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EU Biofuel Policies and The Regulation of Indirect Land Use Change *

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Abstract:

The contribution of biofuels to reducing greenhouse gas emissions (emissions) has recently been questioned by leading scientists because production of biofuel feedstocks causes indirect land use change (ILUC) that in turn causes emissions. The European Commission (EC) put forward policy proposals to control for ILUC that we discuss in this paper. Firstly, we provide a definition of ILUC, briefly present ILUC modelling approaches and display their methodological and data-related shortcomings. As models are neither able to calculate a biofuel feedstock- nor a location-specific ILUC emission factor, modelling results cannot be used to implement a biofuel feedstock- or location-specific ILUC regulation. Thus, we find that the only effective policy for the EC would be to increase the minimum emission saving threshold. What threshold would rule out all biofuel options with a negative emission balance depends essentially on the risk that one is willing to accept for violating the positive emission balance of certain biofuel options. Going beyond the policy proposals of the EC, we conclude that, in the end, ILUC can only be controlled by requiring that all agricultural production is made subject to sustainability assessments by implementing sustainable land use planning and by preventing illegal deforestation.

JEL classification: Q42, Q58, Q56, Q16

Keywords: Indirect land use change, Biofuels, EU renewable energy policy

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1. Introduction

One of the components of the European Commission´s (EC) strategy to replace fossil energy sources by non-fossil renewable sources is to expand the production of biofuels. Biofuels are especially important for reducing the dependency of the transport sector on fossil fuel and for decarbonising the fuel it uses. Through its biofuel sustainability regulation (EU-RED), the EC seeks to achieve a minimum target of 10% renewables in the transport sector by 2020 [13]. The EU-RED was supplemented by a regulation stipulating a mandatory reduction of 6% in the emission intensity of fuels used in transport [14] to emphasise the aim to reduce greenhouse gas emissions (emissions). According to the recently published national renewable energy action plans biofuels will account for1 90% of the mandated target of 10% renewables in the transport sector [8].

The 10% target of the EU-RED has been widely criticised. Due to an increase in biomass demand for feedstocks for biofuel production and a continuously high demand for feedstocks in the food and feed sector, the demand for agricultural land is expected to increase globally [12][18],[19]. Meeting this demand causes emissions from LUC that still contribute approximately 9% to global emissions [17]. Thus, it is questionable whether using biofuels can reduce emissions as long as there are any emissions from LUC.

To ensure that biofuels contribute to a reduction in emissions and that biofuels are sustainably produced, the EU-RED contains a sustainability regulation in order to avoid undesirable LUCs caused by expanding biofuel feedstock production. These undesirable LUCs can be divided into direct land use change (DLUC) and indirect land use change (ILUC).

The definition of DLUC is straightforward: it is the conversion of land that has not been cultivated before, into land used to produce a particular biofuel feedstock. Regarding DLUC, the EU-RED stipulates that biofuel feedstocks may not be produced on land with high carbon stocks, such as continuous forests or peatlands, or on land with high biodiversity.

In addition, in order to assure that biofuels reduce emissions even when they cause emissions from DLUC, the EU-RED stipulates a mandatory minimum emission saving threshold. Accounting also for possible emissions from DLUC, it has to be proofed that each biofuel will provide emission savings of at least 35% compared to the fossil fuel alternatives in order to be counted towards the 10% target imposed on the mineral oil industry. This minimum emission saving threshold will be increased to 50% in 2017 and 60% in 2018 for new installations for biofuel production [13]. Accounting for possible emissions from DLUC is possible as they can be directly linked to a particular biofuel production, and can thus be allocated to the specific emission balance of the biofuel at hand. The EC implemented the EU-RED by adapting six certification schemes aimed at verifying compliance with the sustainability criteria set out in the EU-RED, including those regarding DLUC.

However, the EU-RED does not solve the question of how to deal with emissions from ILUC. Several scientists state that "*current scientific understanding is sufficient to warrant immediate action*", and they urge the EC "*to align the EU biofuels policy with the best scientific knowledge and take into account emissions from ILUC.*" [31]. In addition, a growing literature has put forward several policy proposals that try to take into account emissions from ILUC: The study by the EEA [11], for example, focuses on promoting integrative biofuel production that allows only the use of feedstock for biofuel production that is produced additionally to food and feed production. However, they do not specify a policy instrument to achieve this integrative biofuel production. Bowyer and Kretschmer [2] question the usefulness of overall EU biofuel policy. They find that emissions from the biofuel production volumes anticipated for 2020 are higher than emissions from the fossil fuel alternatives when emissions from ILUC are factored into the emission balances of biofuels. Cornelissen and Dehue [3] promote the idea of identifying biofuels that have a higher risk of having an ILUC effect rather than trying to quantify the effect. In a similar way, Fritsche et al. [16] promotes an ILUC emission factor derived by a deterministic calculation of the ILUC risk of different biofuel feedstocks. His calculation is based on current land use and trade patterns of the biofuel feedstocks without modelling the quantity of emissions from ILUC.

Nevertheless, there is a growing literature that tries to model the quantity of emissions from ILUC that would be caused by the EU target or other biofuel targets [6],[20],[26],[27],[28],[29]]. In order to make these different modelling approaches comparable, Edwards et al. [10] standardise the results of modelling LUC, that is DLUC plus ILUC. They find that the standardised results indicate a considerable and a very large range of emissions for all the biofuel options: biodiesel emissions range between approximately 40 gCO_2/MJ (AGLINK biodiesel EU) and 350 gCO_2/MJ (LEITAP biodiesel EU-DEU) per year, bioethanol emissions range between approximately 140 gCO_2/MJ (LEITAP bioethanol wheat EU-Fr) and about 25 gCO_2/MJ per year (IMPACT coarse grains EU) (see Edwards et al. [10], Fig.22).

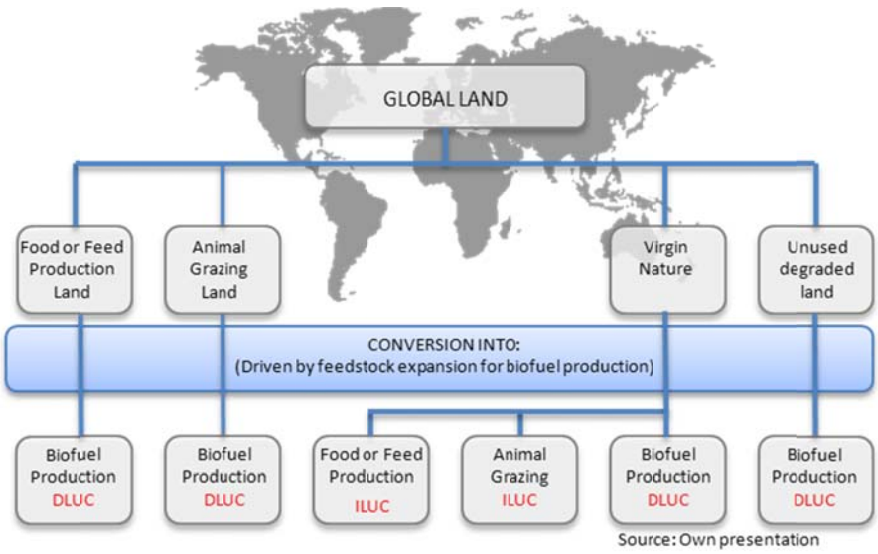
Based on the literature on policy proposals for ILUC regulation and the literature on modelling the quantity of emissions from ILUC, we discuss in this paper how science can contribute to evaluating the emissions from ILUC caused by the EC´s biofuel target and whether existing model results can be used to draft an ILUC regulation. We particularly discuss these questions in order to evaluate the EC policy proposals that could be used within the EU-RED to control for ILUC.

