2020.

In light of the above, the evaluation of option D is carried out using the central values.

Table 8 above shows how certain feedstocks would be excluded (in red) from being counted towards the Directive targets. In addition, attributing estimated indirect land-use change emissions to feedstocks would also lead to incentives for biofuels with lower indirect land-use change emissions due to the accounting and reporting by fuel suppliers under the Fuel Quality Directive which is likely to bring about a significant price differentiation in favour of low-ILUC transport fuels because those biofuels will contribute much more than others to the attainment of a supplier's obligation to reduce the greenhouse gas intensity of the fuels it supplies. This second element is more sophisticated than the exclusion showed in table 8 above as the emission estimates provide incentives for biofuels with low estimated indirect land-use change emissions. Although the effectiveness of this second element cannot be assessed under the methodology being used in this impact assessment, further discussion is included in the sensitivity section of this option.

5.5.2. *Potential scenario - meeting the targets of the Directives*

A range of possible scenarios for how to comply with option D, while meeting the targets, can be developed. As no vegetable oils can be used, it implies increasing the use of bioethanol, advanced biodiesel or electric vehicles. A set of theoretical and extreme scenarios exploring the use of these options are found in Annex XIV. The least unrealistic scenario including a contribution from other technologies (electric vehicles) that would also achieve the Renewable Energy Directive transport target is set out below (these figures are included here for illustrative purposes only as it is not possible to determine what the final mixture of technologies would look like in reality).

	Bioethanol [Mtoe]	**Double counted biodiesel [Mtoe]**	**Electricity in road [Mtoe]**
Baseline	6.7	1.8	2.1
Option D	13.6	9	2.6

The scenario described above would require a doubling in the levels of bioethanol and almost a fivefold increase in the production of double counted biodiesel compared to the volumes set out in the NREAPs.

The increased consumption of ethanol is question of blending possibilities, as the share of petrol consumption in the EU is decreasing, and expected to continue to decline. The JEC Analysis of scenarios for transport in the EU towards 2020[115], finds that in a scenario with an E85 grade (flexi-vehicles) introduced now, and E20 in 2017, the EU would consume 8-9 Mtoe of ethanol. If E20 is introduced in 2015 rather than in 2017 (2 years earlier), it leads to additional 0.7 Mtoe of ethanol being consumed in 2020. This indicates how the consumption of 13.6 Mtoe of ethanol would be very challenging.

The availability of double-counted biodiesel is a question of supply, both in terms of availability of raw-material e.g. waste oil, but also a technical question whether enough production capacity can be cost-efficiently installed by 2020. Achieving a supply of 9 Mtoe of double counted biodiesel would therefore be very challenging.

The scenario also needs increased efforts i.e. 0.6 Mtoe of additional electricity in road transport by 2020. This would be the equivalent of deploying an additional 2.3 million electric cars[116] by 2020 on top of what is foreseen in the NREAPs. The NREAPs estimate that around 2.1 Mtoe of electricity[117] is consumed in electric vehicles in 2020, which implies 8 million electric cars. It should be noted that 2.1 Mtoe includes plug-in hybrids, as well as other road

115 EU renewable energy targets in 2020: Analysis of scenarios for transport – JEC biofuels programme http://ies.jrc.ec.europa.eu/uploads/jec/JECBiofuels%20Report_2011_PRINT.pdf.

116 Assumptions: Electricity consumption of an electric car can be assumed to be approximately 0.2 kWh/km. Average annual electric distance travelled is assumed to be 15.000km. Annual electricity consumption of one electric car will be roughly 3 kWh.. Expressed in toe, this is 3 * 8.6 * 10-5 which gives 0.26 toe. Therefore 1 Mtoe electricity consumption by cars implies 3.9 million cars on the road.

117 The NREAPs estimate a total of 0.7 Mtoe of renewable electricity in road vehicles by 2020. In order to convert this figure to overall electricity it has to be divided by the fraction of renewable energy in the electricity mix of 2020, assumed to be 34% for the EU in the NREAPs. This gives 2.1 Mtoe of electricity. The real figure is likely to be lower, as countries with higher than average share of renewable energy in the electricity mix, will use national values rather than the EU-average.

vehicles using electricity. Again, this means that this scenario is not very likely and these figures are included here for illustrative purposes only.

5.5.3. Effectiveness in reducing greenhouse gas emissions

This is the most effective option in reducing the estimated indirect land-use change emissions, with 40 Mt (85%) of the estimated indirect land-use change emissions taking place in the baseline being avoided in 2020 as a result. Overall emissions would be reduced by 66 Mt compared to the baseline, with biofuels saving an average of 70% emissions compared to fossil fuels. Moreover, the reported savings towards the Fuel Quality Directive target remain at -5.4% when indirect land-use change emissions are included.

The main results in terms of greenhouse gas emissions are shown in the table below.

Direct emissions- biofuels	Direct emissions 2020 (g/MJ)	17
	Direct emission savings 2020 [%]	82%
	Total direct emissions 2020 (Mt)	16
Indirect land-use change emissions- biofuels	Average ILUC emissions 2020 [g/MJ]	10
	Total ILUC emissions 2020 [Mt]	8
Total emissions- direct and indirect- biofuels	Average emissions 2020 [g/MJ]	27
	Overall savings 2020 [%]	70%
Change against baseline	Indirect land-use change emissions (Mt)	-40
	Total emissions (Mt)	-66

Table 9: Effectiveness analysis of option D

5.5.4. Impacts on the Renewable Energy Directive transport target

There is a high risk that the transport target of the Renewable Energy Directive is not achieved, as it will be challenging for industry to produce enough advanced biofuels, particularly since all conventional biodiesel is excluded and 70-75% of the transport fuels are expected to be diesel in 2020, the technological developments needed to achieve required increased bioethanol blends and electric vehicles do not take place.

5.5.5. Economic impacts

The viability of existing investments would be affected in the long run, as Member States and industry cannot continue to follow the submitted National Renewable Action Plans (NREAPs) since no conventional biodiesel feedstocks would be available. This would have significant implications for the existing EU biodiesel industry, and those countries with the largest biodiesel installed capacity (i.e. Germany, Spain, France, Italy and the Netherlands) would be most affected. Moreover, activity will be reduced in related industries such as those involved in the production of vegetable oils/crushing of oil crops for all food/feed/biofuels markets, mainly being present in Germany, France, Spain, the Netherlands and the UK). As foreseen in the Directives[118], the introduction, if appropriate, of an indirect land-use change emission methodology would need to consider the provision of safeguards to investment undertaken from existing installations involved in the production chain that would otherwise have complied with the greenhouse gas emissions requirements.

[118] See chapter 3 for further detail.

On the one hand, it could be argued that certainty for new investments would be increased since the estimated full greenhouse gas emissions impacts are being taken into account. Bioethanol production capacity would need to be increased significantly to make up for the increased demand, which would create economic opportunities in this area. In addition, there would also be significant opportunities for the second generation biofuel industry as their better performance compared with conventionally produced biodiesel would be made apparent. On the other hand, the introduction of indirect land-use change emission factors, and the update of these values, would create uncertainty regarding what an updating might bring in terms of consequences to the industry. This process would therefore need to be managed carefully.

With regard to production costs, the change compared to the baseline is expected to be moderate as most bioethanol feedstocks required to make up for the missing biodiesel remain available once indirect land-use change emission factors have been applied. However, the need for electric vehicles and 2nd generation biofuels will increase the aggregate cost, depending on how the costs of these technologies develop. There are no additional administrative costs associated with this option, as requirements under the current sustainability scheme are neither changed nor increased.

Impacts on security of supply can be adversely affected if the necessary bioethanol blend levels are not available in terms of specification of the vehicle fleet, or the required high-saving biodiesel volumes are not supplied in time. In any case, the need to accelerate developments in order to make the existing fleet to be compatible with higher bioethanol blends will have increased costs for the vehicle manufacturers. Again, the foreseen application of the grandfathering clause on installed capacity would be expected to help with this transition.

Similarly, this option would have a number of trade impacts. Imports of conventional biodiesel feedstocks into the EU would be severely limited. However, trade in second generation biodiesel feedstocks and/or second generation biodiesel if available would increase, as well as in bioethanol feedstocks, and/or processed bioethanol if EU processing capacity does not increase in time.

In terms of WTO compatibility, option D may lead to issues related to its reliance on modelling for the determination of the factors. However, similarly constructed indirect land-use change emission factors applying in US federal and Californian Low Carbon Fuel Standard have not been challenged to date. That said, although the abovementioned legislation leads to a preferential treatment of feedstocks with estimated low-ILUC impacts, it does not lead to certain biofuel feedstocks being totally excluded from receiving financial support or counted towards mandatory targets.

5.5.6. Social impacts

With regard to EU employment, the resulting impacts would depend on whether the opportunities created through the increase in the bioethanol and advanced biodiesel industry are able to make up for the reduction in activity in the conventional biodiesel industry. Again, the foreseen application of the grandfathering clause on installed capacity would be expected to help with the transition.

While rapeseed and sunflower is excluded, the adverse employment effects within the EU for famers are likely to be limited, as farmers would respond to the shift in demand from rapeseed to cereals and sugar beet. Notably, the main Member States producing rapeseed (i.e.

Germany, France, Poland and United Kingdom) are also the main producers of cereals and sugar beet. On the other hand, reduced production of oil crops can be problematic in terms of crop rotation in some areas where sugar beet cannot be grown because of soil requirements (i.e. rapeseed and sugar beet are used as a break crops), and could increase the deficit in feed protein (i.e. oil crops yield higher quality meals compared to cereals), as farmers are unlikely to switch to protein crops (i.e. peas, beans).

Rural development is dependent on the same set of variables, and thus difficult to assess. However, the required increased use of advanced biodiesel would be expected to have positive impacts.

Pressure on vegetable oil prices will be reduced in commodity markets as a result of reduced biodiesel demand. Conversely, pressure on coarse grains and sugar prices will increase, although to a lesser extent as the demand for biofuels of these commodity groups represents a lower share of the global markets than for oil crops. As such, the reliance of the EU on imported vegetable oils would improve, as well as reducing the excess production of cereals and sugars.

5.5.7. Environmental impacts

Based on the results above, this option would also be expected to be the most effective in reducing the biodiversity impacts associated with indirect land-use change. Due to their irreversible and cumulative nature, the extent by which these impacts are addressed would depend on when action is taken.

In addition, this option would also significantly contribute towards avoiding other environmental impacts associated with land conversion (i.e. adverse water, soil and air impacts).

5.5.8. Other impacts

This option would be expected to motivate technological development. Firstly, it would provide strong incentives for accelerating the introduction of advanced biodiesel. Moreover, the increased greenhouse gas emissions requirements should encourage improvements in the performance of 1st generation bioethanol feedstocks. The implementation of the 6% target of the Fuel Quality Directive provides strong price signals for improved greenhouse gas emissions performance for biofuels as a result of the incorporation of indirect land-use change emissions factors, as well as incentives for transport fuels and energy with low estimated indirect land-use change emissions, as explained in section 5.5.1[119].

All biofuels that would be counted towards these targets meet the greenhouse gas emissions thresholds when estimated indirect land-use change emissions are included. As a result, emission savings offered by qualifying biofuels would be coherent with the integrated approach for CO_2 in cars.

Option D would imply that the greenhouse gas calculation methodology would be modified from the existing principles of greenhouse gas performance being the result of the biofuel producer's actions, to a system where the greenhouse gas performance is also dependent on the actions of actors outside the producer's control. Adding the indirect impact to the direct emissions, implies that if the same principles of accounting greenhouse gas emissions as

[119] For example, it is worth noting that following the implementation of the Californian Low Carbon Fuel Standard in 2010, a price differential emerged between biofuels of different carbon intensity.

under option D, were to be applied to all commodities, it would result in double-counting, as the indirect emissions of biofuels are the *direct* emissions of another commodity.

In practical terms it might be less relevant as greenhouse gas emissions from the majority of commodities may never be accounted for globally. However, as discussed in the LULUCF section: If LULUCF accounting were to be implemented globally together with option D, indirect land-use change emissions would be accounted for both as part of the biofuel greenhouse gas performance, and as LULUCF emissions in the country where indirect land-use change took place.

Whether or not to estimated indirect land-use change emissions should be included in the greenhouse gas accounting of the biofuels, also relates to the principle of carbon-neutrality of biofuels. Currently it is assumed that tailpipe carbon emissions are zero, as a similar amount of carbon is absorbed by the feedstocks as they are grown. In a context of biofuels using existing cropland, where crops would have been grown anyway, a similar amount of carbon would also have been extracted from the atmosphere. While it is difficult to assess the overall carbon impact of the land remaining as non-biofuel cropland, option D would to some extent capture this.

The greenhouse gas accounting methodology has to balance the need for ensuring significant savings from the use of biofuels with a stable and predictable policy framework. There are broader implications of option D in that introducing indirect land-use change emission factors for biofuels could lead to similar factors being introduced for other types of bioenergy, especially due to use of the same feedstocks. However, in order to ensure that biofuels and bioenergy successfully contribute towards the EU climate objectives and related specific greenhouse gas emissions reduction targets as set out in the *" A Roadmap for moving to a competitive low carbon economy in 2050"*, it is necessary to ensure that biofuels do not lead, directly or indirectly, to a decrease of the net greenhouse gas benefits. This could be challenging if the indirect emissions associated with land using biofuel are not minimised. Moving forward towards 2050, it is currently considered that indirect emissions could be accounted for through global LULUCF accounting or through adding factors as foreseen in option D.

5.5.9. Sensitivity of option D

5.5.9.1. Uncertainty related to the effectiveness of option D

The considerable increase in demand for double counting biodiesel such as that made from waste and residues would most likely increase the price for such oils, which in turn could lead indirectly to increased use of virgin vegetable oils, as the relative price[120] for virgin oils would decrease.

5.5.9.2. Sensitivity related to the estimated indirect land-use change emissions

If the indirect land-use change emissions are smaller or larger than the estimated central value, the resulting changes in emissions in response to option D4 are set out in the table below:

		Low	Central	High

[120] If the price of waste and residual oil increases, the total cost of using virgin oil goes down, as the cost of using virgin oils is the difference in price between virgin oil and waste/residual oil.

Indirect land-use change emissions- biofuels	Average ILUC emissions 2020 [g/MJ]	4.4	10	17
	Total ILUC emissions 2020 [Mt]	3	8	13
Total emissions- direct and indirect- biofuels	Average emissions 2020 [g/MJ]	21	27	34
	Overall savings 2020 [%]	77%	70%	62%
Change against baseline	Indirect land-use change emissions (Mt)	-26	-40	-53
	Total emissions (Mt)	-52	-66	-79

The introduction of D4 gives overall savings from 62% to 77%. The main conclusion is that under all circumstances, levels higher than 50% greenhouse gas emissions savings would be achieved[121].

Scenario D4 would correspond to levels of an indirect land-use change emission factor being set at 50th percentile. Applying the factors at lower or upper end of the sensitivity range as set out in table 7, are not expected to have major impacts on the overall situation described above (i.e. conventional oil crops would still need to be replaced by equivalent levels of bioethanol, double counted biodiesel and electricity in roads).

5.5.9.1. The impacts of including the estimated indirect land use change greenhouse gas emissions in the reporting of the greenhouse gas emission savings of biofuels.

The reporting of the emissions towards the Fuel Quality Directive would be expected to create a strong price premium for those biofuels with the lowest estimated indirect land-use change emissions. The reason for that is that biofuels with low estimated indirect land-use change emissions will contribute much more than others to the attainment of a supplier's obligation to reduce the greenhouse gas intensity of the fuels it supplies. As it has not been possible to assess this aspect of option D with the assessment methodology applied in this Impact Assessment, this element is further outlined in the text and figure below.

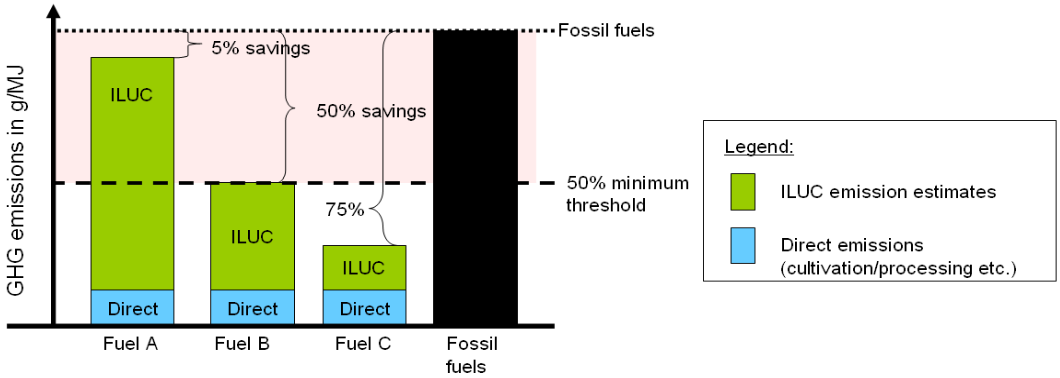


Figure 7: Greenhouse gas savings obtained under the Fuel Quality Directive

- fuels A, B and C offer similar greenhouse gas emission savings when only direct emissions are taken into account;

121 With regard to the Fuel Quality Directive carbon intensity reductions, the 5.4% contribution achieved under the central scenario (factors at 50th percentile) includes indirect land-use change emissions, which are now being reported. The Fuel Quality Directive reduction under the biofuel mix obtained would range between 4.8% and 5.9% depending on whether we have overestimated or underestimated the "real" indirect land-use change emissions.

- when the estimated indirect land-use change emissions are included in the reporting, the contribution to the attainment of a supplier's obligation to reduce the greenhouse gas intensity of the fuels it supplies differs considerably between the three fuels. Fuel A would be completely excluded under this option as it would fail to comply with the greenhouse gas emissions thresholds under the sustainability criteria.

- as such, a fuel supplier would need twice the amount of fuel B to obtain the same savings as by using one volume of fuel C. This is therefore expected to result in a high price premium for fuel C, as it would count twice as much as B towards these targets, hence maximising its share over B in the final mix.

Although it has not been possible to assess the impact on the effectiveness of this aspect of option D in isolation in a quantitative manner with the assessment methodology applied in this Impact Assessment, some possible outcomes are presented in Annex XVI. The findings strongly suggest that significant amounts of further improved biofuels with low risk of indirect land-use change emissions would be expected in the final mix as a result.

5.5.10. Exploring different levels of disaggregation - Indirect land-use change emissions aggregated per crop group (oil crops, starch and sugars)

The results in table 10 show whether feedstocks would comply with the thresholds set out in the Directives respectively when the weighted per crop group average of estimated indirect land-use change emissions resulting from the Monte-Carlo analysis are considered. Table 10 below is thus the crop group average values in Annex XV added to the direct emissions.

	Feedstocks	5th	25th percentile	Central	75th percentile	95th
Biodiesel	Palm oil	85	98	106	114	125
	Palm oil with methane capture	64	76	84	92	104
	Soybean	81	94	102	109	121
	Rapeseed	75	87	95	103	115
	Sunflower	67	80	87	95	107
	2G biodiesel - land using	10	16	18	22	28
	2G biodiesel - non-land using	9	9	9	9	9
Bioethanol	Wheat Process fuel not specified	58	61	63	64	67
	Wheat Natural- gas process fuel CHP plant	41	44	46	48	50
	Corn (maize)	40	43	45	47	49
	Sugar cane	25	30	33	36	43
	Wheat Straw as process fuel in CHP plant	29	32	34	36	38
	Sugar beet	32	37	40	43	50
	2G bioethanol - land using	22	27	30	33	39
	2G bioethanol - non-land using	9	9	9	9	9

Table 10: impacts on the availability of feedstocks when different ILUC factors based on feedstock specific values are computed with expected typical direct emissions in 2020. Feedstocks in red/dark grey fail to

achieve required levels of savings at 50% by more than 5g; in grey the fail by less than 5g, and; in green/light grey those than meet the 50% threshold. All values are shown in grams of CO2-eq./MJ.

None of the oil crops feedstocks are either able to achieve the 50% minimum greenhouse gas emissions thresholds. Similarly, none of the bioethanol crops other than the least efficient wheat processes seem to have any difficulties to meet the required thresholds until conservative indirect land-use change emission estimates are applied.

5.6. Option E - Limit the contribution from conventional biofuels to the Renewable Energy Directive targets.

Option E involves limiting the us of conventional biofuels from food crops by setting the maximum contribution of such biofuels towards the 10% target of the Renewable Energy Directive to current production levels at 5%. To ensure coherence, the equivalemt quantity in energy content is the maximum that can contribute towards the Member States' overall targets for renewable energy.