We begin by providing an appropriate definition of ILUC and proceed with a discussion of the current state of art in modelling ILUC. We use the model results of Laborde [23] in the following sections. Then we illustrate the main instrument to control for undesirable LUC within the EU-RED, namely the mechanism of the minimum emission saving threshold. We discuss the effect of the threshold on the biofuel market, land needed to fulfil the EU biofuel target and related biofuel emission balances. Next, we elaborate on how model results can guide biofuel and ILUC policies within the EU-RED framework by applying current model results to biofuel emission balances. Finally, we use our results to evaluate the policy proposals of the EC to control ILUC and draw conclusions.

2. ILUC- A definition

ILUC is an external effect of the promotion of biofuels. This effect is caused by changes in prices for agricultural products on the world market, particularly food and feed products in the form of grains and oils. The cropland used to produce food and feed is reduced globally when the cropland is used to produce biofuel feedstocks instead. Consequently, the supply of food and feed products on world markets is reduced, which drives up their prices, which in turn creates an incentive to convert new land to produce food and feed. This external effect of biofuel production is caused solely by price increases for agricultural products on global or regional markets. In this context, ILUC can be interpreted as DLUC caused by food and feed production incentivised by the price effect of an increased production of biofuel feedstocks. Figure 1 illustrates this concept.

Figure 1: Different Types of Land Use Change: DLUC and ILUC



Lange [24] shows that the sustainability criteria to control DLUC in the EU-RED generates an incentive, particularly for the biofuel options from temperate regions, to produce biofuel feedstocks on land already used to produce crops. While this effectively avoids DLUC, it increases the ILUC effect caused by the overall EU biofuel target.

3. Modelling ILUC

Defining ILUC as an external effect of the biofuel production is the basic concept that economic models use to evaluate the ILUC effect of biofuel policies. However, a controversial discussion about the ability of economic models to quantify ILUC was initiated by a recently published modelling exercise by Laborde [22] commissioned by the EC to assess the ILUC effect of the EU biofuel target. In this section, we discuss requirements needed to adequately model ILUC. In addition, we briefly present the modelling exercise by Laborde [22], as we want to use his results to discuss the policy proposals put forward by the European Commission that could be used within the EU-RED to control ILUC. In order to evaluate the usefulness of such model results to draft an ILUC regulation, we discuss limitations of current modelling exercises.

i. Requirements for a correct modelling of ILUC

According to the definition of ILUC above, the extent of the ILUC effect depends on global and regional demand and supply conditions for food and feed products, on regional support policies in the agricultural sector, on local infrastructure conditions, and on local markets. In addition, the geophysical suitability of land for agricultural production determines land use decisions. And most importantly, the extent of the ILUC effect depends on the particular biofuel feedstock that replaces the food and feed production.

As a consequence, models that attempt to quantify the ILUC effect need to take into account several substitution effects and linkages between the agricultural sector, the energy sector and land markets for example, the substitution elasticities between feedstocks for a particular end use, the interrelationship between biofuels and fossil fuel markets, or the potential to intensify agricultural production on the existing cropland in contrast to the potential to convert new land to produce crops.

If the quantified ILUC effect is to be disaggregated and causally attributed to each particular biofuel production, this would require the following steps of analysis: firstly, a site-specific identification of which food and feed production is replaced by the biofuel feedstock, secondly, an economic analysis of the global market responses to this replacement, and finally, a site-specific identification of the formerly unused land that is converted into cropland to produce a particular food or feed that has been replaced by the biofuel feedstock. In practice, few of the parameters needed for this specific identification are derived from practical data. Most of them are the educated guesses of the modellers. This is due to the lack of empirical data. To validate the model results on the quantity of the ILUC effect they are, nonetheless, evaluated by using sensitivity analysis.

We can distinguish two model types, used in related studies that attempt to quantify the LUC effect of biofuel policies on a global scale: partial equilibrium (PE) models and computable general equilibrium (CGE) models. The basic mechanism of these models is to equilibrate supply and demand via prices and thus generate equilibrium on markets. These models start with a baseline scenario that simulates current trends on the market up to a certain target year. This baseline scenario is then used to compare scenarios that are run subject to additional policy measures. The comparison of the baseline scenario with the policy scenario provides the information for the assessment of the policy measure. Therefore, both the assumptions for the baseline scenario and for the policy scenario are of importance.

However, regarding their suitability for quantifying of the LUC effect of biofuel policies, one has to distinguish between PE and CGE models. PE models have the advantage of capturing the agricultural sector in more detail. But since they treat changes in other sectors exogenously (e.g. since biofuels do not have an impact on energy prices), they are not able to consider feedback effects between different sectors. CGE models treat changes in other sectors endogenously, as they address the world agricultural market as well as repercussions on the world economy and energy markets. Hence, CGE models are able to quantify the LUC effect of biofuel policies on a global scale.

ii. The MIRAGE Model

In order to quantify the LUC effect of the EU biofuel target and its related emissions, the EC commissioned the International Food Policy Research Institute (IFPRI) to perform a CGE modelling exercise. It was performed by Laborde [22], who uses the CGE model MIRAGE. A first version of this modelling exercise (Al-Raffai et al. [1]) was launched by the EC, and after a public consultation, several model assumptions were changed. Laborde [23] simulates the LUC effect of the EU biofuel target for 2020 and its related emissions using the planned biofuel production in the EU member states, taken from the national renewable energy action plans (EC [8]). We summarise the main results of Laborde [23] in this section. In addition, we use Laborde [23] to discuss the ability of current CGE models to quantify ILUC, as the modelling exercise of Laborde [23] is currently the most sophisticated one available for the quantification of the LUC effect of biofuel policies.

The model used in the modelling exercise of Laborde [23] includes a detailed representation of important biofuel feedstock and biofuel options. LUC is driven by price changes affecting the production activity on a particular type of land. This is because these price changes determine the profitability of a particular type of agricultural production. LUC is addressed both in the form of substitution within cropland between different agricultural production on these croplands and the expansion of croplands into new land. The conversion of a cropland used to produce food and feed into a cropland used to produce biofuel feedstock represents a pure substitution effect. The conversion of new land into cropland used to produce food, feed or biofuel feedstock represents either DLUC or ILUC.

The emissions associated with the conversion of new land are computed in the modelling exercise of Laborde [23] by using the standard values of the EU-RED, which draw on the results of IPCC [21]. Laborde [23] presents his results on the LUC effect of the EU biofuel target for 2020 in the form of marginal, biofuel feedstock specific emissions from LUC [i] and aggregated global emissions from LUC. His results on the LUC effect are the sum of DLUC and ILUC and are presented for two policy scenarios: one simulating the EU biofuel target for 2020 with free trade and one without free trade.

Laborde [23] also performs a Monte Carlo simulation to assess the sensitivity of the results for the LUC effect to the uncertainty range of several key model parameters. We present the characteristics of the Monte Carlo simulation because we use its results as the confidence interval of the results for the LUC effect when we discuss the policy proposals put forward by the EC to control ILUC. The following key model parameters are addressed in the Monte Carlo simulation:

- The shifter in the share of land expansions occurring into primary forest which modifies the emission release by unit of exploited land expansion;
- The shifter in intermediate demand price elasticity of agricultural inputs, indicating how easily the processing sector will release inputs after a biofuel demand shock;
- The ratio between yield on new cropland and average yield;
- The elasticity of substitution between land and other factors (factor intensification);
- The elasticity of substitution between key inputs (feedstuff or fertiliser) and land (input intensification);
- The elasticity of transformation of land and extension elasticity.

A further characteristic is the assumed log-uniform probability distribution for each key model parameter centred on their default values used in the modelling exercise. The range for each key model parameter is based on a literature review conducted by Laborde and Valin [22] (see Table 1 Laborde [23]). From the probability distribution of each key model parameter Laborde [23] draws 1000 different sets of values for the key model parameters. With these 1000 sets, he creates 1000 model baselines and runs model simulations for each set. This results in a set of 1000 different results on the LUC effect calculated with the model. The distribution of the different results on the LUC effect represents the probability distribution of the LUC effect subject to the key model parameters analysed. For the resulting LUC emission values, Laborde [23] displays the 5 and 95 percentile level of the confidence interval. This means that 90% of all the resulting values for LUC emission in the Monte Carlo simulation lie within this confidence interval. In other words, the probability that the values on LUC emission lie outside this confidence interval is very small.

iii. Limitations of models for the determination of ILUC

In order to evaluate the usefulness of model results such as those from Laborde [23] to draft an ILUC regulation we need to address 1) the generic limitations and 2) (current) possible data shortcomings of such model exercises.

With regard to generic limitations, it must be emphasised that, in general, CGE models are the suitable tool to understand effects such as the influence of biofuel policies on the direction of changes in feedstock and energy price or in output quantities. However, to draft an ILUC regulation based on model results, the following generic limitations must be considered:

- The effect of the expansion of croplands is modelled in a simplified way and is only driven by market effects. This is due to the non-consideration of other important factors that likewise play a major role in local land use decisions. In practice, this effect is driven by land market regulations, nature protection laws and their level of enforcement, tenure rights and other local institutional factors.
- The LUC emission factors applied represent average values for a particular land use category. This is due to the limited differentiation within one land category. Only a further differentiation of different land categories in the model would result in LUC emission factors that are more precise. However, a further differentiation would require a much more elaborated database of the spatial distribution of global land categories.
- It is not possible to split up the modelled LUC effect of the EU biofuel target into the ILUC and DLUC effect. This is due to the fact that all markets are cleared simultaneously in CGE models. Consequently, only the net LUC effect can be computed. Thus, a LUC emission factor calculated on the basis of a CGE model will always include DLUC and ILUC effects of a biofuel target which cannot be distinguished.
- The individual LUC effect of a particular biofuel production unit cannot be computed. This is due to the level of aggregation in the model that does not allow for the representation of every production unit.
- A distinction of the effect of the EU biofuel target for a specific biofuel feedstock is not possible. This is also due to the fact that in CGE models, all markets are cleared simultaneously. The assumption that the marginal effect of a particular biofuel feedstock is the same as the effect of that biofuel feedstock when the model clears all markets and feedstocks simultaneously is at least doubtful, as it assumes perfect linearity of effects.

With regard to currently unsolved data shortcomings, the large differences in LUC effects computed by different models indicate both the high sensitivity of results to certain key model parameters and a considerable uncertainty about the exact quantification of the key model parameters. The model comparison by Edwards et al. [10] highlights key model parameters that the authors identify as being responsible for differences in the computed LUC effect. These key model parameters are as follows:

- The quantity of feedstock and its share in the production of biofuel. The study by JEC-IE identified differences in the amount of biofuel feedstock required to produce one unit of each biofuel. They state that these differences are caused mainly by different mixes of biofuel feedstocks.

- The amount of biofuel feedstock saved by substituting by-products. Some models allow by-products to be substituted by animal feed such as fodder feedstocks and oil meals. The degree of substitution and the way substitution can take place varies significantly.
- The average feedstock yields. Average feedstock yields do not vary considerably. They depend on the dataset, feedstock and year used in the model.
- The increase in feedstock yields over time. Average real increases in feedstock yields are positive in all scenarios, leading to a reduced expansion of cropland. However, the rate of increase in feedstock yields varies significantly.
- The effect of feedstock substitution on the demand for cropland (the elasticity of substitution). Feedstock substitution causes a lower demand for cropland when the substituted feedstock has a higher yield than the original feedstock and causes a higher demand for cropland when the substituted feedstock has a lower yield than the original one (Edwards et al. [10], p. 93). The amount of substitution that is possible between different varies significantly.
- The relationship between intensification and expansion (the elasticity of transformation). The higher demand for a particular feedstock can be met by intensifying production on the existing cropland or by expanding the cropland. The relationship between intensification and expansion varies significantly.

While comparing model results of the two modelling exercises with the MIRAGE model (Al-Raffai et al. [1], Laborde [23]), we additionally identified the following sensitive model parameters.

- The quantity of first-generation biofuels assumed to fulfil the EU biofuel target. Al-Raffai et al. [1] assume an amount of 17.6 Mtoe biofuels in 2020 and Laborde [23] assumes an amount of 27.2 Mtoe biofuels in 2020. Furthermore, Laborde [23] adjusted the share of biodiesel in this target to fit the national renewable energy action plans of the member states. This results in a much higher share of biodiesel, 78% compared to 55% in Al-Raffai et al. [1]. One major driver of this high biodiesel share is, for example, Germany, where biodiesel has the highest share in the biofuel sector.
- The fraction of palm cropping on peatland. Al-Raffai et al. [1] assume that a faction of 10% of the new palm cropping expands into peatland for Malaysia and a fraction of 27% for Indonesia. Laborde [23] assumes that a fraction of 33% of the new palm cropping expands into peatlands for both countries. Due to the high carbon content in peatlands, these assumptions have a strong impact on resulting emissions from LUC. Edwards et al. [10] provide an overview of current knowledge about the expansion patterns of palm cropping into peatland in Malaysia and Indonesia, this knowledge is indeed very limited because official statistics do not exist.[ii] The fraction of 33% assumed by Edwards et al. [10] and used by

Laborde [23] needs to be treated as an educated guess as long as there are no better statistics available.

After illustrating the generic limitations and (current) possible data shortcomings of CGE modelling exercises within the context of LUC effects caused by biofuel policies, it must be emphasised that many of the parameters that drive model results are empirically not well established. Comparing these generic limitations and data shortcomings with the requirements defined earlier, it is clear that a conceptually correct identification of ILUC is currently impossible in practice. More so, current modelling of ILUC is far from coming close to quantifying the ILUC effect even on a rather aggregated scale.

4. The Mechanism of the Emission Saving Threshold

The problems in modelling and quantifying ILUC stand in contrast to the fact that the EU biofuel target has already been implemented and an ILUC regulation is pending. Therefore, in this section, we discuss how such an ILUC regulation can be implemented effectively by relying on the understanding of the mechanism of the ILUC effect as defined in Section 2. We start with a theoretical analysis on how the minimum emission saving threshold effects emissions from ILUC, as it is the main instrument to control undesirable LUC within the EU-RED. The understanding of this mechanism provides the basis for our elaboration below on how model results, in spite of above-mentioned shortcomings, can guide biofuel and ILUC policies within the EU-RED framework.

The minimum emission saving threshold within the EU-RED is currently 35%. This means that in the whole production process from the field to the tank, including emissions from DLUC, biofuels may not cause more than 65% of the equivilent emission content in the fossil fuel alternatives. The 35% minimum emission saving threshold and therefore the contribution of biofuels to climate change mitigation was chosen in the political process. A contribution to climate change mitigation, although a small one, would already be realised with only 1% emission savings, and, for energy security aspects, a neutral emission balance of biofuels, compared to the fossil fuel alternatives, would already be sufficient.

In addition to the 35% emission saving threshold, the EC determined standardised default values for emissions from the whole production process and DLUC which represent a conservative estimate of the actual values. [iii] [iv] Consequently, the required 35% emission saving threshold, combined with the default values, should be understood as a risk premium that prevents biofuels from potentially violating the objective of climate change mitigation.

Since the risk premium for emissions from the production process and DLUC does not explicitly account for emissions from ILUC, the questions are:

- whether and how an increase in the minimim emission saving threshold of 35% would influence the emissions from ILUC caused by different biofuel options (see this section); and
- whether the 35% emission saving threshold is high enough to cover potential emissions from ILUC (see Section 5).