5.6.1. Potential scenario - meeting the targets of the Directives

A range of possible scenarios for how to comply with option E, while meeting the targets, can be developed. The cap is assumed to be equivalent to around 14 Mtoe. As less conventional biofuels are likely to be used, it implies increasing the use of advanced biofuels or electric vehicles. A scenario including contribution from other technologies (electric vehicles) that would meet the Fuel Quality Directive target and achieve the Renewable Energy Directive transport target is set out below (these figures are included here for illustrative purposes only as it is not possible to determine what the final mixture of technologies would look like in reality).

	Bioethanol [Mtoe]	**Double counted biofuels [Mtoe]**	**Electricity in road [Mtoe]**
Baseline	6.7	1.8	2.1
Option E	6.7	6.0	2.6

The scenario described above would require more than a tripling of the production of double counted biofuels compared to the volumes set out in the NREAPs. If combined with optoin C2, the reliance on advanced biofuels would be reduced, which would in turn reduce costs and make it easier to comply with the targets of the Directives.

5.6.2. Effectiveness in reducing greenhouse gas emissions

Capping the use of conventional biofuels implies that overall emissions are reduced by 48 Mt compared to the baseline. 27 Mt (56%) of the estimated indirect land-use change emissions occurring in the baseline would be avoided in 2020. The biofuels used are on average saving 44% compared to fossil fuels when indirect land-use change emissions are considered. The emissions reported towards the Fuel Quality Directive target will not reflect estimated indirect land-use change emissions.

The main results are shown in the table below.

Direct emissions- biofuels	Direct emissions 2020 (g/MJ)	24

	Direct emission savings 2020 [%]	74%
	Total direct emissions 2020 (Mt)	21
Indirect land-use change emissions – biofuels	Average ILUC emissions 2020 [g/MJ]	27
	Total ILUC emissions 2020 [Mt]	20
Total emissions- direct and indirect- biofuels	Average emissions 2020 [g/MJ]	51
	Overall savings 2020 [%]	44%
Change against baseline	Indirect land-use change emissions (Mt)	-27
	Total emissions (Mt)	-48

Table 11: Effectiveness analysis of option E

5.6.3. Impacts on achieving the Renewable Energy Directive transport target

There is a risk that the transport target of the Renewable Energy Directive is not achieved, if the technological development required for the significant increase in deploying advanced biofuels is not be achieved. However, this option is the least challenging from a blending perspective as it does not require additional levels of bioethanol, and the overall levels of biodiesel would be expected to be lower than in the baseline scenario as a higher share of double counted biofuels would be expected.

5.6.4. Economic impacts

The change in cost compared to the baseline is expected to be moderate as a range of feedstocks would still available. The increased use of electricity in road transport, and 2nd generation biofuels will increase aggregate costs, depending on how the costs of these technologies develop.

Financial investment stability is affected, as the expected use of conventional biofuel feedstocks would be reduced by a third in 2020. This would have implications for the existing EU biofuel industry, although the impact is limited, as the cap would maintain today's production levels of conventional biofuels. It also implies that Member States and industry may not be able to follow the submitted National Renewable Action Plans (NREAPs), which may have political implications.

Certainty for new investments would be increased as it would be clear what levels of both conventional and advanced biofuels that would be needed by 2020. In addition, there would also be very strong opportunities for the second generation biofuel industry who would as a result of the limit of conventional, have a garanteed share of the market. There are no additional administrative costs associated with this option, as requirements under the current sustainability scheme are neither changed nor increased.

Adverse impacts on security of supply and trade may take place if the necessary volumes of advanced biofuels are not available. In both cases, the limit of on the conventional biofuels would ensure that today's energy security levels and trade volumes are mantained.

5.6.5. Social impacts

With regard to EU employment, current production levels and associated jobs woud be mantained through the cap. The extent of which the additional incentives for opportunities to be created through the increase in the advanced biofuel industry are able to make up for the reduction in activity in the conventional biofuel industry would determine the overall impacts.

While the share of conventional biofuels is reduced by a third, the adverse employment effects within the EU for famers are likely to be limited, as farmers would respond to the shift in demand from growing conventional to growing and collecting advanced biofuel feedstocks.

Rural development is dependent on the same set of variables, and thus difficult to assess. However, the required increased use of advanced biodiesel would be expected to have positive impacts.

The reduction in food based biofuels will lower the pressure on global food and feed markets, in particular for oil crops where the biodiesel production represents a larger share of the global supply, but also for cereals and sugars as bioethanol crops would also be capped.

5.6.6. Environmental impacts

Adverse biodiversity impacts are reduced as it is expected that reduced indirect land-use change emissions are correlated with reduced conversion of bio-diverse areas. This option would also contribute towards avoiding other environmental impacts associated with land conversion (i.e. adverse water, soil and air impacts) as the share of biofuels that need land for their production is limited.

5.6.7. Other impacts

This option would be expected to motivate technological development. Firstly, it would provide very strong incentives for accelerating the introduction of advanced biofuels through limiting the contribution of conventional alternatives. Secondly, it provides clear signals to industry as to what volumes of conventional and advanced biofuels are needed to 2020.

The option is simple in design and implementation.

This option does not change the existing calculation methodology and thus it is not likely to be challenged by the WTO. Moreover, this option does not depend on modelling for the design of the policy measure. However, it does not distinguish between feedstocks according to their estimated indirect land-use change impacts.

As emission savings offered by biofuels would not reflect indirect land-use change, biofuels would contribute less to the integrated approach for CO_2 in cars. As such, larger contributions towards achieving greenhouse gas emissions savings will be needed from energy efficiency and other available technologies.

5.7. Combination of option D with C2 - Attribute a quantity of greenhouse gas emissions to biofuels reflecting the estimated indirect land-use impact whilst providing exemptions to those biofuels feedstocks produced under criteria covered by option C2.

The rational behind combining option D with option C2 is that biofuels produced under C2 requirements could be considered to cause minimal indirect land-use change impacts which would justify such factors not being applied.

It is difficult to provide an accurate quantification of the impacts arising from this option, as it is not possible to estimate the actual changes in biofuels' supply compared to the baseline. And although this approach remains promising, it is worth noting that currently there are no biofuels in the market that have been certified to be compliant with these rules. However, a number of pilots to develop detailed methodological rules for the certification of biofuels produced are underway.

5.7.1. Effectiveness in reducing greenhouse gas emissions

The biofuels that are produced respecting the criteria under option C2 would have minimal risk of displacement effect and thus indirect land-use change emissions[122]. A successful implementation of this option would therefore be expected to further achieve reductions beyond those achieved by option D (40 Mt, or 85% of annual indirect land-use change emissions in 2020).

5.7.2. Economic impacts

As described in more detail under Annex XII, a number of case studies have shown that production costs will generally not be significantly higher under C2 requirements than current practices although these are likely to be project specific.

On the other hand, there will be higher administrative costs associated with the certification of feedstocks produced under C2, as additional proof of compliance to those requirements already in place under the current system would be required. Preliminary data from pilots carried out to date[123] suggest that the additional costs for these requirements could be moderate (i.e. 10-15% increase from current certification costs) if they were integrated as part of current certification schemes as to maximise audit costs already in place. Costs would be expected to be much greater if this certification had to be separated from current process, as it would result in duplication of audit costs.

With regard to investments, providing exemptions to option D is likely to improve the availability of conventional biodiesel feedstocks and so assist with the viability of existing investments in installed biodiesel production capacity. Although this would also help maintaining activity in related biodiesel industries such as those involved in the production of vegetable oils/crushing of oil crops for all food/feed/biofuels markets, costs may be incurred by these industries if their processes need to be adjusted to deal with different feedstocks (i.e. rapeseed crushing to soy). In addition, the foreseen application of the grandfathering clause on installed capacity could be a useful way of helping with the transition for establishing a robust implementation method for the certification and verification of the additional C2 criteria.

Similarly, the combination of these options would reduce the impacts on trade and is likely to increase imports of conventional biodiesel feedstocks into the EU. In terms of WTO compatibility, any potential issues related to its reliance on modelling for the determination of the factors as mentioned under option D may be reduced by the introduction of the possibility to be exempted.

[122] In the case of "yield increases", only the additional production to the average yield levels assumed in the baseline would be considered to have met these additional sustainability criteria.

[123] Preliminary results from pilots as communicated by the Roundtable for Sustainable Biofuels. Most of the cost is based on travel and administration in addition to the auditor time.

5.7.3. *Social impacts*

The social impact would be as for option D, with the exception that the employment effects within the EU for famers will be determined by the degree to which European production can be adjusted to these criteria, and how the industry is adapting to the opportunities created by exemptions created through option C2.

5.7.4. *Environmental impacts*

The environmental impacts are expected to be improved further than for option D.

5.7.5. *Other impacts*

Other impacts would be as for option D.

6. COMPARISON OF POLICY OPTIONS

The table below summarises the main issues related to the different options.

	Effectiveness	Advantages	Disadvantages
Option A	Average total of GHG savings (incl. estimated ILUC) of 22%. 48 Mt of annual estimated ILUC emissions by 2020 (BAU).	Biofuel and other related industries' investment not affected. Development opportunities inside and outside the EU not affected. RED transport targets and FQD are achieved according to NREAPS. No stranded investments.	ILUC emissions and biodiversity impacts not mitigated. No incentives for further technological development (i.e. improved GHG savings and/or advanced biofuels). Pressure on vegetable oil prices. Estimated ILUC emissions not reported.
Option B	Average total of GHG savings (incl. estimated ILUC) of 56%. 14 Mt of annual estimated ILUC emissions by 2020.	Simple in design and implementation, as it is coherent with existing methodology. Reported GHG performance of biofuels is only dependent on action taken by the biofuel producers themselves. Does not exclude all 1st generation biodiesel. Clear incentives for producers to improve direct GHG savings.	Risk of not achieving RED transport target and FQD from reduced biofuel availability. Most oil crops excluded, including all rapeseed which currently represents more than half of the biofuel feedstocks used in the EU. This would require industrial adjustment. The exclusion of rapeseed with a threshold of 60%, and its corresponding environmental and GHG impacts, are sensitive to technological progress in production pathways. Increased administrative costs as certain operators need to report actual direct greenhouse gas emission performance. Estimated ILUC emissions not reported.
Option C1	Estimated ILUC emissions ranging between a reduction of 740Mt to an increase of 3 Mt annual ILUC emissions.	Potentially large emissions savings if countries implement good governance for land-use, reduce deforestation, and limit land-use change emissions from *other* commodities.	Risk of WTO incompatibility. Potential leakage effects as the exclusion of production from certain countries can increase distortions and even in some cases lead to increased emissions.
Option D	Average total of GHG savings (incl. estimated ILUC) of 70%. 8 Mt of annual estimated ILUC emissions by 2020.	Most efficient in reducing estimated ILUC emissions and other environmental impacts such as biodiversity. Strong incentives for development of bioethanol and advanced biofuels, particularly biodiesel. The option for addressing ILUC referred to in the Directives. Targets biofuels with high estimated ILUC directly, reducing demand for such feedstocks.	High risk of not achieving RED transport target and FQD from significant reduction in biofuel availability. Policy methodology dependent on actions outside the control of biofuel producers. Uncertainty for industry due to expected updates of ILUC factors. All oil crops excluded, including all rapeseed which currently represents more than half of the biofuel feedstocks used in the EU. This would require major industrial adjustment. Potential WTO compatibility issues.

Options E	Average total of GHG savings (incl. estimated ILUC) of 44%. 20 Mt of annual estimated ILUC emissions by 2020. .	Efficient in reducing estimated ILUC emissions and other environmental impacts such as biodiversity. Moderate industrial adjustment required to 2020 as current production levels of conventional biofuels would be mantained. Least demanding option with regards to the technical blending compatibility of vehicles. Very strong incentives for development of advanced biofuels and clarity for future investors. No increase in administrative costs.	Some risk of not achieving RED transport target and FQD from reduced biofuel availability. Estimated ILUC emissions not reported. No difference in treatment across conventional biofuels acording to their ILUC impacts.
Option D + C2	Improved efficiency from D expected but not possible to quantify.	**As for option D but in addition:** Increased availability of conventional biodiesel and so lower impacts on biodiesel and related industries. Possibilities for biodiesel derived from vegetable oils to supply the EU, which increases security of supply compared to D. Provides a method under the control of biofuel producers to avoid uncertainty around ILUC factors.	**As for option D but in addition:** Certification methodology for production of low ILUC risk biofuels remains to be developed. Potentially costly and administratively burdensome to comply with C2.

7. CONCLUSION

On the basis of the analytical work presented in this Impact Assessment, it is possible to draw a number of conclusions:

(1) the estimated indirect land-use change emissions are, despite the better understanding and recent improvements in the science, vulnerable to the modelling framework and the assumptions made;

(2) the use of biofuels in the EU saves emissions, also when estimated indirect land-use change emissions are included. In addition, the models indicate a hierarchy of biofuel types according to their indirect land-use change impacts, these being considerably higher for typical biodiesel feedstocks (oil crops), than for bioethanol feedstocks (cereals, and sugar crops);

(3) given the strong reliance on conventional biodiesel, and to a lesser extent conventional bioethanol, in projected biofuel volumes to 2020, there is a high risk that the estimated indirect land-use change emissions will significantly reduce the expected savings from the policy if no action is taken to mitigate indirect land-use change emissions; and;

(4) the development of advanced biofuels, using low-value resources as straw, wood and forestry residues is slower than previously expected, as the costs associated with producing such fuels is higher than the alternative conventional biofuels.

There are reasonable grounds to believe that indirect land-use change emissions could partly undermine the greenhouse gas savings offered by using biofuels. In application of the precautionary principle, option A) is therefore discarded.

Consideration has also been given to options for introducing additional sustainability requirements on certain categories of biofuels, including certain actions that could be implemented at both country and project level. With regard to country-wide sustainability criteria, the assessment showed that this option would need to be implemented globally in order to be fully effective. In respect of project level actions, the Impact Assessment showed that although biofuels produced under these conditions could be effectively promoted through being considered as exemptions to the application of ILUC factors, these criteria are insufficiently developed at this time to be included in legislative proposal as no certification scheme currently exists. As such, option C) must also be discarded.

With regards to a threshold increase, as described for option B), this option would seem effective in reducing indirect land-use change as long as it leads to the replacement of those biofuels with estimated high indirect land-use change emissions (i.e. vegetable oils) by those with estimated low emissions (i.e. cereals, sugars and advanced biofuels). However, the effectiveness of a threshold increase to 60% (i.e. a reduction of indirect land-use change emissions of 70%, from 46 Mt of $CO_{2\text{-eq.}}$/yr to 14 Mt $CO_{2\text{-eq.}}$/yr in 2020) would be reduced by two thirds if further improvements in the greenhouse gas balance of main vegetable oil crops to levels which seem technologically feasible, can be achieved. As such, the uncertainty around the effectiveness of this approach would always remain high unless much higher thresholds are applied across the board, which would discriminate against biofuels with low estimated indirect land-use change emissions. This option in isolation has therefore been discarded.

Option D concerns the introduction of factors to demonstrate compliance with the sustainability criteria as well as the reporting of greenhouse gas emissions towards emission reduction targets. This would seem the most effective option in reducing indirect land use change emissions (i.e. a reduction of indirect land-use change emissions of 85%, from 46 Mt of $CO_{2\text{-eq.}}$/yr to 8 Mt $CO_{2\text{-eq.}}$/yr in 2020). However, the application of this option in isolation would require major industrial adjustment which does not seem achievable in the period to 2020. This is because it would require a) the exclusion of all vegetable oil biodiesel which today represents the vast majority of the market; b) unrealistic levels of bioethanol given the current blend limits; and c) unrealistic levels of advanced biofuels coming into the market. Moreover, the introduction of factors in the sustainability criteria would not take into account the limits of the modelling in the policy design. As such, the application of this option in isolation has been discarded.

The remaining option E, i.e. limiting the amount of conventional biofuels counting towards the Renewable Energy Directive transport target to current production levels, would also be effective in reducing indirect land-use change (i.e. a reduction of indirect land-use change emissions of 55%, from 46 Mt of $CO_{2\text{-eq./yr}}$ to 21 Mt $CO_{2\text{-eq./yr}}$ in 2020). In addition, this option would require moderate industrial adjustment as it would only exclude vegetable oil biodiesel beyond current production levels in the run up to 2020 and would not necessarily pose a technical challenge from a blending limit perspective, while providing a strong incentive for increasing the share of advanced biofuels. The incentives for producing advanced biofuels would be strong, as the amount of double counted advanced biofuels would need to increase significantly[124]. Option E thus appears to provide a basis of a suitable way forward.

This Impact Assessment shows that a balanced approach based on option E, accompanied by complementary elements of options B and D and additional incentives for advanced biofuels, would be the best way to minimise estimated indirect land-use change emissions. This is because

(1) option E avoids any additional ILUC-impacts to happen for the period up to 2020 as it limits the use of conventional biofuels to current production levels, while at the same time the targets for renewable energy of the Renewable Energy Directive remain achievable;

(2) it protects existing investments, while giving a clear message that after 2020 only advanced biofuels will be supported. This provides the needed certainty for new investments in the sector as no further changes would occur up to 2020;

(3) it distinguishes between feedstocks according to their estimated indirect land-use change impacts which would be reported, thereby providing more transparency;

[124] Around 2-3 % of the 10% target of double counted advanced biofuels would be needed. This is equivalent to 6 to 9 Mtoe. For comparison, the US RFS2 is requiring 36 billion gallons by 2022, of which at least 16 billion gallons have to be advanced biofuels from cellulosic material. 16 billion gallons of ethanol is equivalent to around 30 Mtoe, i.e. an energy quantity similar to what is required to reach the 10% transport target of the Renewable Energy Directive.

(4) sustainability of biofuels remains a question of verifiable and measureable direct emissions;

(5) the enhanced incentives and accounting for advanced non-land using biofuels to four times the contribution of conventional biofuels will spur development of such biofuels with zero risk of indirect land-use change emissions, as no land is used for their production.

Although it has not been possible to assess the effectiveness of this package of measures under the current methodology, it is expected to reduce indirect land-use change emissions significantly. As a minimum, the package of measures will reduce indirect land use change emissions as option E in isolation (55% by 2020). However, it is expected that the additional incentives for advanced biofuels will lead to a further shift away from biofuels with high estimated indirect land-use change emissions.

In conclusion this combination would minimise the risks of indirect land-use change emissions, while protecting existing investments and, at the same time, acknowledging and taking into account in the policy design the limits of the modelling.

8. FUTURE MONITORING AND EVALUATION

The Commission will monitor the impacts of indirect land-use change in the framework of its bi-annual reports referred to in Article 23 (1) of the Renewable Energy Directive:

The Commission shall monitor the origin of biofuels and bioliquids consumed in the Community and the impact of their production, including impact as a result of displacement, on land-use in the Community and the main third countries of supply. Such monitoring shall be based on Member States' reports [..] and those of relevant third countries, intergovernmental organisations, scientific studies and any other relevant pieces of information.

Related to this and other monitoring and reporting requirements of the Renewable Energy Directive, a study for the development of baseline data is being carried out[125]. The first Commission report on the basis of this monitoring and analysis is due in 2012. In addition to ex-post assessment of impacts, the monitoring would include the development of the scientific work on ex-ante estimations of the effects of indirect land-use change. In the context of the current understanding of modelling indirect land-use change emissions, including the relative importance of the various parameter involved in estimating indirect land-use change emissions, there is a need to monitor a range of elements, including, but not limited to; the use of co-products, yield increases induced by the biofuel policy, displacement of cropland (i.e. what used to be the land-use of the cropland where biofuels are now grown) and developments on protecting high carbon stock land.

125 Tender specifications available at: http://ec.europa.eu/dgs/energy/tenders/doc/specifications/2009/s112_160619_specifications.pdf.

9. GLOSSARY

Advanced biofuel technologies = biofuels typically produced from non-food/feed feedstocks such as wastes and residues (i.e. wheat straw, municipal waste), non-food crops (i.e. grasses, miscanthus) and algae. Most technologies are at pilot scale or in development.

Bioethanol = alcohol-based biofuel typically produced from starch and sugar crops such as wheat and sugar beet, and used as a petrol additive for its use in motor vehicles.

Biodiesel = oil-based biofuels typically produced from vegetable and animal fats, such as rapeseed oil and tallow, and used as a diesel additive for its use in motor vehicles.

Biofuels = liquid or gaseous fuel used for transport purposes produced from biomass.

Bioliquids = liquid fuels used for energy purposes other than transport, including electricity, heating and cooling, produced from biomass. These are typically produced from vegetable oils such as palm and waste oils.

Biomass = the biodegradable fraction of products, waste and residues from biological origin from agriculture (including vegetable and animal substances), forestry and related industries including fisheries and aquaculture, as well as the biodegradable fraction of industrial and municipal waste.

Conventionally produced biofuels = biofuels typically produced from land using feedstocks which are also used in other markets (i.e. food and feed). These also include the use of certain waste and residues which do not require complex technological processes (i.e. biodiesel from used cooking oil or animal fat).

Direct land-use change = land-use change occurring *directly*, i.e. mostly referred to in the context of the conversion of land areas to cropland.

Direct emissions from biofuels = greenhouse gas emissions associated directly with the production of biofuels. These may include greenhouse gas emissions associated with the cultivation and harvest of feedstocks, with the processing and production of the biofuel, its transportation, direct land-use change.

High carbon stock land = Land with large amounts of carbon stored in biomass (trees, grass, roots etc.) and/or soil.

Indirect land-use change = land-use change occurring *indirectly* i.e. mostly referred to in the context of land-use change as a result of displaced demand previously destined for food/feed/fibre market as a result of biofuel demand.

Land-use change = the conversion of land from one use to another, e.g. from forestry to cropping.

ACRONYMS

ACP African, Caribbean and Pacific States

AEZ Agro-environmental zones

B10 and B30 Diesel blends containing 10% and 30% biodiesel in volume.

CAP Common Agricultural Policy

CARB Californian Air Resources Board

CEPII French: Institute for Research on the International Economy

CFPP Cold Filter Plugging Point

CGE Computable General Equilibrium models

CHP Combined heat and power

CIS Commonwealth of Independent States (Ex-USSR)

CO_2 Carbon dioxide

COP Conference of Parties

COWI Consultancy within Engineering, Environmental Science and Economics

CNG Compressed natural gas

DDGS Dried Distillers Grains with Solubles

EBB European Biodiesel Board

EC European Commission

EJ Exajoule (10^{18} joules)

Epure European Bioethanol association

ETS European Emissions Trading Scheme

EU/EU-27 European Union

E10 and E85 Petrol blends containing 10% and 85% bioethanol in volume

FAME Fatty acid methyl esther

Fediol EU Oil and Protein Meal association

FFC Fossil fuel comparator

FLEGT Forest Law Enforcement, Governance and Trade

FQD Fuel Quality Directive

FT Fischer-Tropsch

g Grams

GAEC Good agricultural and environmental condition

GHG Greenhouse gas

GSP+ Generalised System of Preferences

GTAP Global Trade Analysis Project

ha Hectare

HD High Density

HPO Hydrogenated Pyrolisis Oil

HVO Hydrotreated Vegetable Oil

H_2 Hydrogen (referred to in the context of liquid hydrogen as a fuel)

IEA International Energy Agency

IFPRI International Food Policy Research Institute

IPCC Intergovernmental Panel on Climate Change

JEC Consortium of JRC, EURCAR (the European Council for Automotive R&D) and CONCAWE (the Oil Companies' European Organisation for Environment, Health and Safety)

JRC The Joint Research Centre of the European Commission

LCFS Low Carbon Fuel Standard

LD Low Density

LPG Liquified Petroleum Gas

LULUCF Land-use, land-use change and forestry

Mha Million hectares

MJ Megajoule (10^6 joules)

MS Member States of the European Union

MSA Mean Species Abundance

Mt Million tonnes

Mtoe Million tonnes of oil equivalent

NGO Non-governmental Organisation

NREAPS National Renewable Energy Action Plans

OWL Other wooded land

PBL Netherlands Environmental Agency

PE Partial Equilibrium models

Pg Petagram (10^{15} grams)

Ppm Parts per million

RED Renewable Energy Directive

REDD+ The United Nations Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries

RES Renewable Energy

RSB Round Table for Sustainable Biofuels

TJ Terajoule (10^{12} joules)

UNFCCC United Nations Framework Convention for Climate Change

UNEP United Nations Environment Programme

UK United Kingdom of Great Britain and Northern Ireland

US United States of America

WCMC World Conservation Monitoring Centre

WTO World Trade Organisation

10. ANNEX I – CONSULTATION AND USE OF EXTERNAL EXPERTISE

10.1. Summary of responses from indirect land-use change "pre-consultation"

The Commission sought public views on possible approaches to address indirect land-use change in a "pre-consultation" exercise between 14 June and 31 July 2009. The approaches considered were:

(a) *Extend to other commodities/countries the restrictions on land-use change that will be imposed on biofuels consumed in the European Union.*

(b) *International agreements on protecting carbon-rich habitats.*

(c) *Do nothing.*

(d) *Increase the minimum required level of greenhouse gas savings.*

(e) *Extending the use of bonuses.*

(f) *Additional sustainability requirements for biofuels from crops/areas whose production is liable to lead to a high level of damaging land-use change.*

(g) *Include an indirect land-use change factor in greenhouse gas calculations for biofuels.*

(h) *Other policy elements that respondents may wish to raise.*

A total of 71 responses were received[126], 28% from EU Member States and third countries, 6% from public bodies, and the rest from organisations among which 45% were from industry and businesses, 13% from non-governmental organisations, and 8% from research institutions. Most industry, farmers' associations and third countries supported either no action or dealing with indirect land-use change through wider policy action (either through international action on protection of high carbon stock land and/or extending sustainability criteria to all agricultural commodities). Most NGOs and an industrial stakeholder from the non-biofuel sector supported the inclusion of greenhouse gas emissions associated with indirect land-use change within the existing legislative scheme for determining the greenhouse gas emission for biofuels. Certain NGOs and research institutions supported to lower the 10% target or set a maximum contribution conventional biofuels. Member States were divided on this issue.

10.2. Analytical work

In order to base its work on the best available scientific evidence, the Commission services launched a number of analytical exercises and a review of existing literature on the subject of indirect land-use change during 2009 and 2010[127,128].

The International Food Policy Institute (IFPRI) was commissioned to look at the "*Global trade and environmental impact study of the EU biofuels mandate*". The final report was published in October 2011[129], and has used the most up to date biofuel demand estimates up

126 All responses are available at: http://ec.europa.eu/energy/renewables/consultations/2009_07_31_iluc_pre_consultation_en.htm.
127 http://ec.europa.eu/energy/renewables/studies/land_use_change_en.htm.
128 http://re.jrc.ec.europa.eu/bf-tp/html/documents_main.htm.
129 http://trade.ec.europa.eu/doclib/docs/2011/october/tradoc_148289.pdf.

to 2020 as outlined by the Member States in the national renewable energy action plans[130]. In addition, the study aims to provide a better characterisation of the uncertainty associated with the crop specific indirect land-use change emission values.

A number of other studies were launched by several Commission services:

– "Impacts of the EU biofuel target on agricultural markets and land-use: a comparative modelling assessment", by the Institute for Prospective Technological Studies of the EC's Joint Research Centre;

– "The impact of land-use change on greenhouse gas emissions from biofuels and bioliquids– an in-house review conducted for DG Energy;

– "Indirect land-use change from increased biofuels demand – comparison of models and results for marginal biofuels production from different feedstocks" by the EC's Institute for Energy of the Joint Research Centre;

– "*Biofuels- a new methodology to estimate GHG emissions from global land-use change*" by the Institute for Environment and Sustainability and Institute for Energy of the EC's Joint Research's Centre[131].

10.3. Summary of responses from main indirect land-use change consultation

Following the publication of the relevant analytical work in July 2010, the Commission launched a second public consultation exercise between 30 July and 31 October 2010. This sought views on whether this analytical work provided a good basis for determining the significance of indirect land-use change; whether action was required, and if so what course of action would be appropriate. It also set out a reduced number of possible policy approaches:

(a) *Take no action for the time being*, while monitoring impacts including trends in certain key parameters and, if appropriate, proposing corrective action later;

(b) Take action by encouraging greater use of some categories of biofuel;

(c) Discourage the use of some categories of biofuel by:

– increasing the minimum greenhouse gas saving threshold for biofuels;

– imposing additional sustainability requirements on certain categories of biofuel.

– attributing a quantity of greenhouse gas emissions from indirect land-use change to all biofuels that use land.

(d) Take some other form of action.

A total of 145 responses were received[132] comprising 9% from EU Member States and third countries, 2% from public bodies, and the rest from organisations among which 60% were

[130] http://ec.europa.eu/energy/renewables/transparency_platform/action_plan_en.htm.

[131] In 2011, the JRC carried out additional application of their Spatial Allocation Methodology (SAM) to additional IFPRI-MIRAGE-BIOF scenarios.

from industry and businesses, 23% from non-governmental organisations, and 6% from research institutions.

Responses fell into two broad groups. Most respondents from industry, farmers' associations and third countries considered that the analytical work did not provide a good basis for determining the significance of indirect land-use change. They considered that no further action specific to biofuel policy should be taken, although many supported action on international agreements towards the protection of land with high carbon stock. On the other hand, most NGOs and a few industrial stakeholders from non-biofuel sectors considered that further action was needed and supported the inclusion of the indirect land-use change emissions within the existing greenhouse gas emission calculation. A number of other respondents recognised that action may be needed, favouring a variety of other measures, in particular options aimed at limiting the amount of conventional biofuels while increasing the share of advanced biofuels, which were mainly favoured by NGOs and certain industrial stakeholders.

Member States were divided on this.

10.4. External expertise

Following this public consultation, in November 2010 the JRC organised an expert consultation on behalf of the Commission, which brought together world-recognised academics and experts in the field. This consultation aimed at discussing the main uncertainties related to the estimation of indirect land-use change[133].

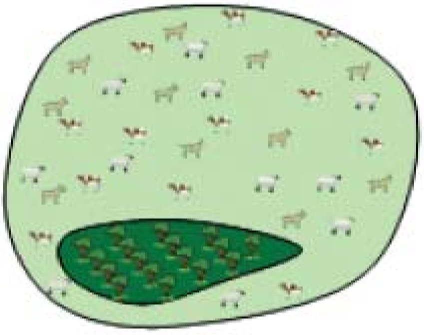
In February 2010, the JRC organized a workshop on “The Effects of increased demand for biofuels feedstocks on world agricultural markets and areas” with the participation of leading experts and modellers from the EU and US. The workshop discussed the results of the JRC modelling comparison study and reasons for differences between models results.

[132] All responses are available at http://ec.europa.eu/energy/renewables/consultations/2010_10_31_iluc_and_biofuels_en.htm.

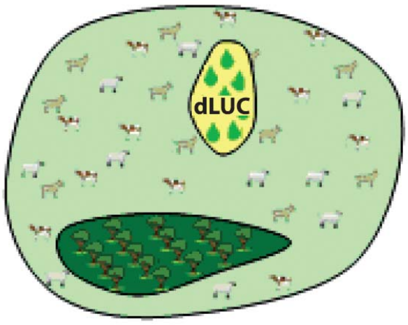
[133] All contributions, including the workshop's report "Critical Issues in Estimating ILUC Emissions. Outcomes of an Expert Consultation" EU report n. JRC64429, are available via http://re.jrc.ec.europa.eu/biof/html/documents_publications.htm.

11. ANNEX II – THE CONCEPT OF INDIRECT AND DIRECT LAND-USE CHANGE EMISSIONS

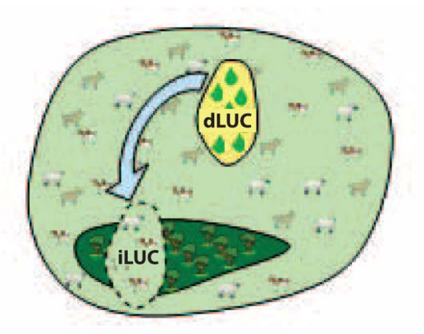
The figure below illustrates in a highly simplified manner how both direct and indirect land-use change takes place.



In this highly simplified example we look at a global agricultural system with only grazing land and forest land. At the outset there is no biofuel production on neither of the two land types.



The introduction of the biofuel production on grazing land leads to direct land-use change and may cause a loss or an increase of soil organic carbon. If the biofuel production is introduced onto the forest land, then the direct land-use change emissions may be large because there is a loss of forest biomass. Both these direct land-use change emissions are included in the overall greenhouse gas calculation of the produced biofuel (part of the sustainability criteria).



Macro-economic effects cause an increase in the value of grazing animals (i.e. meat), as less is now being produced. This creates an incentive to increase the production of meat. This can be done through yield increases (e.g. more animals per hectare) or conversion of more land to grazing land. The latter is indirect land-use change and causes in this example a loss of forest carbon stocks, since grazing has now expanded into forest areas.

There is not a one-to-one relationship between the pasture/cropland area converted to biofuel and the area converted to new pasture/cropland. This relationship depends on the relative productivity of the old vs. new pasture/cropland, markets for co-products and to what extent the macro-economic pressure induces increased productivity and changes in consumption.

Figure 8: Examples of direct and indirect land-use changes arising as a consequence of a biofuel project (pictures from IEA Bioenergy Berndes et.al. 2010)

12. ANNEX III – MODEL LIMITATIONS AND UNCERTAINTIES

12.1. Economic models to estimate indirect land-use change emissions

Modelling of indirect land-use change is usually based on an assessment of what the situation would have been expected to be without policies promoting biofuels and comparing it with an assessment carried out with such policies. Such an assessment can be carried out with more or less degrees of sophistication. Simple calculations based upon the land area that biofuel demand will, assuming displacement of all crops previously grown, represent the theoretical uppermost boundary of the indirect land-use impacts. However, the actual land area required is likely to be much lower due to constraints encouraging higher levels of inputs, higher yields, the production of co-products along with biofuels and the fact that the higher commodity prices will have a dampening effect on other demand for the agricultural commodities. A first approximation of these effects can be taken into account in a spreadsheet based approach to give an improved understanding of the indirect land-use change although there are limitations of such an approach.

To further improve the understanding of indirect land-use change it is necessary to make use of economic models which take account of price impacts to alter the expected behaviour of different parts of the economy. While spreadsheet-models are typically more transparent with regard to key assumptions, and allow for relations between parameters to be established without having regard to the ability of the model to solve all the equations (as in a macro-economic models), they do not capture important knock-on effects and feedbacks between sectors, as macro-economic models do.

There are mainly two groups of macro-economic models that try to capture various feedbacks between economic sectors. These are "Partial Equilibrium models" (PE) and "Computable General Equilibrium models" (CGE). The former typically covers certain sectors of the economy, which are most relevant for the purpose of the modelling effort (e.g. agricultural markets, or energy markets). The CGE models cover the whole economy, although often at a coarser resolution than the specific sectors covered by PE models. Often, various PE models are interlinked in order to capture broader effects.

The models that have been employed to estimate changes in domestic and international crop acreage have not been used in a regulatory context until recently. Rather they have been used to give policymakers an idea of the likely consequences of changes in agricultural and trade policy. As a guide to policy development and understanding, these models have proved very valuable in facilitating such policy agreements.

It is generally accepted that economic models offer the best prospect of understanding the scale and nature of indirect land-use change in terms of land area as well as other impacts. However, it is also known that in reality several non-economic factors influence what land-use change takes place and where it occurs. Some of these drivers are related to political choices (land-use and agricultural policy, land rights, etc.), others to institutional features (proximity to infrastructure and markets, land-use legislation). Therefore conceptual limitations will always remain.

Models typically base their assumption on existing correlations, which are based on historical trends, and are therefore not capturing potential changes in policies that may take place in the future. They therefore have limitations and uncertainties which are further explained in the next section and which would affect this impact assessment by making it difficult to assess the scale of the indirect land-use change phenomena related to biofuels, and the effectiveness and efficiency of the policy options. Furthermore, the risk of contra-productive policies is dependent on the certainty of the science, and to what extent the policies are based on these findings.

12.2. Why models differ in their results

Models attempt to describe the reality in various ways. Fundamentally they vary in structure (CGE, PE, spreadsheet model etc.) coverage (geographical, economic sectors, time-span), data (carbon stocks, transport demand etc.) and assumptions on economic cause and effect relations (elasticities, future projections etc.).

In the context of estimating indirect land-use change emissions, there will always be a range of unsolved issues, which influence the results considerably. Aspects where modelling is based on uncertain assumptions, that however are likely to improve over time as more resources are invested in data and statistical analysis, are; the treatment of co-products[134], existing yields[135], marginal yields[136], type of land converted[137], classification of land[138], elasticities[139], carbon stock values[140], and the modelling of pasture[141].

Aspects that are likely to still be at the centre of dispute also in the longer run are; the drivers of deforestation and the implied causality[142], food and feed consumption[143], and the technology response to higher prices[144].

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134 Most biofuel feedstocks co-produce considerable quantities of co-products. Most models do now take this into account, although at various ratios, greatly influencing model results. Co-products normally replace animal feed, freeing up land that would otherwise be needed for its production.

135 Baseline yield increases are normally assumed to continue at historic rates whereas such predictions are uncertain.

136 There is little empirical evidence on developments of marginal yields.

137 The type of land that is converted to cropland has a major influence, as carbon stocks vary considerably across land types. Due to too course spatial resolution regional differences risk getting lost in the geographical aggregations.

138 Land availability and land classification is an essential input for land-use change modelling, however, figures and terminology are not consistent across datasets.

139 Elasticities are often estimated on basis of data from developed countries, while models suggest that indirect land-use change typically takes place in developing countries.

140 Carbon stock values attributed to different vegetation and soils vary considerably across studies, and play an essential part in determining the indirect land-use change impact.

141 Pasture for animals covers large parts of the globe, and offer potential supply of land for cultivation. However, how pasture is modelled and its interlinkages with feed markets and cropland differ between models. The assumptions has major impacts on the overall results, as pasture is covering a large fraction of the terrestrial surface, and has relatively low carbon stocks.

142 Drivers behind deforestation are complex, where local authorities, land-use rights and political economy all play a role. It is not possible to properly reflect this real world effects in the models, where decision making is reduced to a purely rational economic question.

143 Economic models assume demand being a function of price, with different assumptions as to how the additional demand for biofuels will impact on food and feed commodity markets. The feedback from lowered oil-price to potential lowered food-price also needs consideration (Recommendations from the Food Consumption Subgroup ARB Expert Workgroup on Land-use Change – http://www.arb.ca.gov/fuels/lcfs/workgroups/ewg/010511-final-rpt-food-consumption.pdf).

144 Most models include yields to increase as a result of factor increase (labour, fertiliser, capital), but none reflect the possibility for technology change in response to higher prices.

In addition, the Literature review found that current macro economic models[145] are incapable of capturing a number of factors, including the conversion of forest on peat-land which can lead to considerable carbon emissions. However, the majority of such factors would, if captured, reduce the estimated land-use change impact. These include the allocation of all emissions to crop expansion, whereas deforestation can be driven simultaneously by crop expansion and logging; rate of yield improvements in response to increased demand for biofuels[146]; structural changes[147]; and, the protein content of various feeds and co-products, which is rarely fully reflected[148]. In addition, the effects of the binding sustainability criteria for biofuels in the Directives have not been taken into account.

The literature review also found that the geographical origin of the feedstock could also be a significant variable in estimating the (indirect) land-use change impact of a specific biofuel, i.e. whether the origin of the feedstock matters, as most feedstocks can be produced in various regions of the world. However, none of the modelling done so far has explored this variability, which may in fact not be possible with today's models.

Furthermore, the modelling comparison study found that current models do not capture a number of factors, which if taken into account, would increase the estimated land-use change impact. These factors include emissions from the conversion of peat-lands[149]. Moreover, apart from (indirect) land-use change emissions as discussed in this report, models do not consider at least two additional sources of increased emissions: the emissions from yield intensification due to crop price rises, and the extra emissions from growing crops on marginal land rather than on existing cropland.

The uncertainty in modelling indirect land-use change led the Commission to ask the JRC to organize a workshop with leading indirect land-use change experts to try to explore the main uncertainties. The workshop was held in November 2010[150]. The main topics being discussed were; cropland allocation (including amount of expansion on peatland), emissions factors (including emissions from peatland), yield developments (including marginal yields), as well as the influence of reduced food consumption and how pasture land interacts with cropland. The workshop also discussed briefly the various policy options.

In the last results from the IFPRI-MIRAGE-BioF, there have been attempts to address these concerns. Most notably:

- Peatland emissions, both in terms of the fraction of expansion taking place on peatland, as well as the emissions from drainage.

145 The literature review did not analyse spreadsheet models, as very few were published at the time of writing.

146 Increased yields are a function of a complex set of variables, among them increased investment and research, both of which take place as a response to the biofuel policy. It is however difficult to capture this effect in the models.

147 Structural changes are typically difficult to predict by models as elasticities are based on historical data. Considerable increase in use of land in e.g. CIS is therefore unlikely according to the models, while such a structural change could take place both in the baseline and in the policy scenario.

148 This is underestimating the land saved by co-products. For example, in the EU soy meal is a key source of protein, of which around 97% is imported. There is thus considerable scope of substitution.

149 Many models do not properly take into account the emissions from peat oxidation following drainage process required in the cultivation of palm oil, which could underestimate real emissions by an order of magnitude. Although the estimated emissions from peatlands have been adjusted upwards in recent modelling, the uncertainty as to what the value should be remains.

150 Presentations from the workshop can be found here: http://re.jrc.ec.europa.eu/bf-tp/html/documents_main.htm.

- Food demand is more inelastic
- More co-products from cereals are able to replace meals from oilseeds.