  In order to identify the influence of an increase in the minimum emission saving threshold, it is necessary to understand the emission accounting in the EU-RED.

Whether a biofuel option can under the implemented minimum emission saving threshold be counted towards the EU biofuel target – at least under current EU-RED – is determined purely by the emission balance of its entire production process in the case that no DLUC takes place. Thus, the default values for the production process expressed in gCO_{2eq}/MJ in the EU-RED are the hurdle to take if no individual emission accounting for a specific biofuel production is performed within a certification process. This means that a biofuel is not allowed to exceed ~54,5 gCO_{2eq}/MJ emissions from fossil sources in the whole prodution process, including DLUC, under the current required minimum emission saving threshold at the 35% level. Increasing the minimum emission saving threshold implies that these allowed emissions in the production process are reduced. A reduction in the allowed emissions results therefore in a reduction of the currently available biofuel options in the case that default values are used to calculate the emission balance. Thus, increasing the minimum emission saving threshold reduces the portfolio of biofuel feedstocks eligible for fullfilling the EU biofuel target.

As a next step, it needs to be determined how the effect of increasing the the minimum emission saving threshold on the portfolio of biofuel feedstocks reduces the overall LUC effect of the EU biofuel target and therefore also the ILUC effect.

The portfolio of biofuel feedstocks eligible for fullfilling the EU biofuel target is determined by the biofuel feedstock's energy yield per hectar. Obviously, if a biofuel is eligible for a higher minimum emission saving threshold due to its default values, it causes low emissions throughout the whole production process. An large share of the emissions generated during the production process is contributed by emissions caused by the biofuel feedstock production expressed in gCO_{2eq}/MJ in the default values. Emissions caused by biofuel feedstock production are determined in gCO_{2eq}/ha, expressing the fuel and fertiliser input needed per hectare to produce and harvest the biofuel feedstock. These emissions per hectare are tranformed into CO_{2eq}/MJ via the energy yield per hectare (MJ/ha) of the biofuel feedstock expressing its energy productivity. Thus, a higher energy yield per hectare of a biofuel feedstock results in less CO_{2eq} being allocated to each MJ of the final biofuel. Consequently, a higher production of energy per hectare due to biofuel feedstocks with higher energy yields per hectare (MJ/ha) reduces the amount of land needed to fullfill the EU biofuel target.

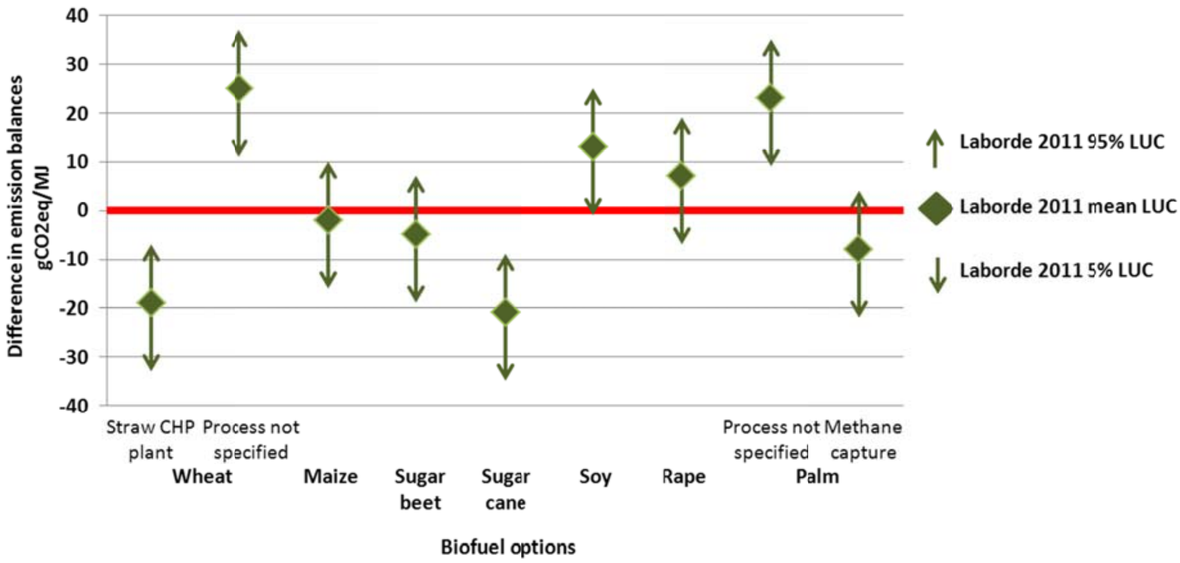
With this mechanism, only those biofuel feedstocks with high energy productivity remain in the portfolio eligible for the EU biofuel target when the minimum emission saving threshold is increased. Consequently, the LUC effect is reduced, as well as the ILUC effect and thus emissions from ILUC.[v] [vi]

5. Can biofuels contribute to climate change mitigation at all? – The range of emission balances using model results.

The question remains how high the overall minimum emission saving threshold should be set in practice in order to assure that biofuels contribute to climate change mitigation when emissions from ILUC are possible. To answer this question, we begin by analysing whether biofuels can contribute to climate change mitigation at all with the currently eligible portfolio of biofuels when possible emissions from ILUC are considered in the emission balances.

In order to do so, we assume that the range of the Laborde [23] model result is the best guess possible about emissions from LUC at the moment. Laborde [23] calculates the probability distribution of the range of emissions from LUC using a Monte Carlo simulation. We combine the results on emissions from LUC of the Monte Carlo simulation with the EU-RED default values for emissions from production process (well-to-wheel emissions = WTW emissions) in order to assess the probability distribution of the total emission balances of different biofuel options. We assume that the emissions from LUC represent the ILUC effect of the EU biofuel target. This represents a worst case scenario for emissions from ILUC when we assume that there are no emissions from DLUC, which corresponds to assuming that all biofuel feedstocks are produced on land already used before as cropland. This assumption is quite realistic due to the sustainability requirements concerning DLUC. To calculate the emission balance, we use the average (and not biofuel-feedstock-specific) value for emissions from LUC computed by Laborde [23] and treat them as pure emissions from ILUC. As the emissions from LUC are the same for every biofuel option, it is only the default value for WTW emissions that causes the differences in emission balances of different biofuel options. Figure 2 summarises the results.

Figure 2: Difference between emission balances of biofuel options and emissions balances of fossil fuel alternatives



Source: Own presentation based on EU-RED (2008), Laborde (2011)

In Figure 2, the vertical axis expresses the difference between emission balances of biofuel options and emissions balances of fossil fuel alternatives. As mentioned before, biofuel emission balances include total emissions from the production process and ILUC. At the zero line, a biofuel option causes exactly the same amount of emissions than the fossil fuel alternatives. Thus, the zero line can be interpreted as the zero emission savings line.

Negative values indicate that a certain biofuel option causes fewer emissions in the total production process, and therefore saves emissions compared to the fossil fuel alternative. Positive values indicate that a certain biofuel option causes more emissions, and consequently does not contribute to climate mitigation.

The green rectangles represent the mean of the distribution for the average values for emissions from LUC in the Laborde [23] Monte Carlo simulation plus the default values for WTW emissions of the EU-RED. The upper arrow points to the 95 percentile limit of the Monte Carlo simulation, denoting that 95% of all LUC values are below this emission value. The lower arrow points to the 5 percentile limit, denoting that only 5% of all LUC values are below this emission value. Thus, the arrows represent the probability distribution of the model results within the 95% and 5% confidence interval caused by the uncertainty range of the key model parameters.