However, a number of issues remain. ATLASS highlights some of them in the final report, noting that *"the model has tested the limits of the CES/CET (constant elasticity of supply/transformation) framework. Both for co-products but also for land-use allocation, this conventional modeling approach leads to too many simplifications. For co-products, the two level CES approach has helped to reinforce the substitution at the protein contents between meals and DDGS. Unfortunately, it has also forced to simplify the representation of substitution between proteins and carbo-hydrates. Similarly for land-use, even if our multi-nested CET has helped to capture substitution between crops, it is not flexible enough to provide the right full substitution matrix across crops. More important from a long run perspective, it is not designed to capture issues such as multi-cropping and crop rotation, both important issues for land-use considerations in a dynamic approach".*

It is also worth noting that the elasticity of substitution and transformation were taken from the – limited – estimates in the literature. The same elasticity of substitution was assumed for all crops and all countries. To what extent these elasticities, which are based on a limited numbers of sources in the literature, are valid, and more importantly represents the likely development towards 2020 remains an open question. In addition, the sensitivity analysis on the demand side has been limited (rigid food demand, changes in price elasticities of intermediate demands). This is key for certain crops, such as cereals, as a large share of their additional production for biofuels is assumed not to be replaced, which would result in higher indirect land-use change impacts if this was not the case.

12.3. How can indirect land-use change emissions estimates be negative?

It is worth noting that one of the most recent spreadsheet models (E4tech) suggest that the likely indirect land-use change values for wheat ethanol range from -53 to -5.1 g/MJ (-5.1 g/MJ being identified as the most likely scenario). These surprising results are identified in the report to be the result of the large credits given to wheat ethanol by assuming that its co-products are replacing soy being grown in Argentina and Brazil for animal feed purposes, to which the same study allocates high land-use change emissions of around 55 g/MJ.

However, some of the assumptions made by this report around the rate of land abandonment in the EU, the amount of carbon lost to foregone sequestration by this land, assumptions on the yields on this land, and how much land would come from yield increases and not area increases have been questioned. Although negative results are rare, they can also be the results from estimating indirect land-use change emissions with macro-economic models, as can be seen in the Monte Carlo results shown in Annex XI where sugar beet has negative indirect land-use change emissions at one of the extremes of the probability distribution range.

13. ANNEX IV – RESULTS FROM ESTIMATING INDIRECT LAND-USE CHANGE WITH MODELS

13.1. Total indirect land-use change emissions

To understand the overall size of total indirect land-use change emissions associated with the additional biofuel demand, various scenarios were modelled in 2009 using the general equilibrium IFPRI-MIRAGE-BioF model and the partial equilibrium AGLINK-COSIMO model. Although only the IFPRI-MIRAGE-BioF model was able to directly estimate the overall greenhouse gas emissions resulting from the modelled land requirements, the JRC have estimated these impacts through the application of their newly developed Spatial Allocation Model. A further run of the IFPRI-MIRAGE-BioF model was carried out in 2011 based on the 2020 biofuel estimates submitted by the National Renewable Energy Action Plans (results are included in this section for comparison and are described in more detail in the baseline section of section 2).

The total estimated land requirements from the additional demand (i.e. change between the projected 2020 levels with the policy and those presumed in the absence of no biofuels policy) as well as the key assumptions are summarised in the table below.

MODEL	**Change in volume [%][a]**	**Bioethanol vs Biodiesel[b]**	**(I)LUC area (Mha)**	**Total GHG[c] (Mt CO_2eq)**	**Total GHG[c] (JRC SAM) (Mt CO_2eq)**
IFPRI-MIRAGE-BioF (5.6%)	2.3	87/13	0.8-1	107-118	201-248
IFPRI-MIRAGE-BioF (8.6%)	5.2	60/40	2.8-3	435-454	731-806[d]
IFPRI-MIRAGE-BioF (NREAPs)	5.7	28/72	1.7-1.9	500[d]	421-472[d]
AGLINK-COSIMO (7%)	5.4	35/65	5.2	n/a	1092

Table 12: Summary of overall GHG impacts from (indirect) land-use change. Source: IFPRI-MIRAGE-BIOF and JRC.
[a] Change in conventional biofuels demand as % of EU 2020 transport fuel consumption.
[b] Estimated mix of bioethanol vs biodiesel in the additional demand.
[c] Emissions from Business as Usual and Free trade scenarios.
[d] Including peat emissions.

MODEL	IFPRI-MIRAGE-BioF (5.6%)	IFPRI-MIRAGE-BioF (8.6%)	IFPRI-MIRAGE-BioF (NREAPs)	AGLINK-COSIMO (7%)
Original model	18	31-33	24-50	n/a
JRC SAM	34-41	53-58	32-36	63

Table 13: Summary of average greenhouse gas impacts from (indirect) land-use change (gCO_2eq /MJ). Source: ATLASS and JRC

The differences between the IFPRI-MIRAGE-BioF runs are driven by the different bioethanol/biodiesel composition and overall mandate volume as described in table 13. In addition, peat land emissions were underestimated compared to current values.

13.2. Marginal indirect land-use change values for feedstocks

To better understand whether indirect land-use change emissions are similar across different biofuel pathways or differ between feedstocks, a modelling assessment of the indirect land-use change caused by individual types of biofuels was carried out. The IFPRI-MIRAGE-BioF model was used to determine values for additional volumes of biofuels based on different feedstocks. The resulting indirect land-use change values from this were as shown in table 14 below.

	Ethanol			**Biodiesel**				
	Sugar Cane	Sugar Beet	Maize	Wheat	Palm oil	Rapeseed oil	Soy oil	Sunflower oil
IFPRI-MIRAGE-BioF (5.6%)	18	16	54	37	46	53	75	60
IFPRI-MIRAGE-BioF (NREAPS)	14	7	10	14	54	54	56	52
JRC-SAM (from IFPRI-MIRAGE-BioF NREAPs	22-26	5-6	13-14	16-17	21-45	43-53	44-53	51-59

Table 14: Summary of IFPRI-MIRAGE-BioF marginal (indirect) land-use change emissions (gCO_2eq /MJ). Source: IFPRI-MIRAGE-BioF and JRC.

As it can be seen from the table, models tend to allocate different (indirect) land-use change emissions to different feedstocks. This is one of the reasons that average emissions in table 14 vary according to the overall feedstock composition predicted in the final mix.

At the crop level, we see much larger differences due to the fact that some parameters have been altered between the studies (i.e. new yields, increased displacement potential between crops, better replacement ratio for co-products), as well as the method used to compute the crop LUC now being based on a much larger share. In addition, it is worth noting that the authors consider some of the new key assumptions affecting the cereal crops to be strongly optimistic, including very high yields for wheat in the EU, and maize in the US and Brazil. This is important as these variations have not been included in the sensitivity analysis but play a significant role in the estimation of indirect land-use change emissions.

The difference between biodiesel crops and ethanol crops has increased. For nearly all crops, except palm oil due to the increase in peat emissions, the estimated indirect land-use change emissions have been reduced, when one compares results from IFPRI-MIRAGE-BIOF from 2010 and from 2011. Estimated indirect land-use change emissions for soybean has been cut by half while maize has been cut by five. However, the ranking between feedstocks remains the same (sugars being the best and oilseeds the worst).

14. ANNEX V – THE IFPRI-MIRAGE-BIOF MODEL: ASSUMPTIONS AND RESULTS

14.1. The principles of the MIRAGE model

The MIRAGE model was initially developed at CEPII. This section summarizes the features of the standard version relevant for this study. MIRAGE is a multisector, multiregion Computable General Equilibrium (CGE) Model for trade policy analysis. The model operates in a sequential dynamic recursive set-up: it is solved for one period, and then all variable values, determined at the end of a period, are used as the initial values of the next one. In order to evaluate the impact of public policies regarding first generation biofuels, ATLASS has developed an extended version of the global CGE MIRAGE, nicknamed IFPRI-MIRAGE-BioF, by improving the standard version in several directions. A detailed description of this version of the model is provided in Bouët et al. (2010)[151] and in other studies (Al-Riffai, Dimaranan, and Laborde 2010a)[152].

The MIRAGE model relies on the Global Trade Analysis Project (GTAP) database for global, economy-wide data. The GTAP database combines domestic input-output matrices which provide details on the intersectoral linkages within each region, and international datasets on macroeconomic aggregates, bilateral trade, protection, and energy. We started from the latest available database, GTAP 7, which describes global economic activity for the 2004 reference year in an aggregation of 113 regions and 57 sectors (Narayanan and Walmsley, 2008). The database was then modified to accommodate the sectoral changes made to the IFPRI-MIRAGE-BioF model. Twenty-three new sectors were carved out of the GTAP sector aggregates -- the liquid biofuels sectors (an ethanol sector with four feed-stock specific sectors, and a biodiesel sector), major feedstock sectors (maize, rapeseed, soybeans, sunflower, palm fruit and the related oils), co- and by-products of distilling and crushing activities, the fertilizer sector, and the transport fuels sector. This process did not consist of a simple disaggregation of parent sectors, but required a full rescaling of agricultural production data according to FAO statistics on quantity and prices, harmonization of prices on substitutable homogenous goods such as biofuels or vegetable oils, and bottom-up reconstruction of production costs for biofuel sectors and crushing sectors for oilseeds.

Goods are consumed by final consumers (public and private agent) and firms or are exported to foreign markets. The final consumption demand system is represented through a LES-CES that is recalibrated each year along the baseline to reproduce consistent income and price elasticities. Imported goods are differentiated from domestic goods following the Armington assumption, which allows us to distinguish different levels of market integration. The sector sub-utility function used in MIRAGE is a nesting of four CES functions. In this study, Armington elasticities are drawn from the GTAP 7 database and are assumed to be the same across regions. But a high value of Armington elasticity, i.e. 10, is assumed for all homogenous sectors (single crops, single vegetal oils, ethanol). For biodiesel, we assume the same elasticity as that for other fossil fuels.

151 Bouët, A., Dimaranan, B. V. and Valin, H. (2010), Modeling the global trade and environmental impacts of biofuel policies, IFPRI Discussion Paper (01018), International Food Policy Research Institute.

152 Al-Riffai, P., Dimaranan, B. and Laborde, D. (2010), Global Trade and Environmental Impact Study of the EU Biofuels Mandate, Final Report for the Directorate General for Trade of the European Commission, International Food Policy Research Institute.

From the supply side in each sector, the production function is a Leontief function of value-added and intermediate inputs: one output unit needs for its production x percent of an aggregate of productive factors (labor, unskilled and skilled; capital; land and natural resources) and (1 – x) percent of intermediate inputs. The intermediate inputs function is a nested system of CES function of all goods: it means that substitutability exists between two intermediate goods, depending on the relative prices of these goods. This substitutability is constant and at the same level for any pair of intermediate goods. Particular care has been paid in the final and intermediary consumption nesting to the substitution possibilities of similar products on the one side (vegetable oils, oilseed meals, ethanol feedstocks) and to the rigidity relative to certain inputs in the production chain (vegetable oil to produce biodiesel, sugar raw products to produce refined sugar, etc). Similarly, in the generic version of the model, value-added is a constant elasticity of substitution (CES) function of unskilled labor, a logistic bundle of land and intensification inputs (fertilizer for crops, feedstuff for livestock), natural resources, and of a CES bundle of skilled labor and capital. This nesting allows the modeler to introduce less substitutability between capital and skilled labor than between these two and other factors. In other words, when the relative price of unskilled labor is increased, this factor is replaced by a combination of capital and skilled labor, which are more complementary.

Moreover, the model relies on many features specifically introduced to adequately represent the effects of biofuel policies. In particular, it includes a detailed description of the insertion of biofuel in the consumption chain, a modeling of binding incorporation mandates, and a representation of co-products production for the bioethanol sector by type of pathway (wheat, corn, sugar beet) and for the four oilseed processing sectors that have been explicitly introduced (rapeseed, soybean, sunflower, and palm fruit).

Factor endowments are fully employed. The only factor whose supply is constant is natural resources. Capital supply is modified each year because of depreciation and investment. Growth rates of labor supply are fixed exogenously. Skilled labor is the only factor that is perfectly mobile. Installed capital and natural resources are sector specific. New capital is allocated among sectors according to an investment function. Unskilled labor is imperfectly mobile between agricultural and nonagricultural sectors according to a constant elasticity of transformation (CET) function: unskilled labor's remuneration in agricultural activities is different from that in nonagricultural activities. This factor is distributed between these two series of sectors according to the ratio of remunerations.

To capture the interactions between biofuels production and land-use change, the model has specific features focusing on a decomposition of land-use and land-use change dynamics. Land resources are differentiated between different agro-environmental zones (AEZ). The possibility of extension in total land supply to take into account the role of marginal land (and potential lower yield) is also introduced. The modelling of land-use change captures both the substitution effect involved in changing the existing land allocation to different crops and economic uses, and the expansion effect of using more arable land for cultivation. Land allocation decision across crops, pasture and managed forest is based on a three level nested CET structure. Land extension into pristine environment is based on an elastic land supply function, depending on the cropland price and having an elasticity decreasing with the amount of suitable agricultural land potentially available.

With regard to yields projections, the ATLASS consortium based them on the 2010 new baseline of the Aglink-Cosimo used in the Agricultural Outlook of DG AGRI's forecast.

	Maize	Palm-Fruit	Rape-seed	Soy-beans	Sugar beet/cane	Sun-flower	Wheat
EU27	8.1		3.9	1.9	70.4	2.3	8.0
Brazil	10.5	41.4	3.5	3.5	96.7	3.1	5.0
Central America and Caribbean countries	3.0	26.1		4.7	121.0		5.2
China	6.8	36.4	2.5	2.3	146.0	2.1	5.4
Commonwealth of Independent States (inc Russia)	5.2		1.9	1.4	54.2	2.2	2.6
Indonesia/Malaysia	5.0	34.1		1.9	94.5		
Other Latin America countries	5.7	26.0	2.6	3.2	120.1	1.8	3.8
Rest of OECD (inc. Canada & Australia)	11.6	6.4	2.4	3.4	129.3	2.9	2.4
Rest of the World	6.8	4.7	2.6	2.0	130.7	2.0	4.9
Sub-Saharan Africa	2.4	6.6	1.9	2.0	99.5	1.7	3.1
USA	13.7		2.7	2.7	84.9	1.6	3.9
World	**7.7**	**20.5**	**2.8**	**2.9**	**108.4**	**2.1**	**4.3**

Table 15: Yields. tonnes per Ha. 2020. Baseline. Source: IFPRI-MIRAGE-BIOF (2011) (Sugar cane and sugar beet according to region where it grows; i.e. sugar beet in the EU and sugar cane in Brazil)

14.2. More results from IFPRI-MIRAGE-BioF

The global effects of changing land-uses are shown in an informative manner in table below, where the amount of displaced land per TJ of biofuels is shown. The columns are indicating:

	Explanation
Column 1	Amount of land needed to produce 1 TJ of biofuel using the specific feedstock indicated.
Column 2	Amount of land changed to energy crops as a result of using 1 TJ of the biofuel feedstock.
Column 3	Change in total amount of cropland. This amount of land will have to be converted from managed or unmanaged (natural) land
Column 4	Change in total amount of pasture
Column 5	Change in total amount of exploited land (i.e. land not previously used like primary forest)

	Column 1	Column 2	Column 3	Column 4	Column 5
	Scenario Feedstock	**Net Energy Crops**	**Net Cropland**	**Pasture**	**Net Exploited Land**
Biodiesel_PalmFruit					
EU27		0.35	0.08	-0.01	0.03
World	3.89	5.74	1.97	-0.91	0.12
Biodiesel_Rapeseed					
EU27	4.42	2.94	0.51	-0.10	0.14
World	10.91	11.72	3.90	-1.39	0.64
Biodiesel_Soybean					
EU27	0.14	0.77	0.10	-0.02	0.03
World	11.61	11.41	3.86	-1.50	0.76
Biodiesel_Sunflower					
EU27	4.28	2.53	0.33	-0.06	0.09
World	13.59	12.42	4.90	-2.04	0.71
Ethanol_Beet					
EU27	5.34	2.23	0.17	-0.05	0.02
World	5.75	2.97	0.41	-0.13	-0.13
Ethanol_Cane					
EU27		0.01	0.03	-0.01	0.00
World		2.70	1.48	-0.88	0.15
Ethanol_Maize					
EU27	2.40	1.13	0.08	-0.02	0.01
World	6.52	3.69	0.88	-0.40	0.00
Ethanol_Wheat					
EU27	3.27	1.77	0.17	-0.04	0.03
World	7.64	4.99	1.39	-0.54	0.10

Table 16: Global effects of changing land-use in amount of displaced land per TJ of biofuels

The table above shows that of the additional land needed to produce 1 TJ of biofuels (column 1), only a fraction is needed in terms of additional cropland (column 3) and out of the additional cropland an even smaller fraction comes from natural areas (primary forests and grassland – column 5). Note e.g. that 1 TJ of maize does not take any new unused land into production, while sugar beet returns 0.11 ha *back to natural areas*. Rapeseed and soy bean and sunflower are the crops that takes the most new land into production, with aroud 0.8 ha per TJ of biofuel.

However, it is not only the amount of land that is important, but also what amout of carbon stock is on that particular land. These aspects are shown in the figure below, indicating the balance between amount of land needed by certain crops (column 3 above), and the average carbon stock of that land.

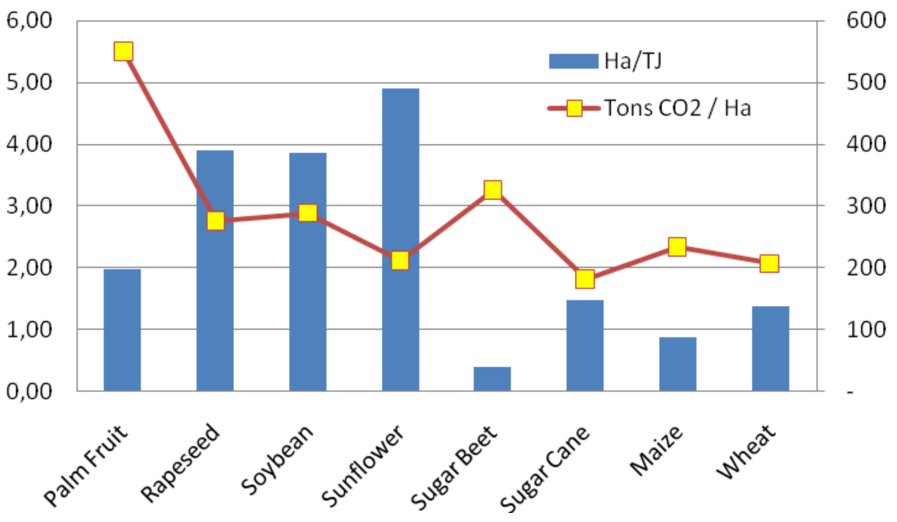

Figure 9: Amount of land converted, and the corresponding carbon stock. Source: IFPRI-MIRAGE-BIOF

The figure below is showing the relation between cropland expansion (column 3), compared to additional exploited land (natural land – primary forest and grassland – column 5). One can observe that most of the expansion takes place into managed forest and pasture, since the changes in these two land-uses explains the gap between exploited land and crop land.

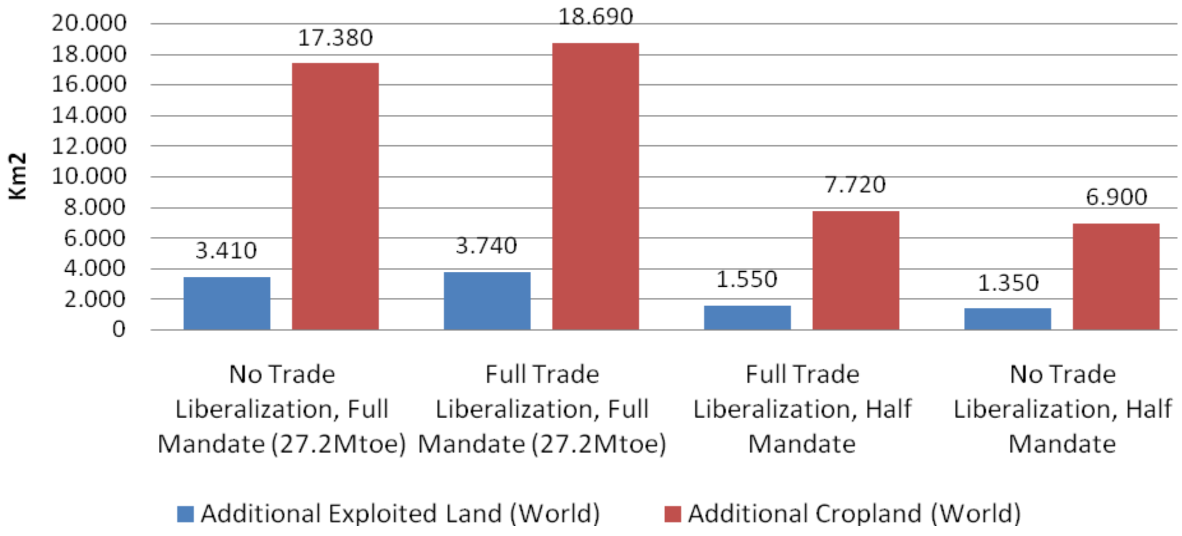

Figure 10: Cropland extension versus exploited land extension [Km2]. Source: IFPRI-MIRAGE-BIOF

15. ANNEX VI – FOSSIL FUEL COMPARATOR

The Joint Research Centre (JRC) has calculated the expected fossil fuel comparator (FFC) used in this impact assessment. It is estimated to be 90.3 g/MJ. The main assumptions are set out below.