The large arrows and thus the large confidence intervals of the total emission balances of the various biofuel options occur due to the strong sensitivity of model results to several key model parameters. Only if the upward arrow is below the zero emission saving line does the particular biofuel option contribute to climate change mitigation with a high degree of certainty. Accordingly, only bioethanol derived from sugarcane or from wheat processed by efficient straw fired combined heat and power

(CHP) plants contributes to climate change mitigation with a high degree of certainty. In contrast, biodiesel derived from palm with processing without methane capture and ethanol derived from wheat processed by inefficient plants will most likely not contribute to climate change mitigation.

Due to the large confidence intervals for all other biofuels, it is uncertain whether these biofuels would contribute to climate change mitigation or not, when combining default values for WTW emissions with results on emissions from LUC. However, there is a good chance that biofuels derived from options derived from maize, sugar beet and palm with processing with methane capture contribute to climate change mitigation by having a positive emission balance.

The size of the confidence intervals for the emission balances may become somewhat smaller with more sophisticated modelling and improved data. However, a range of uncertainty will remain. In order to assure, nevertheless, that biofuels will contribute to climate mitigation, this raises the following question: How does ILUC have to be regulated so that only those biofuel options are chosen that have a positive emission balance with a sufficient degree of confidence? What constitutes a sufficient degree of confidence is open to discussion and would need to be established by policy makers depending on how risk averse people are.

6. Which emission saving threshold provides a positive emission balance with a “sufficient” degree of confidence?

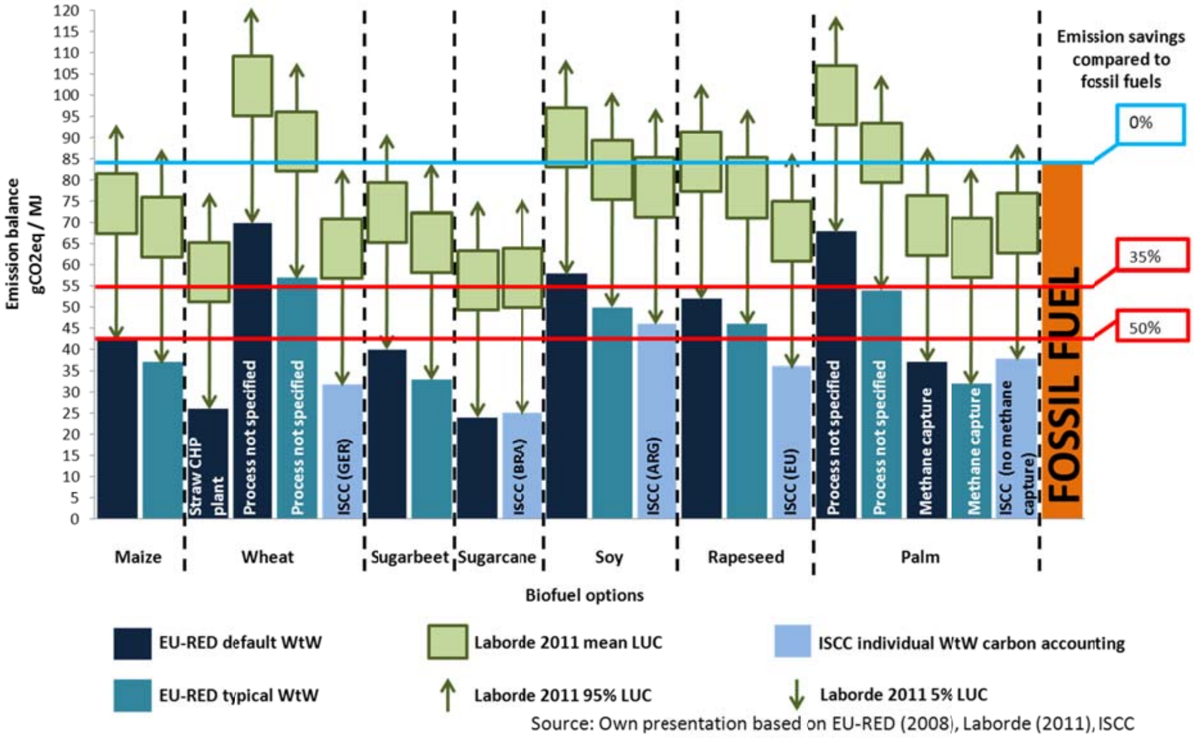
In order to evaluate what type of ILUC regulation would provide a positive emission balance with a particular degree of confidence, we relate in this section the emission balance confidence intervals determined in the previous section to various levels of the minimum emission saving threshold.

In doing so, we have to keep in mind that a higher minimum emission saving threshold reduces the LUC effect of the EU biofuel target. Thus, strictly speaking, when determining the effect of various levels of the minimum emission saving threshold, one would also need to consider the changes in emissions from LUC caused by changing the level of the minimum emission saving threshold. To compare the LUC effects under various levels of the minimum emission saving threshold, the model would have to be applied using various biofuel feedstock portfolios that are derived from various levels of the minimum emission saving threshold. However, we continue with the available results computed by Laborde [23] as his model scenarios only consider emissions from LUC caused by the biofuel portfolio given the current 35% minimum emission saving threshold.

To compare various levels of the minimum emission saving threshold, we again compare the emission balances of different biofuel options with the emission balances of the fossil fuel alternatives, using Laborde’s results on emissions from LUC and various data on WTW emissions. The results of that comparison are displayed in Figure 3, which shows the emission balances of different biofuel options in gCO_{2eq}/MJ. The dark blue bars represent the default values for WTW emissions from the EU-RED.

Since the default values are intentionally set at a high level in order to capture less efficient production processes, we also include the typical values for WTW emissions from the EU-RED.[vii] Furthermore, where available, we consider values for WTW emissions calculated in practice by the biomass certification system ISCC (International Sustainability and Carbon Certification), which has been recognised by the EC for performing individual emission accounting in order to verify compliance with the sustainability criteria of the EU-RED.

Figure 3: Full Emission Balances of Various Biofuel Options



In Figure 3, the green rectangle with arrows represents the confidence interval of the values for emissions from ILUC in the Laborde Monte Carlo study. As in Figure 2, we use the average (and not biofuel-feedstock-specific) value for emissions from LUC computed by Laborde [23] and treat it as pure emissions from ILUC. The lower arrow points to the 5 percentile limit, the lower arrow plus the rectangle to the mean value plus the upper arrow points to the 95 percentile limit of emissions from LUC resulting from the Monte Carlo simulation. Thus, the upper arrow represents the upper range of the model results on emissions from ILUC.

The results displayed in Figure 3 can be interpreted as follows.

The blue bars on WTW emissions plus the green arrows on emissions from ILUC denote the total emission balance of a particular biofuel option. This total emission balance needs to be compared to emissions from the fossil fuel alternatives (orange bar) in order to see whether the biofuel option still causes fewer emissions than the fossil fuel alternative and thus contributes to climate change mitigation. The value at which emissions from the fossil fuel alternative and the biofuel emissions balance are equal (83.8 gCO_{2eq}/MJ fuel = 0% emission savings) is highlighted with a light blue line. Thus, if the whole biofuel emission balance (blue bar on WTW emissions plus the green arrows on emissions from ILUC) exceeds the blue line, the biofuel option causes more emissions than the fossil fuel alternative. This replicates the results shown in Figure 2.

In order to rule out all biofuel options that cause more emissions than the fossil fuel alternatives and therefore do not contribute to climate change mitigation, a functional minimum emission saving threshold should rule out all biofuel options that, when considering a possible ILUC risk, exceed 83,8 gCO_{2eq}/MJ (blue line). When considering the values for emissions from LUC computed by Laborde as the possible ILUC risk without DLUC, a specific biofuel option could cause WTW emissions amounting to 45,4 gCO_{2eq}/MJ for the mean value of emissions from LUC (and to 33,4 gCO_{2eq}/MJ for the 95 percentile limit or to 58,9 gCO_{2eq}/MJ for the 5 percentile limit) and then cause exactly as many emissions as the fossil fuel alternatives.