The extraction emissions for existing oilfields gradually rise with time because the energy needed to extract the crude increases. The resulting average production emissions from fields supplying EU in 2020 are expected to reach 6.8 gCO2/MJ crude, or 7.2 g/MJ final fuel, ignoring any potential effect of the Fuel Quality Directive.

Updated figures from Concawe suggest that the production (upstream emissions) greenhouse gas intensity (not including transport) is 5.6 g/MJ final fuel. The 2020 gasoline value would become 87.6-5.6+7.2 = 89.2 and the 2020 diesel value becomes 89.1-5.6+7.2 = 90.7

If the diesel/gasoline split is 75:25 the weighted average is 90.3 g/MJ final fuel.

The assumed baseline for calculating the contributions to the Fuel Quality Directive is set at 88.3 g/MJ which is a weighted average of fossil fuels used in the EU in 2008.

16. ANNEX VII – TRENDS IN LAND-USE- AVAILABILITY AND EXPANSION GLOBALLY

16.1. Land-use change emissions

Land-use change and the use of fossil fuels are the main contributors to anthropogenic greenhouse gas emissions. The figure below shows the accumulated anthropogenic carbon emissions to the atmosphere since 1850. Land-use change emissions – primarily associated with the conversion of forests to agricultural land – have contributed roughly one-third during this period, with land-use change's share of the total diminishing over the last decades.

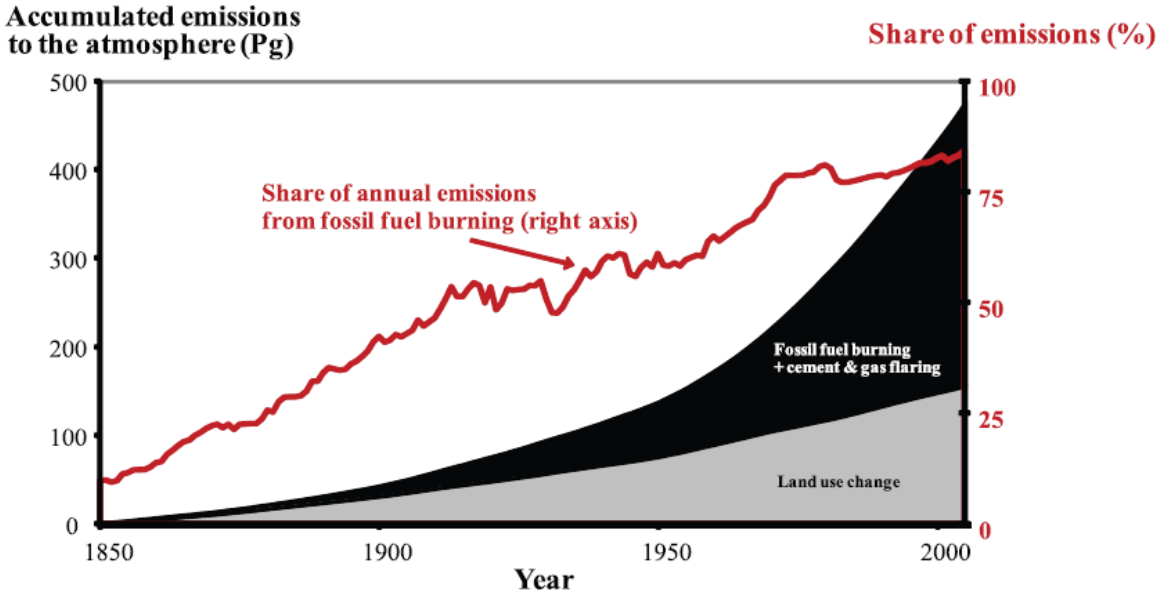

Figure 11: Accumulated anthropogenic carbon emissions to the atmosphere since 1850. Source: IEA Bioenergy Berndes et.al. 2010

In the next decades it is foreseen that a higher world population and standards of living will lead to increasing demand for food, feed, energy and fibre from the earth's ecosystems. Global agricultural production must increase by 70 percent – almost 100 percent in developing countries – by 2050 to feed the world's forecast 9.1 billion people, and current levels of investment are not enough to reach these levels. FAO estimates[153] that net investments to agriculture must top USD 83 billion per year – up roughly 50 percent from current levels – to meet future demand[154]. Furthermore, in developing countries, one fifth of the increase in production will come from increase in agricultural land and four fifths from improved productivity on existing land. The increased use of biofuels in the EU adds to this existing demand for agricultural commodities[155].

16.2. Trends in land availability globally

153 http://www.fao.org/fileadmin/templates/wsfs/docs/expert_paper/How_to_Feed_the_World_in_2050.pdf

154 FAO Investment Centre website: http://www.fao.org/tc/tci/whyinvestinagricultureandru/en/.

155 This is also clear from the modelling referred to in the chapters below, where the overall land-use change in the baseline (what would happen without a policy promoting biofuels in the EU) is 20 times larger than then additional land-use change caused by biofuels.

The extent to which land availability is limited in various regions of the world is much debated. Figure 5 below[156] depicts the harvested area in different regions of the world. Compared to 1981 the harvested land has significantly declined in Europe, CIS and North America, thus suggesting that there would be low carbon stock land available[157].

The time-series is divided into three segments, where distinct trends can be observed:

- 1961 – 1981 (20 years) harvested area increases rapidly with roughly 150 million hectare (Mha) globally (on average 7.4 Mha per year).
- 1981 – 2001 (20 years) harvested area increases slowly with 56 Mha globally (on average 2.8 Mha per year).
- 2001 – 2008 (7 years) harvested area increases rapidly with 95 Mha (13.6 Mha per year)

It is worth to note that the rapid increase in harvested area seen for the period 2001 – 2008 has not been continued into 2009, when harvested area actually *decreased* by -1.2 Mha. However, this might be the result of the economic crises unfolding in 2008, as farmers responded to reduced demand. Countries taking part in the global agricultural trade had the steepest decrease with e.g. 2.6 Mha less area harvested in North America.

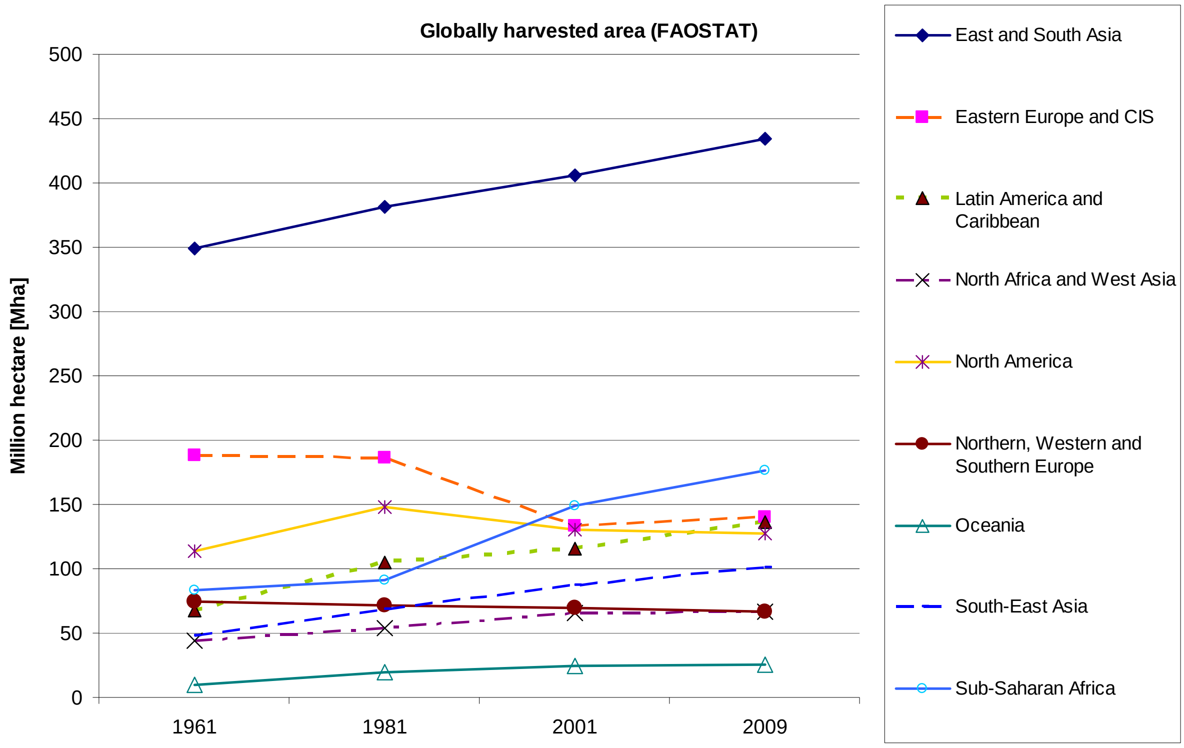

Figure 12: Globally harvested area from 1961 to 2009

156 FAO Statistics. Note that there is an important difference between "harvested area" and "cultivated area". Double-cropping in a field would double the amount of harvested area, while cultivated area remains constant.

157 However, if it is the least fertile land that has been recently abandoned, then its future production could be expected to show typical yields below average, leading to either increased land requirements or increased use of fertilisers. In addition, if the land is under a process of managed reforestation, its reversion to agricultural production could result in the release of carbon emissions.

With regard to the EU, DG AGRI has estimated that the EU will continue to reduce agricultural area with around 0.5 million ha each year.

	2010	2012	2014	2016	2018	2020
Cereals	**56.3**	**57.1**	**57.4**	**57.8**	**58.0**	**58.3**
of which EU-15	34.3	34.8	34.9	35.1	35.3	35.4
of which EU-12	22.0	22.3	22.5	22.7	22.8	22.9
Soft wheat	23.0	23.3	23.4	23.7	23.8	24.0
Durum wheat	2.9	2.9	2.8	2.8	2.8	2.8
Barley	12.4	12.8	12.8	12.7	12.7	12.7
Maize	8.1	8.3	8.5	8.7	9.0	9.2
Rye	2.6	2.6	2.6	2.6	2.5	2.5
Other cereals	7.3	7.3	7.3	7.2	7.2	7.1
Oilseeds	**10.9**	**10.9**	**11.0**	**11.0**	**11.0**	**11.1**
of which EU-15	5.9	6.0	6.0	6.0	6.0	6.0
of which EU-12	5.0	5.0	5.0	5.0	5.0	5.0
Rapeseed	6.9	7.0	7.1	7.1	7.2	7.3
Sunseed	3.7	3.6	3.5	3.5	3.4	3.4
Soyabeans	0.4	0.3	0.3	0.4	0.4	0.4
Sugar beet	**1.4**	**1.4**	**1.4**	**1.4**	**1.4**	**1.3**
Protein crops	**1.1**	**1.1**	**1.0**	**1.0**	**1.0**	**1.0**
Total selected arable crops	**69.8**	**70.5**	**70.8**	**71.2**	**71.4**	**71.6**
Total utilized agricultural area	**188.3**	**187.2**	**186.1**	**185.0**	**183.9**	**182.8**

Table 17: Area under arable crops in the EU, 2009-2020 (million hectare) Source DG AGRI

There are also estimates of marginal land[158] that is available for bioenergy production. Hoogwijk (2003; 2004 cited in Hennenberg et.al (2010)) estimates that between 430 and 580 Mha of land is marginal and can potentially be used. However, Okoinstitut in the report "Sustainable Biomass Production from degraded lands" (Hennenberg et.al (2010)) concluded that it is very challenging to quantify the amount of degraded land available, while at the same time suggesting that the estimates done by Hoogwijk are at least 10-times too high.

16.3. Trends in agricultural land expansion

Although land is available it is not necessarily the case that the marginal supply of agricultural crops is planted on marginal land. However, it is clear that a significant amount of land is available in certain areas of the world, although it is difficult to govern the proper use of these land areas. In fact, recent studies suggest that tropical forests were the primary sources of new agricultural land in 1980-90s (i.e. over 80% of land coming from forests across the tropics, see figure 6 below), with various studies highlighting a significant role of soy and cattle ranging, and palm into the expansion of agricultural land into the Amazon and South East Asia respectively[159]. However, since 2005 deforestation rates in the Amazon have been going down significantly[160].

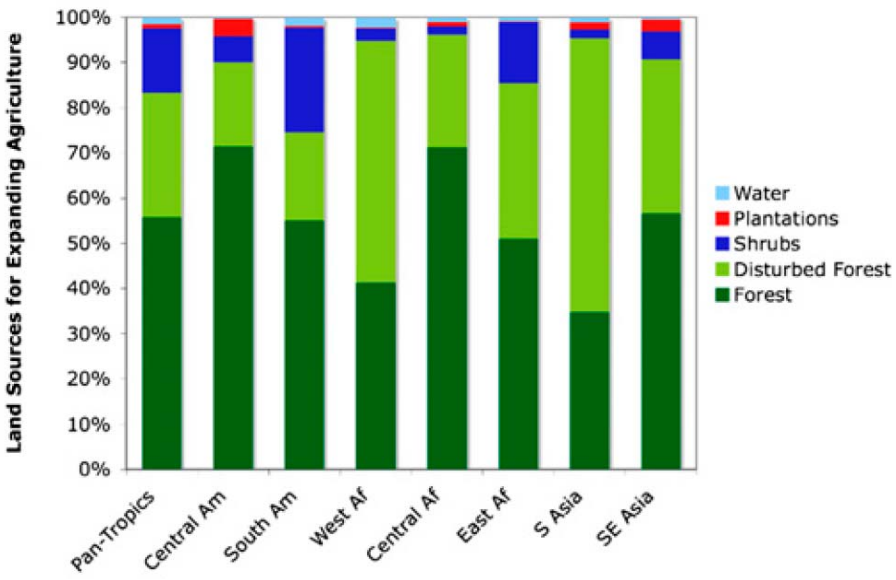

Figure 13: The origins of new agricultural land, 1980–2000, of which 80% took place in tropical areas. Bars show the average proportion of land sources comprising new agricultural land in major tropical regions (Source: Gibbs et.al. 2010).

Further to the spatial limited availability of low-carbon stock land in some areas, the lack of effective protection of forests and carbon rich areas is another factor that allows damaging indirect land-use change to take place. If conversion of carbon rich areas were to be limited, the risk of damaging indirect land-use change would be minimized. This is particularly applicable to forests and wetlands although significant carbon stocks can be lost from other land types, in particular grasslands. However, progress towards such a situation is slow. It

158 Definitions of marginal land vary across studies. Figures from the Okoinstitut report are specifically referred to as abandoned cropland and particularly unused degraded land.

159 Tropical forests were the primary sources of new agricultural land in the 1980s and 1990s. H. K. Gibbs, A. S. Rueschb, F. Achardc, M. K. Claytond, P. Holmgrene, N. Ramankuttyf, and J. A. Foleyg 2010.

160 Based on official data from the Brazilian National Institute of Space Research.

should also be noted that as long as these areas represent an important source for increasing total agricultural production, reducing such conversions is likely to increase global agricultural commodity prices.

There are highly relevant lessons to be learned from the long standing policy and research work done on limiting deforestation. The Commission has taken part in various efforts to reduce deforestation, through development cooperation, trade policies and international negotiations, most notably through the UNFCCC, where the discussions of the REDD mechanism (Reduction of Emissions from Deforestation and forest Degradation) is the centrepiece. Extensive information on activities aimed at reducing deforestation can be found in the Communication on "Addressing the challenges of deforestation and forest degradation to tackle climate change and biodiversity loss"[161], which notes that the most important direct cause of forest destruction is changes in land-use to pursue profitable alternative uses of land, such as obtaining commodities, while the most important underlying cause of deforestation is ineffective governance, linked to poorly enforced land-use policies and uncertain land tenure regimes.

[161] COM(2008) 645 - Available here: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2008:0645:FIN:EN:PDF.

17. ANNEX VIII – INTERACTIONS BETWEEN EXISTING LEGISLATION AND INDIRECT LAND-USE CHANGE

17.1. Existing EU legislation

The Renewable Energy Directive and the Fuel Quality Directive, are at the origin of the debate on potential indirect land-use change caused by EU biofuels policy. So far there is no existing regulatory legislation either at EU level or at Member State level that effectively addresses the issue, although the legislation does include a measure in order to increase the amount of land available for the cultivation in form of a greenhouse gas bonus to biofuel produced on severely degraded and heavily contaminated land.

Measures which are taken to control land-use change for biofuels directly, for example to protect forest or grassland in the EU, will have limited impact on indirect land-use change emissions. This is because while they may prevent this land from being converted to agriculture, they do not limit the total demand for agricultural commodities and the extra demand might be supplied where it is most cost effective to do so. In some cases that is likely to be from conversion of new land to agriculture, while in others it can come from yield increases.

The sustainability criteria adopted under the Directives hinders biofuels that come from land where damaging land-use change has taken place, also referred to as 'direct land-use change', to be used in the EU through the requirement to calculate the carbon stock change of the land-use change.

The estimated indirect land-use change emissions coming from the implementation of the Directives are shown in the section laying down the baseline for this Impact Assessment.

17.1.1. The Renewable Energy Directive

The Renewable Energy Directive requires Member States to achieve jointly a 20% renewable energy share of total energy consumption over all sectors by 2020. Specifically in the transport sector, Member States are required to achieve a minimum of 10% renewable energy by 2020. In line with overall EU energy policy, the aim of these targets is threefold, i.e. to reduce greenhouse gas emissions, to promote the security of energy supply, to promote technological development and innovation and provide opportunities for employment and regional development, especially in rural and isolated areas.

Based on the demand estimate figures supplied by the Member States (NREAPs), it seems that the vast majority of the 10% transport target (around 9%) will be met through the use of conventional biofuels. In contrast, bioliquids are expected to play a small role in contributing towards the 20% target.

17.1.2. The Fuel Quality Directive

The Fuel Quality Directive requires fuel suppliers to achieve a 6% reduction in greenhouse gas intensity of the energy they supply by 2020 compared to a 2010 baseline. Blending of biofuels is expected to be the main route of compliance, where volumes needed are expected to be similar to those estimated by Member States to comply with the 10% renewable energy target under the Renewable Energy Directive. Proper accounting of emissions is necessary for the Fuel Quality Directive to work in the desired way, i.e. providing incentives for fuels that have less greenhouse gas intensity.

17.2. Other policies

17.2.1. Agricultural policies

Agriculture policies are essential in influencing the indirect land-use change impact. There are basically three theoretical possibilities to mitigate indirect land-use change. First, bringing back into cultivation idle low-carbon stock land. Second, agricultural policy could target improvements in land productivity beyond the rate which would have prevailed otherwise. Third, agricultural policy can provide incentives for the production of biofuels with low indirect land-use change emissions.

The Common Agricultural Policy (CAP) is currently in its final phase of almost entirely decoupling its support to farmers from production. Farmers have to ensure that their land remains in good agricultural and environmental condition (GAEC). This provision aims at ensuring that agricultural land which becomes idle remains available for production in the future. Furthermore, Member States are required to report on changes in grassland and to take measure against, if conversion occurs. Although the effectiveness of this requirement varied across all Member States, this provision has helped to slow down and reverse the loss of grassland in the EU.

The introduction of direct payments was accompanied by a reduction of guaranteed prices to farmers. Lower agricultural prices contributed to less input use. Lowering cereal prices in the EU to world market level also led to a strong increase in cereal use, especially for feed, substituting imports of feedstuffs.

All in all, EU farmers are free to decide whether, how much and for what purpose they grow crops. The decoupling of support significantly improved their responsiveness to changing market signals. A re-introduction of coupled support, e.g. for biofuel crops would not be in line with WTO rules.

It is through the Rural Development Policy of the CAP where the EU offers financial support to farmers who engage, amongst others, into increasing their competitiveness, including by improving yields, or into taking agri-environmental commitments.

17.2.2. Environmental policies

EU environmental legislation, including the new EU biodiversity strategy, is aimed to reduce environmental degradation, including, damaging land-use change impacts in the EU. However, it is neither intended nor possible for biodiversity actions alone to prevent the impacts of other policies. For that to happen biodiversity considerations must be integrated and mainstreamed into the development and implementation of all national an EU policies related to natural resource management, such as agriculture, food security, forestry, fisheries and energy, as well as spatial planning, transport, tourism trade and development. At international level, the recently adopted post-2010 global biodiversity Strategic Plan of the Biodiversity Convention may help reducing the loss of carbon and biodiversity rich habitats including forests. As part of its 2008 Communication on tropical deforestation, the Commission committed to studying the impact of EU consumption of imported food and non-food commodities (e.g. meat, soy beans, palm oil, and metal ores) that are likely to contribute to deforestation. Such work could lead to considering policy options that reduce indirect land-use change effects.

With regard to forest policy in the EU, it is the competence of Member States to implement sustainable forest management. A number of MS have tight restrictions on deforestation. The EU currently contains 5 % of the world's forests and EU forests have continuously expanded for over 60 years, although recently at a lower rate. EU Forests and other wooded land (OWL) now cover 155 million ha and 21 million ha, respectively, together more than 42 % of EU land area[162]. Most of EU forests, including those under continuous management, have also grown in terms of wood volume and carbon stock, thus effectively removing CO_2 from the atmosphere.

According to FAO data (Forest Resource Assessment 2010), EU27 has reported a net increase of almost 7.3 million ha of forest area (+5%) between 1990-2000, and only 2.5 (+3%) between 2000-2010. This includes both afforestation and natural reforestation, e.g. on abandoned land. The area of protected and protective forests in the EU has also increased during the last decade[163].

However, the overall spending on afforestation measures through rural development programmes under Common Agricultural Policy in the EU has declined. According to current target figures, Member States expect that about 0.9 Mha of new forests will be established during the current programming period through Rural Development Programmes.

Currently, an average of 0.5 Mha of forest burn in the EU annually with associated emissions, most affected are Spain, Italy, Greece, France and Portugal.

17.2.3. Climate policies

Climate change legislation may also help reducing the risk of indirect land-use change. At the 16th Conference of the Parties to the UNFCCC ("COP16") in 2010 it was agreed to support developing countries to better protect their tropical forests by establishing a global mechanism to Reducing Emissions from Deforestation and Forest Degradation (REDD)[164]. The UNFCCC decision affirms "(...) that all Parties should collectively aim to slow, halt and reverse forest cover and carbon loss" and therefore encourages them to "(...) address drivers of deforestation".

International accounting rules applicable to annex 1 parties for land use, land use change and forestry (LULUCF) for the post 2012 period were agreed at the 17th Conference of the Parties to the UNFCCC ("COP17") in Durban in December 2011.

In order to transpose this decision into EU law, the Commission is proposing as a first step robust, common accounting, monitoring and reporting rules for LULUCF within the EU and compulsory LULUCF action plans in Member States. The Commission propose that

[162] TBFRA 2000 - http://www.unece.org/timber/fra/welcome.htm.

[163] Protected forest area was 38.1 million hectares in 2005 compared with the 30.1 million hectares in 2000, forests with protective functions increased by one million hectares to 21.6 million hectares by 2005. Forest habitat types designated as Natura 2000 sites cover over 22 million ha in 2008, according to Eurostat. Forests undisturbed by man/, account for about 9 million ha.

[164] http://www.un-redd.org/.

accounting for croplands and grasslands become mandatory within the EU, while left voluntary at international level. This will ensure that perennial energy crops grown on agricultural lands will enter accounting[165]. As a second step it may consider how LULUCF could be taken into account in the EU's GHG emission reduction commitment.

LULUCF accounting can reduce land-use changes by internalising the environmental cost of the related emissions at the national level, therefore making activities that increase such emissions less attractive, but only once a target is agreed for the sector in the context of a second step. However, it should be noted that LULUCF accounting alone is not likely to be effective at controlling LUC emissions. LULUCF accounting acts at the national level and costs are born by the government, while land-use decisions are taken at the local level by land managers. In the absence of dedicated policy instruments, the GHG cost of LUC, even if internalised, will be passed on to the government budget. In addition, LULUCF accounting provides only a price signal commensurate to the average abatement cost at the national level. The GHG abatement cost of biofuels is significantly higher than the prevailing carbon price, and demand for biofuels is highly inelastic due to binding targets and mandates. Therefore, the incentive to convert land is likely to be generally higher than the disincentive provided by LULUCF accounting. Therefore, while accounting for LULUCF ensures that land-use emissions are monitored the actual land-use changes and resulting collateral environmental impacts may not be effectively reduced.

17.2.4. Trade policies

Changes in biofuels import tariffs affect the land-use change impact of the overall biofuels mandate because it induces changes in the composition of the supply of biofuels, from different origins and feedstocks. While EU tariffs are low on biodiesel imports, they are relative high on bioethanol. Reducing these tariffs would consequently have significant effects on bioethanol imports and production, less so for biodiesel. Imported bioethanol is mainly produced from tropical sugarcane, a feedstock with very high direct emission savings. Though the indirect land-use emissions may be higher than for EU-produced bioethanol feedstocks (wheat, sugar beet), the net emission savings are higher for imported sugarcane ethanol.

The risks of indirect land-use changes in producing countries vary. The EU has effective protection of carbon rich areas and land-use expansion is strictly controlled. Land-use control systems may be less effective in developing countries. Sustainability Impact Assessments of trade agreements can help to detect and understand these potential negative side effects, including on tropical deforestation. They enable the EU to develop policies and flanking measures to enhance the sustainability and reduce land-use emissions of biofuels exports to the EU.

The 2003 EU action plan for Forest Law Enforcement, Governance and Trade (FLEGT) sets out a process and a package of measures to address the problem of illegal logging and related trade. The cornerstone of the Action Plan is the establishment of voluntary FLEGT Partnership Agreements (VPA) between the EU and timber producing countries, aimed at stopping illegal logging. In December 2005, the Council adopted a Regulation (No 2173/2005) that establishes a licensing scheme and a mechanism to verify the legality of timber imports into the EU from partner countries. The VPAs together with the recently approved EU Timber Regulation (No 995/2010) will discourage unregulated and

165 Only perennial crops will enter, as international accounting rules consider annual crops carbon neutral.

unsustainable exploitation of forests and thus address one of the drivers of deforestation and forest degradation. In addition, the negotiations provide an opportunity to challenge the legal framework, particularly with respect to land conversion and environmental sustainability of forest management and where the frameworks are not clear or judged insufficient by stakeholders.

17.2.5. Development policies

Under its development policy, the EU is committed to increasing expenditure on demand-led agricultural research, extension and innovation by 50% by 2015.[166] Focus is placed on "ecologically efficient agricultural intensification for smallholder farmers" that improves equitable and sustainable access to resources, including land, water, (micro) credit and other agricultural inputs with the aim of reducing food insecurity and poverty. The projected annual budget in this area is a minimum of € 87 million per year between 2011 – 2013. Although not aimed only at yield increases, development policy reduces indirect land-use change by improving agricultural productivity, especially by stepping up research to improve the productivity and sustainability of agriculture in developing countries.

17.2.6. Research policies

The research into feedlots and animal diets in order to maximise the use of biofuel co-products to feed European livestock will reduce the imports of protein rich animal feed, notably soya (Weightman[167] et.al. 2010), which can significantly influence the indirect land-use change. Weightman et.al. calculate that today's diets for pigs, poultry and ruminants can reduce land-use change in South America by 64 – 138 g/MJ of biofuel produced from wheat in the EU. The average credit is 82 g/MJ and if higher usage is made possible through nutritional research the credit can nearly double (Weightman et.al. 2010).

Since the inception of 7th Framework Programme for Research ("FP7"), the Commission has issued calls for demonstration projects that put particular emphasis on biofuel production from lignocellulosic biomass and addresses practically all value chains from sustainable biomass resources to a final marketable biofuel that meets the thresholds laid down in the Directives for 2018, i.e. minimum 60% reduction compared to fossil fuels for new installations. Sustainability is a key issue in all calls. Under FP7 the Commission has supported projects for sustainable biofuels in excess of €150 million.

At the end of 2007, the European Commission proposed the European Strategic Energy Technology Plan (SET-Plan)[168] targeting a strategic approach to technology development and deployment in order to ensure the achievement of energy objectives. Bioenergy was covered by the SET Plan and it was accompanied by "A Technology Roadmap for Bioenergy" presenting the fundamental roadmaps which serve as a basis for strategic planning and decision making[169]. The main tool for the implementation of the SET Plan are the Industrial

166 http://ec.europa.eu/development/icenter/repository/COMM_PDF_COM_2010_0127_EN.PDF.

167 Opportunities for avoidance of land-use change through substitution of soya bean meal and cereals in European livestock diets with bioethanol coproducts, GCB Bioenergy (2010).

168 COM(2007)723, Communication from the Commission to the Council, the European Parliament the European Economic and Social Committee and the Committee of the Regions, "European Strategic Energy Technology Plan (SET-Plan), Towards a low carbon future" 2009.

169 SEC(2009)1295, Commission Staff Working Document Accompanying document to the Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions on Investing in the Development of Low Carbon Technologies (SET Plan) "A Technology Roadmap", 2009.

Initiatives, public-private initiatives led by industry, aiming to accelerate industrial research and innovation at the EU and Member States level[170]. Most relevant for biofuels is the European Industrial Bioenergy Initiative (EIBI), which is characterised by innovative technologies and high-risk investments aiming to bring new technologies onto the market for the first time. The focus (related to biofuels) is primarily on second-generation biofuel production from lignocellulosic biomass and algae[171].

In addition, and in line with the priorities identified by the SET Plan, at least four lignocellulose-to-biofuels demonstration projects at pre-commercial scale are potentially eligible for co-financing under the so-called NER 300 funding programme, which provides financing for commercial-scale carbon capture and storage (CCS) and innovative renewables technology demonstration projects from 300 million allowances reserved in the new entrants reserve of the EU Emissions Trading System[172].

[170] For an overview of the European Industrial Initiatives, see the Commission website: European Commission, "SET-Plan, towards a low-carbon future", available here: http://ec.europa.eu/energy/technology/set_plan/doc/setplan_brochure.pdf.

[171] Kyriakos Maniatis & Stefan Tostmann, " EU Technology Strategy on Bioenergy: From Blue-Sky Research to Targeted Technology Development", in Renewable Energy Law and Policy Review, Vol 1, N°2, p169-179.

[172] For more information see: http://ec.europa.eu/clima/funding/ner300/index_en.htm.

18. ANNEX IX – BIOFUELS AND RELATED INDUSTRIES BASELINE TABLES

	2002	2003	2004	2005	2006	2007	2008	2009
Austria	0.0	0.0	0.1	0.1	0.1	0.2	0.2	0.3
Belgium	0.0	0.0	0.0	0.0	0.0	0.1	0.3	0.4
Bulgaria	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cyprus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Czech Republic	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1
Denmark/Sweden	0.0	0.0	0.1	0.1	0.1	0.1	0.2	0.2
Estonia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Finland	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2
France	0.3	0.3	0.3	0.4	0.7	0.8	1.6	1.8
Germany	0.4	0.6	0.9	1.5	2.4	2.6	2.5	2.3
Greece	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1
Hungary	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1
Ireland	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Italy	0.2	0.2	0.3	0.4	0.4	0.3	0.5	0.7
Latvia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lithuania	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1
Luxemburg	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Malta	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Netherlands	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.3
Poland	0.0	0.0	0.0	0.1	0.1	0.1	0.2	0.3
Portugal	0.0	0.0	0.0	0.0	0.1	0.2	0.2	0.2
Romania	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
Slovakia	0.0	0.0	0.0	0.1	0.1	0.0	0.1	0.1
Slovenia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Spain	0.0	0.0	0.0	0.1	0.1	0.2	0.2	0.8
UK	0.0	0.0	0.0	0.0	0.2	0.1	0.2	0.1
TOTAL	**1.0**	**1.3**	**1.7**	**2.9**	**4.4**	**5.2**	**7.0**	**8.2**

Figure 14: European biodiesel production by country (in Mtoe). Source: EBB

	2003	2004	2005	2006	2007	2008	2009	2010
Austria	0.0	0.1	0.1	0.1	0.3	0.4	0.6	0.5
Belgium	0.0	0.0	0.0	0.1	0.3	0.6	0.6	0.6
Bulgaria	0.0	0.0	0.0	0.0	0.1	0.2	0.4	0.4
Cyprus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Czech Republic	0.0	0.0	0.2	0.2	0.2	0.2	0.3	0.4
Denmark	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.2
Estonia	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1
Finland	0.0	0.0	0.0	0.0	0.0	0.2	0.3	0.3
France	0.5	0.5	0.5	0.7	0.7	1.8	2.3	2.3
Germany	0.9	1.0	1.7	2.4	3.9	4.8	4.7	4.5
Greece	0.0	0.0	0.0	0.1	0.4	0.5	0.6	0.6
Hungary	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.1
Ireland	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1
Italy	0.4	0.4	0.7	0.8	1.2	1.4	1.7	2.1
Latvia	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1
Lithuania	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1
Luxemburg	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Malta	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Netherlands	0.0	0.0	0.0	0.0	0.1	0.5	0.9	1.2
Poland	0.0	0.0	0.1	0.1	0.2	0.4	0.5	0.6
Portugal	0.0	0.0	0.0	0.1	0.2	0.4	0.4	0.4
Romania	0.0	0.0	0.0	0.0	0.1	0.1	0.3	0.3
Slovakia	0.0	0.0	0.1	0.1	0.1	0.2	0.2	0.1
Slovenia	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1
Spain	0.0	0.1	0.1	0.2	0.5	1.1	3.3	3.7
Sweden	0.0	0.0	0.0	0.0	0.2	0.2	0.2	0.3
UK	0.0	0.0	0.1	0.4	0.6	0.7	0.5	0.5
TOTAL	**1.8**	**2.0**	**3.8**	**5.5**	**9.3**	**14.4**	**18.9**	**19.8**

Figure 15: European biodiesel capacity by country (in Mtoe). Source: EBB

	2004	2005	2006	2007	2008	2009
Austria	0.0	0.0	0.0	0.0	0.0	0.1
Belgium	0.0	0.0	0.0	0.0	0.0	0.1
Bulgaria	0.0	0.0	0.0	0.0	0.0	0.0
Czech Republic	0.0	0.0	0.0	0.0	0.0	0.1
Denmark	0.0	0.0	0.0	0.0	0.0	0.0
Finland	0.0	0.0	0.0	0.0	0.0	0.0
France	0.1	0.1	0.1	0.3	0.5	0.6
Germany	0.0	0.1	0.2	0.2	0.3	0.4
Hungary	0.0	0.0	0.0	0.0	0.1	0.1
Ireland	0.0	0.0	0.0	0.0	0.0	0.0
Italy	0.0	0.0	0.1	0.0	0.0	0.0
Latvia	0.0	0.0	0.0	0.0	0.0	0.0
Lithuania	0.0	0.0	0.0	0.0	0.0	0.0
Netherlands	0.0	0.0	0.0	0.0	0.0	0.0
Poland	0.0	0.0	0.1	0.1	0.1	0.1
Romania	0.0	0.0	0.0	0.0	0.0	0.0
Slovakia	0.0	0.0	0.0	0.0	0.0	0.1
Slovenia	0.0	0.0	0.0	0.0	0.0	0.0
Spain	0.1	0.2	0.2	0.2	0.2	0.2
Sweden	0.0	0.1	0.1	0.1	0.0	0.1
UK	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	**0.3**	**0.5**	**0.8**	**0.9**	**1.4**	**1.9**

Figure 16: European bioethanol production by country (in Mtoe). Source: ePure

	2005	**2006**	**2007**	**2008**	**2009**	**2010**
Austria	0.0	0.0	0.1	0.1	0.1	0.1
Belgium	0.0	0.0	>0.0	0.3	0.3	0.3
Bulgaria	0.0	>0.0	>0.0	>0.0	>0.0	>0.0
Czech Republic	>0.0	>0.0	>0.0	0.1	0.1	0.1
Denmark	0.0	0.0	0.0	0.0	0.0	0.0
Finland	0.0	0.0	>0.0	>0.0	>0.0	>0.0
France	0.4	0.4	0.7	0.9	1.0	1.0
Germany	0.2	0.4	0.4	0.6	0.6	0.6
Hungary	0.0	0.1	0.1	0.1	0.1	0.1
Ireland	0.0	0.0	0.0	0.0	0.0	>0.0
Italy	0.2	0.2	0.2	0.2	0.2	0.2
Latvia	>0.0	>0.0	>0.0	>0.0	>0.0	>0.0
Lithuania	>0.0	>0.0	>0.0	>0.0	>0.0	>0.0
Netherlands	0.0	>0.0	>0.0	>0.0	>0.0	0.3
Poland	0.0	0.1	0.1	0.1	0.2	0.2
Romania	0.0	0.0	>0.0	>0.0	>0.0	>0.0
Slovakia	0.0	0.0	0.1	0.1	0.1	0.1
Slovenia	0.0	0.0	0.0	0.0	0.0	0.0
Spain	0.1	0.3	0.3	0.3	0.3	0.3
Sweden	0.1	0.1	0.1	0.2	0.2	0.2
UK	0.0	0.0	>0.0	>0.0	>0.0	0.2
TOTAL	**1.0**	**1.5**	**2.1**	**2.9**	**3.1**	**3.6**

Figure 15: European bioethanol capacity by country (in Mtoe). Source: ePure

(x 1000 tonnes)	Soya	Rape	Sunflo wer	Palm-kernel	Linseed	Castor	Maize germ	Grape pips	Palm	TOTAL
Austria*	0	136	30	0	1	0	0	0	0	**167**
Belgium	21	356	0	0	136	0	49	0	0	**562**
Bulgaria **	0	0	147	0	0	0	6	0	0	**153**
Cyprus	0	0	0	0	0	0	0	0	0	**0**
Czech Republic**	8	284	15	0	1	0	0	0	0	**308**
Denmark	9	214	0	0	0	0	0	0	0	**223**
Estonia**	0	37	0	0	0	0	1	0	0	**38**
Finland	2	104	4	0	0	0	0	0	0	**110**
France	49	1329	472	0	0	0	49	0	0	**1899**
Germany	643	3185	88	0	53	0	13	0	0	**3982**
Greece*	63	22	14	0	0	0	4	0	0	**103**
Hungary*	0	110	315	0	0	0	17	0	0	**442**
Ireland	0	0	0	0	0	0	0	0	0	**0**
Italy	259	18	157	0	6	0	50	12	0	**502**
Latvia**	2	30	1	0	0	0	0	0	0	**33**
Lithuania**	0	60	1	0	0	0	0	0	0	**61**
Malta	0	0	0	0	0	0	0	0	0	**0**
Netherlands	572	336	127	0	0	0	0	0	0	**1035**
Poland**	1	693	10	0	2	0	0	0	0	**706**
Portugal*	199	35	63	0	0	0	4	0	0	**301**
Romania**	37	70	222	0	0	0	0	0	0	**329**
Slovakia**	4	71	39	0	0	0	0	0	0	**114**
Slovenia**	0	5	0	0	0	0	0	0	0	**5**
Spain	549	35	361	0	1	0	17	0	0	**963**
Sweden*	0	100	0	0	0	0	0	0	0	**100**
UK	106	678	0	0	4	0	23	0	0	**811**
EU-27	**2524**	**7914**	**2065**	**0**	**204**	**0**	**233**	**12**	**0**	**12947**

Figure 16: 2008 production of crude vegetable oils and fats. Source: Fediol

(x 1000 tonnes)	Soyabeans	Rapeseed	Sunflower-seeds	Palm kernel	Linseed	Castor	Maize germs	Grape pips	Palm	TOTAL
Austria	0	332	72	0	4	0	0	0	0	**408**
Belgium	109	869	0	0	367	0	103	0	0	**1448**
Bulgaria**	1	12	350	0	0	0	12	0	0	**375**
Cyprus	0	0	0	0	0	0	0	0	0	**0**
Czech Republic**	47	720	35	0	2	0	0	0	0	**804**
Denmark	55	465	0	0	0	0	0	0	0	**520**
Estonia**	0	91	1	0	0	0	2	0	0	**94**
Finland	10	275	9	0	0	0	0	0	0	**294**
France	280	3157	1060	0	0	0	102	0	0	**4599**
Germany	3364	7705	198	0	150	0	27	0	0	**11444**
Greece	351	54	37	0	0	0	8	0	0	**450**
Hungary*	0	270	750	0	0	0	35	0	0	**1055**
Ireland	0	0	0	0	0	0	0	0	0	**0**
Italy	1787	45	388	0	15	0	120	89	0	**2444**
Latvia**	13	74	2	0	0	0	0	0	0	**89**
Lithuania**	0	148	3	0	0	0	0	0	0	**151**
Malta	0	0	0	0	0	0	0	0	0	**0**
Netherlands	2898	799	289	0	0	0	0	0	0	**3986**
Poland**	6	1732	24	0	6	0	0	0	0	**1768**
Portugal	1170	90	157	0	0	0	8	0	0	**1425**
Romania**	217	179	532	0	1	0	0	0	0	**929**
Slovakia**	22	180	92	0	1	0	0	0	0	**295**
Slovenia**	0	13	0	0	0	0	0	0	0	**5**
Spain	3026	91	903	0	3	0	35	0	0	**4058**
Sweden*	0	250	0	0	0	0	0	0	0	**250**
UK	559	1654	0	0	10	0	48	0	0	**2271**
EU-27	**13915**	**19205**	**4902**	**0**	**559**	**0**	**500**	**89**	**0**	**39162**