In Figure 3, the two levels of the minimum emission saving threshold proposed in the EU-RED are illustrated by red lines. Since the implemented 35% threshold in the EU-RED has so far only been applied to emissions from WTW and DLUC only the blue bar indicating WTW emissions has to be compared to the red line indicating the minimum emission saving threshold. The blue bar on WTW emission of a biofuel option may not exceed the respective red line of the minimum emission saving threshold in order to be eligible under a certain level of the minimum emission saving threshold. We included the currently implemented level of 35% and a possible increase to 50%.

7. Analysis of policy proposals put forward by the EC to control ILUC.

After analysing the mechanism of the already implemented regulation of emissions from biofuels in the EU-RED, we discuss, as a next step, the policy proposals put forward by the EC that could be used within the EU-RED to specifically control emissions from ILUC.

The EU-RED has a provision requiring the EC to report on the issue of ILUC [13], which it did in the "Report from the Commission on ILUC related to biofuels and bioliquids" [7]. In this report, the EC discusses the difficulties to quantify and model specific emissions from ILUC. Besides the difficulties involved in modelling ILUC, the EC acknowledges that "*in the absence of intervention* - *there can be an effect of ILUC on the GHG balance of biofuels with the potential to substantially reduce their impact on climate change mitigation*" (EC [7] p. 14). According to this first report regarding ILUC regulation, a final, not yet published impact assessment of the EC will focus on four policy proposals:

1. Take no action for the time being, while continuing to monitor;
2. Increase the minimum emission saving threshold for biofuels;
3. Attribute a quantity of emissions to biofuels that reflects the estimated ILUC effect;

4. Introduce additional sustainability requirements for certain categories of biofuels.

In the following, we analyse each of these four policy proposals by relying on the analysis of the mechanism of the minimum emission saving threshold and the knowledge about the quantity of possible emissions from ILUC computed by Laborde´s [23] modelling exercise. In particular, we rely in our analysis on the following intermediate conclusions.

- The range of the confidence interval of the Laborde [23] results for emissions from LUC indicate that if WTW emissions are sufficiently low, several biofuel options actually contribute to climate mitigation even if DLUC and/or ILUC takes place. Thus, effective ILUC regulation should favour biofuel options with lower WTW emissions.
- Increasing the minimum emission saving threshold introduces incentives to become more efficient in the production process and thus to reduce WTW emissions, and to prove this in the certification process. In such cases, default values for WTW emissions from the EU-RED would usually rule out such biofuel options.
- The question which level of the minimum emission saving threshold is appropriate to ensure that producing biofuels without a climate mitigation impact is unlikely to take place depends essentially on the risk that would be accepted for ignoring that the biofuel option causes less emissions than the fossil fuel alternative. A risk averse approach would suggest a high minimum emission saving threshold.

  Based on these conclusions, we evaluate the policy proposals put forward by the EC to control ILUC as follows:

Policy proposal 1 and 2: **Take no action for the time being, while continuing to monitor or increase the level of the minimum emission saving threshold.**

Policy proposal 1 implies that the minimum emission saving threshold will remain at the 35% level until 2017 and will then be increased to 50%. Policy proposal 2 implies that the minimum emission saving threshold will be increased to 50% at an earlier stage.

If the minimum emission saving threshold remained at the 35% level, it would not rule out all biofuel options that cause more emissions than the fossil fuel alternatives when possible emissions from ILUC are considered (see Figure 3). Only biofuels derived from sugar beet, sugar cane, and maize would cause less emissions than the fossil fuel alternatives, according to the sum of the biofuel emission balance based on the average values for emissions from LUC as computed by Laborde [23] and the default values for WTW emissions of the EU-RED. According to this sum of the emission balance, biofuel derived from rapeseed would cause more emissions than the fossil fuel alternative, however, the 35% level of the minimum emission saving threshold would not rule this option. In addition, if, to compute the sum of the biofuel emission balance, one were to use the typical values for WTW emissions of the EU-RED instead of the default values, biofuels derived from palm processed without methane capture, and from rapeseed, soy and wheat would meet the requirements pertaining to the 35% level despite causing more emissions than the fossil fuel alternatives.

With the 50% level for the minimum emission saving threshold (Option 2), the portfolio of eligible biofuel feestocks is strongly reduced. According to the sum of the biofuel emission balance based on average values for emissions from LUC and the default values for WTW emissions, biofuel derived from wheat processed by efficient straw fired CHP plants, and from sugar beet and sugar cane would meet the requirements pertaining the 50% level. Biofuel derived from palm processed with methane capture would be the only eligible biodiesel option. Despite the reduced portfolio, it needs to be emphasised that the 50% level for the minimum emission saving threshold would rule out all biofuel options that cause more emissions than the fossil fuel alternatives, when considering the average values for emissions from LUC computed by Laborde [23].

However, the use of the average values for emissions from LUC may rule out some biofuel options even though they may not cause more emissions than the fossil fuel alternatives. This is due to the large range of the confidence interval of the emissions from LUC computed by Laborde [23] which is due to the high variance in the assumed distribution of the key model parameters analysed. Suppose we use the 5 percentile limit of the confidence interval of emissions from LUC to illustrate whether the minimum emissions saving threshold rules out biofuels that cause more emissions than the fossil fuel alternatives. In this case, using the default values for WTW emissions, only biofuel derived from wheat processed by inefficient plants and palm processed without methane capture would actually cause more emissions than the fossil fuel alternatives. However, the 50% minimum emission saving threshold would also rule out biofuels derived from soy and rapeseed.

These results illustrate the role of risk when specific levels of the minimum emission saving thresholds are chosen. The 50% level essentially ensures that there is a high likelihood that the biofuels that pass this threshold actually cause less emissions than the fossil fuel alternatives. On the other hand, it rules out several biofuel options although they may cause less emissions than the fossil fuel alternatives. The 35% level, to the contrary, may accept some biofuel options that probably do not cause less emissions than the fossil fuel alternatives. The choice between the two options therefore comes down to a choice between two errors, that of ruling out some biofuel options although they would cause less emissions than the fossil fuel alternatives and that of including some biofuel options although they would cause more emissions than the fossil fuel alternatives.

Of course, these results depend heavily on the modelling results for the net effect of emissions from LUC induced by the expansion of biofuel feedstock production. As these results are generated by only one model and depend on a number of assumptions that still need to be verified by empirical observations and by additional modelling exercises, there still exists considerable uncertainty concerning the robustness of the conclusions that can be drawn.

Despite this uncertainty, the advantage of proposal 2 is that it can be implemented easily and quickly within the current EU-RED. This is because it builds upon the sustainability regulation already in place, on especially the certification schemes approved by the EC. Schemes like the ISCC provide a means to account WTW emissions individually, which could potentially reduce the accounted WTW emissions and thus bring the overall emission balance in line with the 50% level of the minimum emission saving threshold.

Most importantly, the advantage of proposal 2 is that by addressing the minimum emission saving threshold, it uses the mechanism that actually affects the LUC effect of the EU biofuel target and therefore also reduces the related emissions from LUC.

Policy proposal 3: Attribute a quantity of emissions to biofuels reflecting the estimated ILUC effect

This policy proposal implies that an ILUC emission factor is added to the emission balance of the different biofuel options based upon results derived from modelling exercises that compute LUC. The mechanism utilised by this proposal is similar to the increase of the minimum emissions saving threshold under proposals 1 and 2. However, if an ILUC emission factor is added to the sum of the emissions from WTW and DLUC, several problems need to be resolved:

- Current models only compute LUC values and not ILUC, i.e. they can only identify the combined effect of DLUC and ILUC. Hence, computing DLUC as in the current emission balance according to the EU-RED would need to be dropped. Otherwise emissions from LUC would be counted double.
- It is impossible to assign a particular LUC emission factor to a certain biofuel feedstock, as only the combined effect of DLUC and ILUC can be identified. Hence, no biofuel-feedstock-specific emissions from LUC can be computed.
- A general LUC emission factor including DLUC and ILUC destroys the individual incentive for producers to reduce DLUC. Hence, without direct control of the producer´s land use for biofuel feedstock production, the direct incentive for a good agricultural practice would vanish.