*estimate**Source: Oilworld

Figure 17: 2008 crushing of oilseeds. Source: Fediol

(x 1000 tonnes)	Wheat	Barley	Grain maize	Rye and maslin	Cereals total (including rice)	Sugar beet	Rape	Sunflower
Austria	1523	835	1891	195	5144	3083	171	71
Belgium	1928	451	754	3	3221	4569	42	0
Bulgaria	4000	815	1273	15	5273	0	231	1301
Cyprus	15	40	0	0	57	0	0	0
Czech Republic	4358	2003	890	178	7832	3038	1128	61
Denmark	5996	3421	0	245	10200	2011	637	0
Estonia	346	380	0	39	879	0	136	0
Finland	887	2171	0	42	4261	559	140	0
France	38325	12880	15300	130	70000	33146	5562	1676
Germany	25190	12288	4527	4325	49748	25550	6307	57
Greece	1830	280	2352	37	4820	902		16
Hungary	4396	1033	7543	75	13571	708	565	1306
Ireland	951	1089	0	0	2384	45	29	0
Italy	6341	1049	7878	12	15892	3308	51	280
Latvia	1036	265	0	162	1663	0	209	0
Lithuania	2100	858	24	208	3806	682	416	0
Luxembourg	91	54	3	7	189	0	18	0
Malta	0	0	0	0	0	0	0	0
Netherlands	1402	310	245	11	2089	5735	12	0
Poland	9790	3984	1707	3968	29827	10849	2497	4
Portugal	110	76	594	18	1057	137	0	14
Romania	5205	1183	8035	36	14934	685	572	1083
Slovakia	1538	676	988	57	3330	899	387	187
Slovenia	137	71	303	2	533	262	10	0
Spain	4797	7400	3479	181	17833	4089	29	876
Sweden	2284	1677	0	219	5249	2406	302	0
UK	14379	6769	0	36	22036	8330	1951	2
EU-27	**138 954**	**62057**	**57782**	**10202**	**295828**	**110992**	**21399**	**6934**

Figure 18: Harvested production of some of the main crops, in 1 000 tonnes, 2009. Source: Eurostat

19. ANNEX X – IMPACTS ON BIODIVERSITY

According to the central scenario of IFPRI-MIRAGE-BioF model, the estimated additional cropland requirements globally amount to 1.7 Mha, mainly taking place in Commonwealth of Independent States, Sub-Saharan Africa and Brazil regions. New cropland is allocated by IFPRI-MIRAGE-BioF estimating changes in the economic use of land, i.e. among forestry, cropland and pasture uses. The results of the IFPRI-MIRAGE-BioF study showed that this new cropland is taken from pasture (42%), managed forest (39%), primary forest (3%) and savannah and grassland (16%), which will have biodiversity and wider environmental impacts.

A qualitative estimation of the impacts to biodiversity of land-use changes calculated by IFPRI-MIRAGE-BioF was made by the JRC[173] using the Mean Species Abundance (MSA) values provided by the Global Biodiversity Model (GLOBIO 3)[174]. This model is built on a set of equations which link environmental drivers and biodiversity impacts. The environmental drivers used as input for GLOBIO3 are land-use change (including forestry), climate change, N deposition, harvesting, energy use etc.

Biodiversity is described in GLOBIO3 on the basis of the remaining mean species abundance (MSA) of original species, relative to their abundance in pristine or primary vegetation, which are assumed to be not disturbed by human activities for a prolonged period. MSA is therefore considered as the indicator for biodiversity.

The following table was extracted from Alkemade et al, 2009 and adapted to IFPRI-MIRAGE-BioF lands uses to evaluate MSA values for the land-use transitions (and LU classes) in IFPRI-MIRAGE-BioF scenario.

IFPRI-MIRAGE-BIOF Land-use class	**Sub-category**	**Description**	**MSA_{LU}**
Pasture		Grasslands where wildlife is replaced by grazing livestock	70%
Managed Forest	Secondary forest	Areas originally covered with forest or woodlands, where vegetation has been removed, forest is re-growing or has a different cover and is no longer in use	50%
	Agroforestry	Agricultural production intercropped with (native) trees. Trees are kept for shade or as	50%

173 Literature: EU Commission, DG ENVIRONMENT: Land-use Modelling – Implementation. Preserving and enhancing the environmental benefits of "land-use services". Final report, 1 April 2010. Alkemade, R., Van Oorschot M., Miles L., Nellemann C. , Bakkenes M. and Ten BrinkB.: GLOBIO3: A Framework to Investigate Options for Reducing Global Terrestrial Biodiversity Loss.Ecosystems (2009) 12: 374–390. Van Oorschot M.,Ros J. and Notenboom J.:Evaluation of the indirect effects of biofuel production on biodiversity: assessment across spatial and temporal scales. PBL (Netherlands Environmental Assessment Agency), Final report 27 May 2010. Campbell A., Doswald N.: The impacts of biofuel production on biodiversity: A review of the current literature. United Nations Environment Programme – World Conservation Monitoring Center. Final report, December 2009.

174 GLOBIO 3 is developed by a consortium made up of UNEP world Conservation Monitoring Centre (WCMC), UNEP/GRID-Arendal and the Netherlands Environmental Agency (PBL). [Alkemade et al, 2009].

IFPRI-MIRAGE-BIOF Land-use class	Sub-category	Description	MSA_{LU}
		wind shelter	
Primary Forest		Minimal disturbance, where flora and fauna species abundance are near pristine	100%
Scrublands and grasslands		Grassland or scrubland-dominated vegetation (for example, steppe, tundra, or savannah)	100%
Cultivated and managed areas		High external input agriculture, conventional agriculture, mostly with a degree of regional specialization, irrigation-based agriculture, drainage-based agriculture*.	10%

Table 18: Land-use classes used to determine mean species abundance (MSA)

* The JRC assumes land management factor for cropland as "medium or high input with manure" in its calculations (JRC report n.24483). For consistency the same assumption is taken here.

For example, according to the MSA values in the table, a transition from pastureland (MSA 70%) to cropland (MSA 10%) will cause a loss of 60%of MSA on top of the 30% already lost from the conversion from natural land to pastureland..

An estimation of the land-use transition biodiversity loss in the additional croplands which may result from IFPRI-MIRAGE-BIOF scenario has been calculated with a weighted average of MSA values for IFPRI-MIRAGE-BIOF land-use changes as:

$$MSA\ loss\ (\%) = \sum_i (MSAi \ * \ \%i) - MSA_{ca}$$

Where:

MSAi = Mean Species Abundance of land-use type i

%i = % of land conversion according to IFPRI-MIRAGE-BIOF results

MSAca = Mean Species Abundance of cultivated and managed areas

Considering that 42% of new cropland will come from pasture, 39% from managed forest, 3% from primary forest and 16% from savannah and scrublands, this will results in a "weighted" MSA value of 68%, and the transition to cropland will cause 58% decrease in the MSA index in affected areas. In addition to this there will also be indirect losses when part or all of the pasture and managed forest that was converted is moved elsewhere into natural areas. Considering this, total loss could build up to 90% when all pasture and forestry is moved into natural land (gradual land-use conversion in several steps). These results are just preliminary rough estimates, and more research is needed to provide a qualitative and more precise assessment in particular of the indirect effects.

This result, in line with the conclusions of GLOBIO3 study, shows that the extensive use of bioenergy crops will increase the rate of loss of biodiversity, and often the GHG reduction from biofuels production are insufficient to compensate for the losses due to land-use change (Van Oorschot et al., 2010).

20. ANNEX XI – MONTE-CARLO ANALYSIS OF INDIRECT LAND-USE CHANGE EMISSIONS ESTIMATES

ATLASS created 1000 baselines, and then performed simulations, using 1000 set of seven parameters. The parameters are drawn from a log uniform distribution, centered on the default value of the model, and the range of values is defined based on a literature review of potential meaningful figures (see CARB 2011, for a discussion on elasticity values[175]). Key elements of the parameter distribution are displayed in Table. As shown by the ratio average/median, nearly all distributions of the sample have a right tail-feature[176] driven by the log uniform assumption of the probability used to build these samples. The same set of parameters is used for assessing the indirect land-use change emissions uncertainty of the full mandate as well as for each individual crop.

	Shifter in the share of extension occurring in primary forest	Shifter in intermediate demand price elasticity of agricultural inputs	Ratio between yield on new cropland and average yield	Elasticity of substitution between land and other factors (factor intensification)	Elasticity of substitution between key inputs (feedstuff or fertilizer) and land (input intensification)	Elasticity of transformation of land (intermediate level)	Land extension elasticity
Average							
DC	0.99	1.18	0.75	0.07	0.11	0.30	0.02
DV	0.99	1.18	0.75	0.07	0.20	0.30	0.05
Median							
DC	0.91	1.21	0.75	0.06	0.08	0.25	0.01
DV	0.91	1.21	0.75	0.04	0.15	0.25	0.04
Maximal Value							
DC	1.81	1.83	0.99	0.18	0.29	0.74	0.04
DV	1.81	1.83	0.99	0.33	0.59	0.74	0.17
Minimal value							
DC	0.46	0.47	0.50	0.01	0.02	0.09	0.00
DV	0.46	0.47	0.50	0.01	0.04	0.09	0.01
Standard Deviation							
DC	0.39	0.41	0.13	0.05	0.08	0.18	0.01
DV	0.39	0.41	0.13	0.06	0.16	0.18	0.04

Table 19: Range of parameters for Monte Carlo analysis. Source: IFPRI-Mirage-BioF Monte Carlo parametersNote: DC=Developed countries. DV=Developing countries

Before discussing the list of parameters and their expected effects, one needs to indicate how the draws are done. A first solution would have been to consider that the value of a parameter for each sector (if relevant) and each region and AEZ is independent of the value for other sectors/regions. For instance it would have implied that the value used for the elasticity of land transformation into European AEZ are independent or that the level of potential factor

175 CARB (2011), Final Recommendations from the Elasticity Values Subgroup, ARB LCFS Expert Workgroup, California. Available here: http://www.arb.ca.gov/fuels/lcfs/workgroups/ewg/expertworkgroup.htm.

176 However, since some parameters can increase indirect land-use change emissions when other can reduce it, the right tail distribution of the parameter distribution does not involved a right tail biased in the LUC expected distribution.

intensification in the wheat sector in the US is uncorrelated with the level for the corn market. In such a case, we will have drawn for each parameter a specific value for each sector/region combination considering systematic uncertainty. This approach is not followed. Rather ATLASS considered that the key uncertainty is not about the exact value for a country/sector and its correlation with other regions/sectors but about the real location of the parameters distribution in the space of potential value and that all sectors/regions are affected in a similar way. It implies that we consider a perfect correlation between parameter values across sectors and across countries (or group of countries). For instance, for each draw, ATLASS shifted the value of a parameter, e.g. land elasticity of transformation, for all developed countries in the same direction. All developed countries will be able to relocate land more easily among crops (or less) at the same time. However, the distribution for each parameter is considered from other parameters: the shifter in demand behavior is drawn independently from the value of fertilizer intensification parameter. If parameter values would have been uncorrelated, a high elasticity in one region may have been compensated by a lower in another. Consequently, for each draw the world median would have been closer to the distribution median and the overall land-use effects would have been closer to the median value (even if the geographical pattern of the land-use will have been much more dispersed)[177]. ATLASS have chosen full correlation, since we the key challenge for many parameters, e.g. yield price response, is to know the change in average magnitude and not the question about the correlation and the heterogeneity among countries/sectors. There are still independent draws across parameters. A large yield response can still be combined to a strong sensitivity of cropland extension to land prices. The combination of effects among parameters is not biased in a way that will increase/decrease the results dispersion.

ATLASS selected seven parameters to study, most of them – except the two first of the following list – focused on the agricultural supply response and the extensification/intensification trade-off:

- Shifter in the share of extension occurring in primary forest, this coefficient multiplies[178] the initial share of land extension taken place in primary forest in the Winrock coefficient dataset. It does not affect the economic response of the model and only modify the carbon release by unit of exploited land expansion: a value above one will increase the share of primary forest and the carbon release;

- Shifter in intermediate demand price elasticity of agricultural inputs, this shifter multiplies the price elasticity of intermediate demand (by non primary sectors) for agricultural commodities. In the model, the elasticity of substitution in the intermediate consumption nested CES structure is recalibrated accordingly. A value above one implies that processing sectors will release more easily inputs (crops or vegetable oils) following the biofuel demand shock, and therefore reduces the LUC effect;

- Ratio between yield on new cropland and average yield: this parameter gives the marginal productivity of new hectare of cropland compared to existing one. The expected direct effect is that reduced yield will lead to larger requirement of new land to meet the additional crop demand and will increase indirect land-use change emissions. However, more complex effects take place in the model. Indeed, in the

177 Indeed, assuming perfect correlation among crops or regions does not affect the relative properties, and comparative advantages of different crops. The geographical pattern of effects and the feedstock mix for the overall scenario will not be subject to large modifications in this framework.

178 Other shares (grassland, shrub) are rescaled to be sure that the sum of share is equal to one.

dynamic baseline, assuming lower yield on marginal land leads to more land extension[179]. Since the “managed land” supply elasticity in the model is not constant but decreases with the ratio between used agricultural land and total suitable land for agriculture, the large expansion in the baseline needed to compensate the low productivity of new land reduces the remaining amount of available land in the baseline and decreases the price elasticity of land expansion that prevails when the biofuel scenario takes place. Therefore, the net effect of a low/high marginal yield is ambiguous;[180]

- Elasticity of substitution between land and other factors (factor intensification) . This is a core parameter in the endogenous yield response of the model; it shows how production can increase through additional capital/labor use by unit of land. A larger value describes a more flexible production system that will reduce the land-use change effect(more intensification);

- Elasticity of substitution between key inputs (feedstuff or fertilizer) and land (input intensification). This is the other driver of intensification, both in crop production and livestock sector, since it allows to substituting land to inputs (fertilizer or feed). A larger value is associated to a lower indirect land-use change emissions (more intensification);

- Elasticity of transformation of land (intermediate level) among broad categories of agricultural production. A larger value is associated to a lower indirect land-use change emissions since increased production of energy crops can displace other agricultural production before requiring new cropland (more land reallocation).

- Land extension elasticity. This parameter describes the land supply response – extension of managed agricultural land to pristine environments – following an increase in cropland price. Even if this value is not constant in the model, as discussed above it evolves the ratio between used and available land for agriculture, the change in the Monte Carlo modifies the initial value and its path of evolution. A larger elasticity value reinforces the indirect land-use change emission effect (more extension).

- Last, for several parameters, ATLASS assumed more uncertainty i.e. a more dispersed distribution for developing countries parameters; it should lead to more dispersed land-use change for crops produced in these regions (e.g. sugar cane) than for others. The parameters involved are the intensification parameters (fertilizers, feed, and factors) and the land extension elasticity. Similar crops with similar initial technology (share of fertilizer in total cost) and production location (concentrated in developed countries or in developing countries e.g. tropical crops) are expected to display high correlation in land-use change in the Monte Carlo simulations. ATLASS did not implement uncertainty of the household demand behavior, neither uncertainty on substitution among subset of inputs (animal fat versus vegetable oil for instance). Other aspects such as carbon stocks or direct saving coefficients from the life cycle

179 Indeed, cropland extension in the baseline, driven by economic and demographic growth is much larger than the effects of the biofuels scenario studied here.

180 It also emphasises the role of the baseline behavior in our assessment and the importance to understand that we compute the effects of the biofuel policy as a marginal deviation from this baseline when all other ongoing changes have already been taken into account.

analysis are considered as known even if their role in overall land-use change uncertainty competition should not be neglected (see Plevin et al, 2010[181]).

[181] Plevin, R. J., OHare, M., Jones, A. D., Torn, M. S. and Gibbs, H. K. (2010), Greenhouse Gas Emissions from Biofuels Indirect Land-use Change Are Uncertain but May Be Much Greater than Previously Estimated, Environmental Science and Technology 44(21), 8015-8021.

21. ANNEX XII – POTENTIAL FOR MITIGATING INDIRECT LAND-USE CHANGE EMISSIONS AT PROJECT LEVEL

A number of measures can in theory be put in place at the production site in order to prevent indirect land-use change. A short description of these, which are being assessed under section 5, as well as a comment on their potential is included in this section.

21.1. Increase use of unused/degraded land

Using land without provisioning services[182] that would be unlikely to be taken into production in the absence of biofuel demand (i.e. typically land that either requires some form of remediation prior to being used or where significant barriers exist). Expanding production on unused land may lead to direct land-use change, but the latter would be addressed by the current sustainability criteria and therefore directed to those areas where effects are acceptable.

Another potential way for mitigating against (indirect) land-use change would be to increase the production of biofuels in areas that are not in agricultural production and would be likely to remain the same in the absence of intervention. This could be because of the existence of some sort of "barriers" for this land to become into cultivation (i.e. remediation is needed prior to cultivation or regulatory barriers).

In terms of potential, a recent project[183] highlighted that a total 35Mha of Imperata grassland (a type of invasive grassland of low biodiversity value) could be available for the cultivation of palm oil in South East Asia, with about 4Mha being available in Indonesia alone[184]. This would present a significant opportunity for mitigating against indirect land-use change as the baseline predicts a very significant part of the emissions to be associated with peatland drainage. Opportunities for intensification through this method would seem to be more limited in densely populated/exploited regions such as the EU, although it would be difficult to estimate what the availability may be.

Moreover, the reduction in cropland expected in the EU from 2010 to 2020 of around 5.5 million hectares. It is however important to note that the potential to mitigate indirect land-use change emissions through using more land in the EU (besides institutional, political and social factors) would depend on the opportunity costs of and yields on this land, as well as what would the carbon content and GHG balance of the land be if not used for biofuel production. It should be noted that the source of the steady expansion of the forest area of the EU in the past decades, and the resulting forest sink amounting to 10% of the EU’s total GHG emissions, was the reduction of agricultural land-use. A reduction or reversal of this trend would involve significant carbon costs. As can be recalled from figure 5 in chapter 2.4; there has also been abandonment of agricultural land in the CIS countries as well as in the US.

21.2. Increasing yields

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182 The Millennium Ecosystem Assessment distinguishes four categories of ecosystem services: Provisioning services, regulation services, cultural services and supporting services. Provisioning services are defined as harvestable goods such as fish, timber, bush meat, genetic material, etc.

183 Ecofys and Winrock. Available here: http://www.ecofys.nl/com/publications/Responsible_Cultivation_Areas.htm.

184 Total amount of land in oil palm cultivation in Indonesia is supposed to be 4.5Mha.

Increasing yields above projected future trends which would not have happened in the absence of biofuel demand. This would in theory suggest that the biofuel feedstocks are produced without increasing the pressure on land and therefore limiting indirect land-use change emissions. In this case, only the additional feedstock production should be considered as meeting this requirement.

Although there are certain technical ceilings beyond which yields cannot be improved due to regional characteristics (i.e. soil, climate, water availability, etc), the baseline yield data in table 3 suggests that there could be significant potential for certain crops to improve their yields if the right policy tools were put in place. For example, typical yields of certain crops such as palm fruit are assumed to be over 5 times higher in Indonesia/Malaysia compared to those achieved in sub-Saharan Africa.

A project investigating the potential for achieving yield improvements in the palm oil harvest in Liberia, found that an average increase of 2t/ha of crude palm oil would be achievable through improved mechanisation and the introduction of high yielding palm varieties. This seems significant as a total of 100,000 ha are under palm oil cultivation. Other countries in the region that show a similar potential could be Democratic Republic of Congo, parts of Guinea, Cote d'Ivoire, Benin, Nigeria and Cameroon[185].

Although opportunities for intensification through yield increases are less readily available in regions already achieving yields above the world's average (i.e. EU and USA), improvements would seem possible. For example, recent research trials suggest that oil seed rape and winter wheat yields could be improved significantly through improved agronomy in areas of EU where the yields are already very high[186].

21.3. Integration of biofuel production with non-bioenergy systems

Integrating biofuels with non-bioenergy production systems in ways that would lead to higher land productivity. This integration would need to be additional to what would have happened in the absence of the biofuel demand.

In theory, it would seem possible to mitigate against indirect land-use change through the integration of biofuel production with non-bioenergy systems (i.e. land used for cattle farming). This could present particularly significant opportunities for regions, such as Brazil, where extensive ranching areas are available. It is in this context that a recent project looked at the potential for integration of cattle farming with the production of sugarcane. This project reported a total potential of over 140Mha of pasture land could be freed for sugarcane production in Brazil alone through this method (total current land used for sugarcane production is estimated to be at 8Mha). This is significant as Brazil is one of the regions where most cropland extension is likely to take place[187].