Policy proposal 4: Introduce additional sustainability requirements for certain categories of biofuels

This proposal, implies that more sustainability criteria than currently implemented would be applied in the certification process. Sustainability criteria can only be applied to DLUC because only DLUC is directly related to a particular biofuel production process that is subject to a certification process. As the sustainability criteria currently applied to DLUC have already resulted in production of biofuel feedstocks predominantly on land already used before to produce crops, additional sustainability criteria would not make much of a difference as regards which areas are used to produce biofuel feedstocks [25]. And, more importantly, they would not change the ILUC effect of the EU biofuel target, since they would not reduce the pressure on land already used to produce crops. This is because they would not influence the price mechanisms for agricultural products on world markets nor LUC decisions for feedstocks other than biofuel feedstocks.

There is only one sustainability criterion that could influence the ILUC effect of the EU biofuel target, namely one that would allow biofuel feedstock production only on degraded land. However, there is no consensus about the location, and definition of degraded land. Hence, such a sustainability criterion can not be implemented currently. Even if a workable defintion of degraded land could be established, it is doubtful whether biofuel feedstock production on such land would be profitable.

8. Discussion and Conclusions

We show in our analysis that it is impossible to calculate the ILUC effect of different biofuel options using current modelling approaches. Even conceptually, there is no way of causally linking ILUC to a particular type of biofuel production. Nor can it be linked to a specific type of biofuel production in a particular region or from a particular biofuel feedstock. This is due to the fact that the ILUC effect is driven by price effects in international markets that are themselves determined by the complex interplay of many market forces, on both the supply and the demand side. The policy proposal to allocate biofuel feedstock and region-specific ILUC emission factors to the emission balance of biofuels has therefore no defendable scientific or conceptual base.

We argue that the only feasible and effective policy proposal is the one that would increase the minimum emission saving threshold. As a consequence, only the most efficient biofuel feedstocks in terms of emission savings could meet the sustainability requirements of the EU-RED. Thus, the risk of allowing the production of biofuels that pose a high risk of causing more emissions than the fossil fuel alternatives would be avoided. However, decisions about how much to increase the minimum emission threshold would depend on the decisions about the level of two probabilities, namely first the probability to rule out biofuels with potentially higher emissions than the fossil fuel alternatives and second the probability to avoid that biofuels with lower emissions than the fossil fuel alternatives are ruled out of the market.

To illustrate the impact of different levels of the minimum emission saving thresholds, we add up the WTW default emissions calculated by the EU-RED with the emissions that are likely to come from the global LUC effects of the biofuel target, i.e. DLUC and ILUC. To do so we use the results of the Laborde [23] modelling exercise. If the 35% level of the minimum emission saving threshold is maintained, those biofuel options that have the highest default values for WTW emissions and thus are likely to cause more emissions than the fossil fuel alternatives are effectively ruled out of the market. However, there are several biofuel options that would fulfil the 35% minimum emission saving threshold but are nevertheless likely to cause more emissions than the fossil fuel alternatives when emissions from ILUC are considered.

On the other hand, increasing of the minimum emission saving threshold to 50% would ensure that only biofuel options that have a very high probability of causing less emissions than the fossil fuel alternatives and thus would contribute to climate mitigation would enter the market. However, our results show also in some cases that there is a possibility that they would be ruled out of the market even though they might cause less emissions than the fossil fuel alternatives.

Our results are computed using of the results of the Laborde [23] modelling exercise, the currently most sophisticated modelling exercise available for this purpose. We show that there can still be considerable improvement in the modelling of the LUC effect. Both the empirical validation of key model parameters and several ad hoc assumptions about a number of unknown model parameters, and also the model architecture, can be improved upon. This might change the resulting size of the LUC effect. However, it will not change the fact that biofuel feedstock and region-specific ILUC emission factors cannot be computed in such models.

Thus, by going beyond the policy proposals of the EC, the only way to really control ILUC is by requiring that all agricultural production be subject to sustainability assessments (see also Lange [25], Delzeit and Holm-Müller [4]), especially to an emission balance. The problem of ILUC regulation is only a problem of an incomplete emission accounting of land use practices when only biofuel production is subject to such accounting, but food, feed and bioenergy production other than biofuel production are not. If, in contrast, all land use practices (forestry, animal grazing, food, feed and bioenergy production) were subject to emission accounting, the burden of LUC would always be imposed on the agricultural production that has replaced the previous type of production. All considerations about accounting for ILUC would then become meaningless.

In addition, the LUC effect of biofuel policies depends heavily on the change in demand for land for other types of agricultural production, mainly food and feed production. Erb et al. [12] show that the potential for bioenergy production, the development of agricultural production technologies, and a potential change to a more vegetarian diet are important and strongly interrelated determinants of the demand for land for agricultural production. Thus, the LUC effect following an increase in biofuel feedstock production depends on the land needed for food and feed production, which in turn depends on diets and advances in agricultural production technologies.

Finally, the type of land converted into cropland strongly influences the emissions from LUC. Normally, land with very high carbon stocks, such as peatland soils and tropical forests, is already subject to protection laws in many countries. The fact that they are nevertheless converted into cropland indicates that weak public institutions, corruption and a lack of property rights are major factors influencing how global emissions from LUC will develop in the long run.

References

[1] Al-Raffai, P., Dimaranan, B. and Laborde, D. 2010. Global Trade and Environmental Impact Study of the EU Biofuels Mandate. Report by ATLASS consortium, March 2010.

[2] Bowyer, C. and Kretschmer, B. 2011. Anticipated Indirect Land Use Change Associated with Expanded Use of Biofuels and Bioliquids in the EU – An Analysis of the National Renewable Energy Action Plans. Report by Institute for European Environmental Policy. http://www.ieep.eu/publications/2011/03/final-report-for-the-assessment-of-the-6th-environment-action-programme (09.09.2011)

[3] Cornelissen, S. and Dehue, B. 2009. Summary of approaches to accounting for indirect impacts of biofuel production. Report by Ecofys. http://www.globalbioenergy.org/bioenergyinfo/sort-by-date/detail/en/news/37271/icode/ (09.09.2011)

[4] Delzeit, R. and Holm-Mueller K. 2009. Steps to discern sustainability criteria for a certification scheme of bioethanol in Brazil: Approach and difficulties. In: Energy (34), p.662-668.

[5] DG Energy 2010. The Impact of Land use change on greenhouse gas emissions from biofuels and bioliquids – Literature review. An in-house review conducted for DG Energy as part of the European Commission's analytical work on indirect land use change. Brussels, July 2010.

[6] Dumortier, J, Hayes, D. J., Carriquiry, M., Dong, F., Du, X., Elobeid, A., Fabiosa, J. F., and Tokgoz, S. 2009. Sensitivity of carbon emission estimates from indirect land-use change. Technical report, Working Paper 09-WP 493, Center for Agricultural and Rural Development, Ames, Iowa.

[7] EC (European Commission) 2010. Report from the Commission on indirect land-use change related to biofuels and bioliquids. COM(2010) 811 final. Brussels, 22.12.2010.

[8] EC (European Commission) 2011. Renewable Energy, Action Plans & Forecasts, National Renewable Action Plans. http://ec.europa.eu/energy/renewables/action_plan_en.htm (08.08.2012).