21.4. Production costs

A number of case studies have shown that production costs will not be significantly higher under C2 requirements than current practices although these are likely to be project specific. For example, a review of previous case studies exploring the feasibility of the development of

[185] Ecofys and Winrock 2009. Mitigating indirect impacts of biofuel production. Case studies and Methodology.

[186] Agrovista and Northeast biofuels grower network research programme in North East England. 2011.

[187] See table 3 in chapter 2 of this impact assessment.

oil palm on degraded land in Indonesia suggested that barriers to extension could be more of a cultural/social nature as costs could in fact be relatively low. In fact, total planting costs reported were between 500-1000€/ha cheaper when previous status was Imperata grassland compared to secondary forest and heathland. Similarly, operating costs were up to 500€/ha cheaper on Imperata grassland[188].

[188] Sustainable Oil Palm development on degraded land in Kalimantan (Fairhurst T, McLaughlin D, 2009).

22. ANNEX XIII – ASSESSMENT METHODOLOGY

The assessment of the policy options described in section 4 can give raise to a range of environmental, economic, social and wider impacts. The most relevant impacts are listed in table 20 below.

Effectiveness	*Minimise the impact of indirect land-use change on greenhouse gas emissions of biofuels, within the wider policy objectives of the targets that by 2020 at least 10% of transport fuels are renewable and that greenhouse gas intensity in road transport is reduced by at least 6% compared to 2010.*
	Achievement of the 10% target of the Renewable Energy Directive
Environmental	Greenhouse gas emissions balance (quantified)
	Biodiversity
	Other (water, soil, air, etc)
Economic	Costs (including production and administrative as appropriate).
	Financial investment stability
	Security of supply (energy and food/feed)
	Trade policies
Social	Employment
	EU rural development
	Third countries: development objectives
	Commodity markets
Other	Promoting technological development and innovation
	Coherence with existing GHG methodology

Table 20: List of key impacts being considered in this assessment.

23. ANNEX XIV – POSSIBLE RESPONSE SCENARIOS TO REDUCED BIOFUEL AVAILABILITY THROUGH THE INTRODUCTION OF ADDITIONAL REQUIREMENTS

As explained in section 5, it is expected that options will limit the availability of qualifying biofuel feedstocks, particularly biodiesel feedstocks as these typically present both higher direct and estimated indirect land-use change emissions. Assumptions are then needed to develop potential scenarios as to where the additional contributions required to meet the legislative targets will come from.

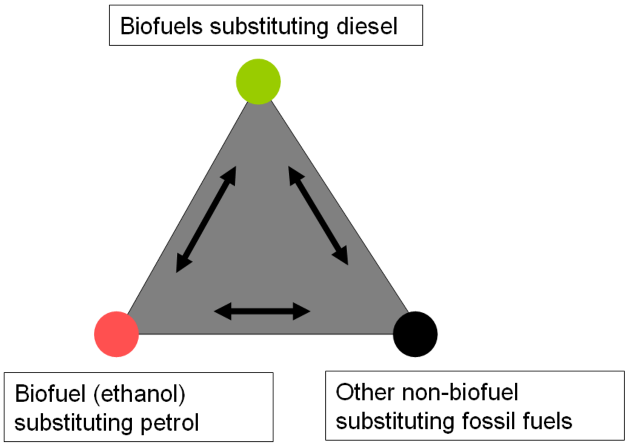

Figure 19: Possible responses to a limited supply of biofuels

Therefore, the state of play on a number of issues, such as vehicle compatibility with higher biofuel blends and relevant R&D developments, as well as possible developments on greenhouse gas emissions performance of conventional biofuels need to be considered.

23.1. Option B: Possible extreme scenarios

The main scenario considered here implies that when the threshold is raised to 60%, the least efficient palm oil, soy and rapeseed are excluded and not replaced by an increased share of the available conventional biodiesel feedstocks (i.e. sunflower and palm oil with methane capture) but by other available technologies (i.e. non-biofuel, bioethanol, etc). As such, for analytical purposes the following extreme scenarios have been considered,

B1) Targets set out in the Directives are met through fossil fuels and/or other renewable energies, without increasing bioethanol blends, or the use of waste/residues biodiesel or 2nd generation biodiesel beyond what is already necessary to reach the levels estimated in the NREAPs.

B2) Targets set out in the Directives are met through higher bioethanol blends. No development of 2nd generation biodiesel or waste/residues biodiesel beyond what is estimated in the NREAPs.

B3) Targets set out in the Directives are met through increased use of waste/residues biodiesel and 2nd generation biodiesel. Other renewable energies and bioethanol blends remains as estimated in the NREAPs.

The tables below outline the required contribution from each technology for biofuels to maintain their contribution to the Fuel Quality Directive on the baseline (5.4%).

	Bioethanol [Mtoe]	**Double counted biodiesel [Mtoe]**	**Electricity in road [Mtoe]**
Baseline	6.7	1.8	0.7

B1	6.7	1.8	1.9
B2	18.3	1.8	0.7
B3	6.7	11	0.7

These scenarios are included for illustrative purposes only. None of the scenarios above are considered realistic as only the contribution from one technology at a time is increased, giving rise to very significant additional requirements by 2020, notably:

- B1: Increased contribution of 3.9 Mtoe of electricity in road would be required by 2020. This would be the equivalent to deploying an additional 9 million electric cars by 2020[189]. For comparison, EU annual car sales are roughly 15 million per year.

- B2: Increased levels of bioethanol, with the average bioethanol blends in petrol cars increasing from 11% to 25%, as well as an increase in bioethanol processing capacity in the EU.

- B3: Increased contribution of 9.2 Mtoe of biodiesel coming from waste/residues and 2nd generation.

23.2. Option D: Possible extreme scenarios

Based on the preliminary analysis of the impacts of different indirect land-use change emission factors at feedstock level, the overarching trend seems to be the need to replace the oilseeds that fail to qualify with either other biodiesel feedstocks available and/or increased the volume of bioethanol. In line with the broad approach as set out at the beginning of this Annex, a number of extreme scenarios have been considered.

D1) Targets set out in the Directives are met through fossil fuels and/or other renewable energies, without increasing bioethanol volumes, or the use of waste/residues biodiesel or 2nd generation biodiesel beyond what is already necessary to reach the levels estimated in the NREAPs.

D2) Targets set out in the Directives are met through higher bioethanol volumes. No development of 2nd generation biodiesel or waste/residues biodiesel beyond what is estimated in the NREAPs.

D3) Targets set out in the Directives are met through increased use of waste/residues biodiesel and 2nd generation biodiesel. Other renewable energies and bioethanol volumes remain at estimated levels in the NREAPs.

The tables below outline the required contribution from each technology for biofuels to maintain their contribution to the Fuel Quality Directive on the baseline (-5.4%). However, the contribution from biofuel technologies towards this target is much smaller under this option than under all others, as the estimated indirect land-use change emissions are not only included in the greenhouse gas emissions methodology to check whether the biofuel feedstock

[189] Assumptions: Electricity consumption of an electric car can be assumed to be approximately 0.13 kWh/km. Average annual electric distance travelled is assumed to be 10,000km since they cannot be used for long distances. Annual electricity consumption of one electric car will be roughly 1300kWh.. Expressed in toe, this is 1300 * 8.6 * 10-5 which gives 0.12 toe. Therefore 1 Mtoe electricity consumption by cars implies 8 million cars on the road.

in question would pass or not, but also included in the reported carbon intensity reduction (using the 50th percentile values of sensitivity).

	Bioethanol [Mtoe]	Double counted biodiesel [Mtoe]	Electricity in road [Mtoe]
Baseline	6.7	1.8	0.7
D1	6.7	1.8	2.3
D2	26	1.8	0.7
D3	6.7	16	0.7

These scenarios are included for illustrative purposes only, as only the contribution from one technology at a time is increased, giving rise to scenarios with following requirements to 2020 of either, i.e.

- increased contribution of 5.4 Mtoe of electricity in road would be required by 2020. This would be the equivalent to deploying an additional 13 million electric cars by 2020[190] for D1. For comparison, EU annual car sales are roughly 15 million per year.

- D2 requires increased levels of bioethanol, with the average bioethanol blends in petrol cars needed to increase accordingly (it would need to increase from 11% to 32% for this tool alone to achieve given bioethanol volumes). Bioethanol processing capacity in the EU would also need to increase (current levels at 4.3 Mtoe) or the total amount of bioethanol imports.

- increased contribution of 14 Mtoe would be needed from biodiesel coming from waste/residues and 2nd generation for D3.

23.3. Vehicle compatibility limitations with increasing usage of higher biofuel volumes in current fleet

In the context of the policy options, the issues around the compatibility of higher ethanol volumes with current fleet, as well as higher uptake of certain biodiesel feedstocks such as palm oil, should be considered. These issues are discussed in more detail in the baseline section in chapter 2.

23.4. Biodiesel from non-conventional sources

There are a number of ways in which developments in research and development could help replacing the production of biodiesel from feedstocks with estimated high indirect land-use change impacts. These include bringing forward commercialisation pathways, currently at pilot stage, for producing biodiesel from non-land using feedstocks (i.e. algae, pyrolysis oil, etc). In addition, research into the development of biodiesel from sugars is also ongoing and at pilot stage but could come into the market before 2020. In addition, it may be possible to increase the contribution from waste feedstocks, such as used cooking oil, for which no technological developments are needed.

190 Assumptions: Electricity consumption of an electric car can be assumed to be approximately 0.13 kWh/km. Average annual electric distance travelled is assumed to be 10,000km since they cannot be used for long distances. Annual electricity consumption of one electric car will be roughly 1300kWh.. Expressed in toe, this is 1300 * 8.6 * 10-5 which gives 0.12 toe. Therefore 1 Mtoe electricity consumption by cars implies 8 million cars on the road.

23.5. Potential improvements in greenhouse gas performance

According to the assessment methodology being applied, the question of compliance with the threshold is binary (i.e. whether biofuel feedstocks are in compliance or not), independently of how close to compliance the feedstock might be. This is an important point for further consideration as in practice biofuel producers can put in place measures to improve their greenhouse gas emissions performance beyond the levels assumed in 2020.

Although it is difficult to establish where such "performance ceiling" of different biofuel feedstocks may be, it is believed that emission saving levels of around 75%-80% can be reached if certain agricultural practices (including using organic fertiliser), using bio-methanol for trans-etherification (for producing biodiesel from vegetable oil), and better processing technologies available today (including processing the feedstocks using biomass) are used.

23.6. Potential contribution to Fuel Quality Directive targets from non-RES sources

The potential for achieving additional reductions in fossil fuel carbon intensity is high. The main areas of opportunity are at source (up-stream savings) and where the fuel is consumed (combustion savings). During the Fuel Quality Directive negotiations, the Commission estimated that a total of 300 Mt CO_{2eq} greenhouse gas emissions associated with global oil production from both flaring and venting was possible, and that a third of these emissions could be avoided through alternative uses of the gas at relatively low costs. Further contributions are also possible from capture and storage of refinery emissions depending on the development of this technology, and the supply of alternative fuels other than biofuels (LPG, CNG and H_2)[191].

[191] Assuming life-cycle GHG emissions for CNG around 76.7gCO2eq/MJ and for LPG 73.6g CO2eq/MJ, each 1% increase in the sales of use of natural gas and LPG across the EU as road transport fuel sales, would result in a potential reduction of around 0.1% in greenhouse gas intensity.

24. ANNEX XV – DEVELOPING INDIRECT LAND-USE CHANGE EMISSION FACTORS FROM THE RESULTS OF THE MONTE-CARLO ANALYSIS

There are two basic approaches towards developing indirect land-use change emissions factors according to the level of disaggregation desired. The results in table below show the range of estimated feedstock specific indirect land-use change emissions from the Monte Carlo analysis used for the assessment. All values are shown in grams of $CO_{2\text{-}eq.}$/MJ.

[g/MJ]	5th	25th percentile	Central	75th percentile	95th
Maize	6	8	10	12	13
Sugar beet	1	4	7	10	13
Sugar cane[192]	7	13	15	18	26
Wheat - Not specified	8	12	14	16	18
Wheat - Natural gas/CHP	8	12	14	16	18
Wheat - Straw/CHP	8	12	14	16	18
Palm oil	47	51	54	57	60
Palm oil with methane capture	47	51	54	57	60
Rapeseed	28	45	55	66	81
Soybean	38	50	56	61	74
Sunflower	31	46	54	60	72

Table 21: Estimated indirect land-use change emissions per feedstock. Source: IFPRI-MIRAGE-BioF(2011)

There are a number of ways for developing ILUC factors from these estimates. For example, one way would be to directly incorporate these numbers into the greenhouse gas emissions performance calculation for biofuels. In that case, no further adjustment would be required. However, it could also be argued that average values for each specific crop group could be developed from weighted average of the feedstock data. These are outlined in the table below.

	5th	25th percentile	Central	75th percentile	95th
Maize	7	10	12	14	16
Sugar beet	5	10	13	16	23
Sugar cane	5	10	13	16	23

192 Although the estimated land-use impacts associated with second generation feedstocks were not specifically modelled, they have been assumed to be equal to Brazilian sugar cane in this assessment (i.e. high yield energy crop with non-land saving co-products).

Wheat - Not specified	7	10	12	14	16
Wheat - Natural gas/CHP	7	10	12	14	16
Wheat - Straw/CHP	7	10	12	14	16
Palm oil	34	47	55	63	74
Palm oil with methane capture	34	47	55	63	74
Rapeseed	34	47	55	63	74
Soybean	34	47	55	63	74
Sunflower	34	47	55	63	74

Table 22: Estimated indirect land-use change emissions per feedstock. Source: Commission's calculations based on weighted average of IFPRI-MIRAGE-BioF (2011) crop specific values.

The impacts associated with both approaches have been considered in the assessment of option D.

25. ANNEX XVI – POTENTIAL EFFECTS OF INCLUDING THE ESTIMATED INDIRECT LAND USE CHANGE GREENHOUSE GAS EMISSIONS IN THE REPORTING OF THE GREENHOUSE GAS EMISSION SAVINGS OF BIOFUELS

Option D provides incentives for low indirect land-use change emissions biofuels in two ways, as described in chapter 5.5.1 and chapter 5.5.9.1, through; a) the exclusion of biofuels with too low savings, ILUC included, compared to the fossil fuels they replace and b) the incentives for biofuels with lower ILUC due to the accounting and reporting by fuel suppliers under the Fuel Quality Directive which is likely to bring about a significant price differentiation in favour of low-ILUC transport fuels. This is because these biofuels will contribute much more than others to the attainment of a supplier's obligation to reduce the greenhouse gas intensity of the fuels it supplies. As it was only possible to analyse the effectiveness of the first element using the methodology in this Impact Assessment, the effectiveness of the second element is explored further in this Annex.

The discussion here focuses on the market incentives (element b) and thus ignores the exlusion of certain feedstocks resulting from element a. The allocation of feedstocks is therefore rather done through cost-minimisation of fuel supplier's expenditure on fuels as required to achieve the greenhouse gas emissions reductions mandated by the Fuel Quality Directive. This exercise obviously depends on a range of assumptions, of which some of them are listed in a footnote[193]. As the methodology used in this analysis is very sensitive to variation in feedstock price (i.e. those feedstocks with lowest carbon abatement costs are prioritised witrhout looking at any other variables and their availability is assumed to be in most cases unlimited), conclusions presented here are only intended as an illustration of the likely impacts.

The feedstocks are limited to the list know from chapter 5 of the Impact Assessment (i.e. with the same estimated GHG performance once the estimated indirect land use change impacts are included), however with 3 additions: "Improved vegetable oil1", "Improved vegetable oil2" and "ILUC-free vegetable oil", whose assumed GHG performance fro this exercise is included in the table below. The inclusion of the two first categories is intended to reflect the possibility of vegetable oil producers to improve their ***direct*** greenhouse gas emissions, while still including the ILUC estimate in the reported emissions. The last category reflects the potential succesfull development of "ILUC" free biofuels, where the biofuels are produced in ways that are certified not to lead to indirect land-use change emissions (with additional certification costs). However, the latter catergory is not included in the mix, as no such certification scheme has been developed yet.

193 Prices of ethanol and vegetable oils are mostly based on F.O Lichts "World ethanol & biofuels report, vol. 10 no. 16 April 2012, page 335 and "Oils & Fats Int June 2012 Vol25 No5, page32. Cost of crushing is assumed to be 20 $/ton. When costs have not been available, an estimate has been made. Biodiesel from FAME is limited to 12.8 Mtoe due to blending constraints (B7 – scenario 2 of the JEC study), ethanol is limited to max 7.1 Mtoe in line with scenario 2 of the JRC study (see reference in chapter 2.8.1.5), 2nd generation non-land using biodiesel, which in this case refers to biodiesel from residues and wastes, and improved vegetable oil2, are limited to 3 and 7 Mtoe respectively due to resource constraints, sugar cane import is limited to 3.5 Mtoe, which is similar level as found in the IFPRI study. Fossil fuel price is assumed to be 120 $/barrel, and finally it is assumed that 4%points of the 6% target of the FQD are achieved with the use of biofuels, the rest being achieved through increased use of electricity in road transport and reduction in flaring and venting emissions).

	Direct emissions [gCO_2/MJ]	Estimated ILUC emissions [gCO_2/MJ]	Total emissions [gCO_2/MJ]	Estimated CO_2 abatement costs of different biofuels [gCO2/€]
Biodiesel - non-land using (UCO etc.)	9.3	0.0	9.3	354
Sugar cane	20.2	15.4	35.6	540
Sugar beet	27.1	7.2	34.3	580
Wheat Straw as process fuel in CHP plant	21.6	13.8	35.3	644
Corn (maize)	32.7	10.1	42.7	683
Wheat Natural gas as process fuel in CHP plant	33.5	13.8	47.3	755
2G ethanol - non-land using	9.0	0.0	9.0	882
Wheat Process fuel not specified	50.3	13.8	64.0	1124
2G ethanol - land using	16.7	15.4	32.1	1272
2G biodiesel - land using	5.4	15.4	20.8	1753
Improved vegetable oil 2	25	54.9	79.9	4153
Palm oil with methane capture	29.3	54.0	83.3	5004
Improved vegetable oil 1	28	54.9	82.9	5443
Sunflower	32.4	53.5	85.9	6699
Fossil fuels	90.3	0	90.3	0

Rapeseed	40.2	54.9	95.1	No abatement
Soybean	46.9	56.3	103.2	No abatement
Palm oil	51.1	54.0	105.1	No abatement

Table 23: Estimated carbon abatement costs of biofuels when ILUC emissions are included.

A rough assessment of the impacts of the estimated costs and greenhouse gas emissions performance outlined above suggests that the production of bioethanol, and that of advanced biodiesel and vegetable oils with an improved greenhouse gas performance would be greatly favoured. A number of observations can be made:

- Firstly, advanced 2nd generation land using biodiesel[194] with high costs (3 times the cost of 1st generation biofuels) would seem to become competitive for the fuel suppliers due to their good greenhouse gas performance compared to other available sources of biodiesel.

- The use of conventional vegetable oils would be strongly discouraged unless their greenhouse gas performance is improved, as otherwise they would seem to be of a higher or similar carbon intensity than conventional fossil fuel sources. However improved vegetable oil pathways are being used, and every gram they save is highly appreciated by the fuel suppliers. This is highlighted by the fact that the "improved vegetable oil2" is only saving 3 g/MJ more than "improved vegetable oil1", while being 7% more expensive, it is still more competitive.

- Analysing the boundary conditions, i.e. what value would it have if one could change one of the them (the shadow price), it is clear that the fuel costs for complying with the Fuel Quality Directive would be greatly reduced if more ethanol could be blended in. This is because the ethanol feedstocks are assumed to be cheaper and in general delivers higher greenhouse gas savings, ILUC included, which would result in a more favourable carbon abatement price compared to biodiesel alternatives.

Another question is the availability of so-called "ILUC-free" vegetable oil based biofuels[195]. In the assessment above they are excluded from the mix as no such biofuels currently exist. Should these become available at moderately higher costs compared to uncertified alternatives, they would become more attractive to fossil fuel operators than advanced biodiesel (i.e. as their price would be lower for similar carbon abatement costs) and non-ILUC-free conventional biodiesel (i.e. as their carbon abatement cost would be three times higher for the moderate increase in costs).

[194] The amount of non-land using biodiesel from waste (i.e. UCO and animal fat) is thought to be limited and as such has been capped at 3Mtoe. Should more of this cheaper alternative be available, it is expected to take priority over the more expensive 2nd generation land using biodiesel alternative.

[195] Such biofuels could be similar to the biofuels described under option C2. They are here assumed to cost on average 30% more than other vegetable oils.