[9] EC-Guidelines (European Union) 2010. Commissions Decision of 10 June 2010 on guidelines for the calculation of land carbon stocks for the purpose of Annex V to Directive 2009/28/EC. Official Journal of the European Union, L151/19 of 17.6.2010.

[10] Edwards, R., Mulligan, D. and Marelli, L. 2010. Indirect Land Use Change from Increased Biofuels Demand: Comparison of Models and Results for Marginal Biofuels Production from Different Feedstocks, Joint Research Center - European Commission.

[11] EEA (European Environment Agency Scientific Committee, 15 September), 2011. Opinion of the EEA Scientific Committee on Greenhouse Gas Accounting in Relation to Bioenergy.

http://www.eea.europa.eu/about-us/governance/scientific-committee/sc-opinions/opinions-on-scientific-issues/sc-opinion-on-greenhouse-gas

[12] Erb, K.-H., Haberl, H., Krausmann, F., Lauk, C., Plutzar, C., Steinberger, J. K., Müller, C., Bondeau, A., Waha, K., Pollack, G. 2009. Eating the Planet: Feeding and fuelling the world sustainably, fairly and humanely – a scoping study. Commissioned by Compassion in World Farming and Friends of the Earth UK. Institute of Social Ecology and PIK Potsdam. Vienna: Social Ecology Working Paper, 116.

[13] EU-RED (European Union) 2009. Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC. Official Journal of the European Union, L140/16 of 5.6.2009.

[14] European Union 2009. Directive 2009/30/EC of the European Parliament and of the Council of 23 April 2009 amending Directive 98/70/EC as regards the specification of petrol, diesel and gas-oil and introducing a mechanism to monitor and reduce greenhouse gas emissions and amending Council Directive 1999/32/EC as regards the specification of fuel used by inland waterway vessels and repealing Directive 93/12/EEC. Official Journal of the European Union, L140/88 of 5.6.2009.

[15] Fritsche, U. R., 2011. Sustainable Biofuels? Some thoughts and data on the ILUC issue in the EU 27. Informal paper by Oeko Institut, Darmstadt.

[16] Fritsche, U. R., Hennenberg, K., Hünecke, K., 2010. The “ILUC Factor” as a Means to Hedge Risks of GHG Emissions from Indirect Land Use Change. Working Paper July 2010. Oeko Institut, Darmstadt.

[17] Global Carbon Project 2011. Carbon budget and trends 2010. www.globalcarbonproject.org/carbonbudget (4.12.2011)

[18] Haberl, H., Erb, K.-H., Krausmann, F., Bondeau, A., Lauk, C., Müller, C., Plutzar, C., Steinberger, J.K. 2011. Global bioenergy potentials from agricultural land in 2050: Sensitivity to climate change, diets and yields. Biomass and Bioenergy

[19] Hertel, T., Golub, A., Jones, A., OHare, M., Plevin, R. and Kammen, D. 2010. Effects of US Maize Ethanol on Global Land Use and Greenhouse Gas Emissions: Estimating Market-mediated Responses, *BioScience* 60(3), 223-231.

[20] Hertel, T.W., Tyner, W.E., Birur, D.K. 2008. Global bioenergy potentials from agricultural land in 2050. GTAP Working Paper No. 51

[21] IPCC, 2006. 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Prepared by the National Greenhouse Gas Inventories Programme, Eggleston H.S., Buendia L., Miwa K., Ngara T. and Tanabe K. (eds). Published: IGES, Japan.

[22] Laborde D. and Valin H. 2011. “Modelling Land Use Changes in a Global CGE: Assessing the EU biofuel mandates with the MIRAGE-BioF model”, Forthcoming.

[23] Laborde, D., 2011. Assessing the Land Use Change Consequences of European Biofuel Policies. Final Report prepared for the European Commission DG Trade. Implementing Framework Contract No TRADE/07/A2. http://trade.ec.europa.eu/doclib/docs/2011/october/tradoc_148289.pdf

[24] Lange, M. and Klepper, G., 2011. Biofuels: The Best Response of Developing Countries to High Energy Prices? A Case Study for Malawi. Kiel Policy Brief No. 32.

[25] Lange, M., 2011. The GHG balance of biofuels taking into account land use change. Energy Policy, 39, p. 2373–2385.

[26] McDougall, R.,Golub, A. 2009. GTAP-E: A Revised Energy-Environmental Version of the GTAP Model. GTAP Research Memorandum No. 15.

[27] OECD, 2008. Economic assessment of biofuel support policies. (http://www.wilsoncenter.org/news/docs/brazil.oecd.biofuel.support.policy.pdf).

[28] Prins, A., B. Eickhout, M. Banse, H. van Meijl, W. Rienks, and G. Woltjer. 2011. Global impacts of European agricultural and biofuel policies. *Ecology and Society* **16**(1): 49. [online] URL: http://www.ecologyandsociety.org/vol16/iss1/art49/.

[29] Rosegrant, M.W., T. Zhu, S. Msangi and T. Sulser. 2008. "Global Scenarios for Biofuels: Impacts and Implications." Review of Agricultural Economics, 30(3): 495-505.

[30] Taheripour, F., Hertel, T. W., Tyner, W. E., Beckman, J. F. and Birur, D. K. 2010. Biofuels and their by-products: Global economic and environmental implications, *Biomass and Bioenergy* 34(3), 278-289.

[31] UCS (Union of Concerned Scientists), 2011. International Scientists and Economists Statement on Biofuels and Land Use - A letter to the European Commission. http://www.ucsusa.org/assets/documents/ global_warming/International-Scientists-and-Economists-Statement-on-Biofuels-and-Land-Use.pdf (12.12.2011)

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iFor a description of the calculation of feedstock specific ILUC emission factors see Laborde (2011) p. 23.-28.

iiThey expect the expansion into peatland to increase over time because there are not many other areas left for expansion. Different sources for different regions are cited which indicate rates that range from 25% of palm concessions on peatland in Indonesia up to 80% deforestation of forest on peatland in some regions.

iiiFor a detailed discussion of these EC Guidelines see Lange (2011).

ivA company can replace the default values by a process based detailed proof of the actual carbon balance.

vThe European Environmental Agency (EEA) concerned that this mechanism can even increase the LUC effect of the EU mandate if feedstock producers try to improve their carbon balance via the reduction of fertiliser inputs, the lion´s share of the cultivation emissions. They claim that with less fertilizer input, yields are reduced and thus, more land is needed to produce the same amount of energy (EEA 2011). However, this would only be the case if sustainability verification was built upon a track and trace system. With the mass balance system at hand, this effect is not going to occur, since feedstock input is not physically differentiated into feedstock for biofuel or food/feedstuff production within storage. For example, for a mill to have ¾ of its output certified, ¾ of the feedstock input needs to be certified as well at least over a certain time frame. However, the certificate is not physically connected to the biofuel feedstock harvest. Thus, farmers do not know during cultivation whether the harvest is used for biofuel production or other uses, and thus they do not have a prior incentive to reduce fertiliser inputs.

viBesides the influence of the increased threshold on LUC, in case biofuel producers choose an individual carbon accounting via certification scheme, an increased threshold sets incentives to reduce WTW emissions. This is necessary if the default WTW emissions are too high to make the biofuel option eligible automatically. When the individual carbon accounting is successful with respect to fulfilling the minimum emission saving threshold, these biofuel options contribute to a reduction of the carbon emissions of the target compared to a lower threshold. Even with possible emissions from ILUC it is more likely that the biofuel still contributes to climate mitigation when production emissions are low. This fosters the role of biofuels as a climate mitigation instrument; however, the LUC effect of the target stays the same.

viiThe EU-RED provides the default and typical values. The default values represent very conservative estimates in order to capture also less efficient production. They need to be used when no individual carbon accounting is realised in the certification process. The provided typical values serve only as an orientation about the potential result of individually calculated values.