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# Biofuel Policies and Indirect Land Use Change

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## Biofuel Policies and Indirect Land Use Change

The European Union sees the expansion of biomass production for bioenergy as one of the components of its strategy to replace fossil energy sources by non-fossil renewable sources. However, the target of 10% renewables in the transport sector by 2020 set in the Directive 2009/28/EC on the promotion of the use of energy from renewable sources (EU-RED) has been widely criticised. Due to an increase in biomass demand for feedstocks for biofuel production and a continuously high demand of the food and feed sector, the demand for land to be used for both food and production and bioenergy is expected to increase globally (see e.g. Hertl et al. 2008, Haberl et al. 2011). Considering that already today deforestation for agricultural expansion and for conversion into pasture, but also forest degradation, infrastructure development, destructive logging and fires cause nearly 20% of global GHG emissions (UN-REDD 2009), the contribution of biofuels to climate mitigation is at least questionable.

To ensure that biofuels contribute to GHG emission savings and that their overall sustainability is maintained, the EU-RED has put forward a sustainability regulation in order to avoid undesirable land use change (LUC) caused by expansion of bioenergy feedstock production. LUC effects must be differentiated into direct land use change (dLUC) and indirect land use change (iLUC).

DLUC refers to the direct conversion of before untouched areas into cropland for biofuel feedstock production. Through the sustainability criteria for dLUC in the EU-RED and the recent recognition of 7 certification schemes, of which some also are approved to control for dLUC in their sustainability assessments, an effective control for dLUC is implemented.

ILUC,is an external effect of the promotion of biofuels which occurs through price effects on the world market. As many biofuel feedstocks are cultivated on areas already in use for agricultural products, the area available for food and feed production is reduced. Consequently, this reduction in the supply of food and feed on world markets raise their prices, which create incentives to convert areas formerly not used for food production into agricultural land. This iLUC effect of the biofuel feedstock production comes about only through the price mechanism of the global or regional food market. In this context one could also view iLUC as dLUC caused by food production incentivised by cross-price effects of an increased production of biofuel feedstocks which then translates into an additional demand for so far unused land areas.

Lange (2011) shows that the control for dLUC according to the sustainability criteria of the EU-RED leads to an incentive—especially for the biofuel options from temperate regions—to grow biofuel feedstocks on land already in use for crop production. While this effectively avoids undesirable dLUC, it increases the iLUC effect of the overall biofuel mandate.

However, the question of how to treat iLUC is still unsolved. With a recently published letter to the European Commission (EC), several internationally recognised scientists refocused the attention of media to European biofuel policies by saying that "*without addressing land use change, European Union´s target for renewable energy in transport may fail to deliver genuine carbon savings in the real world".* The scientists state that "*current scientific understanding is sufficient to warrant immediate action"*, and that they urge the EC "*to align the EU biofuels policy with the best scientific knowledge and take into account emissions from indirect land use change*." (International Scientists and Economists Statement on Biofuels and Land Use 2011).

At the same time, a recently published study by Laborde (2011) commissioned by the European Commission to analyse the iLUC impact of the European biofuel mandate has fuelled a controversial discussion about the ability of economic models to display iLUC emissions. Several proposals have been put forward which try to more or less accurately take into account emissions caused by iLUC. However, they not only use different assumptions regarding the computations of iLUC, some of them—at least to our understanding—use methodologically misguided concepts.

Based on this discussion in this policy brief we discuss in which way a research-based analysis can contribute to concretise European policies on iLUC. We focus on the four policy options presented in the Report from the Commission on indirect land-use change related to biofuels and bioliquids (EC 2010) which will be the focus in the pending impact assessment for amending the EU-RED.

1. Take no action for the time being, while continuing to monitor
2. Increase the minimum greenhouse gas saving threshold for biofuels,
3. Attribute a quantity of greenhouse gas emissions to biofuels reflecting the estimated indirect land-use impact.
4. Introduce additional sustainability requirements on certain categories of bio-fuels.

We start with a discussion how iLUC could be reduced for the whole EU biofuel mandate by theoretically demonstrating the mechanism of the minimum emission saving threshold on the amount of land used to fulfil the mandate. In the next section, we shortly present the requirements to model iLUC, which is followed by a discussion on how model results can help to concretise iLUC policies. Finally, we relate modelling results to iLUC policy options of the EU and draw conclusions and policy advice.

## The Mechanism of the Emission Saving Threshold

Currently the EC requires a biofuel option to save at least 35% emissions compared to fossil fuels. That means that in the whole production process from the field to the tank including dLUC emissions, biofuels are not allowed to cause more emissions than 65% of the carbon content in fossil fuels. This 35% limit was chosen arbitrarily in the political process. A climate change mitigation impact, although a small one, would already be realised with only 1% emission savings and for energy security aspects an equal carbon balance of biofuels compared to fossil fuels would be sufficient.

In addition to the 35% rule, the EC has determined standardised default values for carbon emission for the whole production process and dLUC which represent a conservative estimate of the actual values.[1] Consequently, the required 35% emission savings combined with default values should be understood as a risk premium or safety belt that prevent biofuels from potentially violating the climate protection objective.

Since iLUC is not explicitly taken into account in these procedures the question is, 1) whether the 35% emission saving threshold is high enough to cover potential iLUC emissions, and 2) whether and how an increase of the threshold of 35% would influence on the iLUC emissions of different biofuel production pathways. We cannot answer the first question theoretically, and therefore come back to it when discussing results from numerical possible models.

In order to identify the influece of an increase in the minimum saving threshold, we first need to understand the mechanism of emission accounting in the EU-RED.

If no individual carbon accounting is performed within a certification process, the default values for the different production steps expressed in gCO2eq/MJ in the EU-RED are the hurdle to take. For required minimum emission savings at the current 35% level this means that a biofuel is not allowed to exceed ~54,5 gCO2eq/MJ emission in the whole prodution process including dLUC. Increasing the threshold implies that these maximum emissions in the production process are reduced. In the case that default values are used, an increase in the minimum emission savings would result in a reduction of the currently available biofuel options. Thus, increasing the threshold reduces the portfolio of feedstocks that can be used to fullfill the EU mandate.

This choice of eligible feedstock is determined by the feedstock's energy yields per hectar: obviously, if a biofuel is eligible for a higher emission saving threshold due to its default values, it causes low emissions within the whole production steps. An important share of the carbon balance along the process chain is contributed by feedstock cultivation emissions expressed in gCO2eq/MJ. They are determined in gCO2eq/ha expressing the fuel and fertilizer input needed per hectare to produce and harvest the feedstock. Thus, emissions can be reduced by producing more energy per ha, and thus by achieving higher energy yields per land unit (MJ/ha). Thus, a higher energy yield per hectare results in less CO2eq allocated to each MJ biofuel. Therefore, a reduction of the LUC impact of the EU biofuel mandate and thus the reduction of LUC emissions is only achieved when more energy per hectare is produced meaning using feedstocks with higher energy yields per hectare (MJ/ha).

[1] There are default emission values for each production step differentiated by crop in the EU-RED 2008 that can be used to determine the carbon balance of a particular biofuel production. A company can replace the default values by a process based detailed proof of the actual carbon balance.

According to this mechanism, an increased threshold would result in the fact that only those feedstocks with high energy productivity remain in the portfolio for the EU mandate. The same amount of energy would be produced with less land due to the use of crops with a high energy productivity, and thus LUC emission are reduced.

Producers of biofuels based on feedstocks which do not take the hurdle due to their high default values have the possibility to perform an individual carbon accounting. The European Environmental Agency (EEA) is concerned that this mechanism can even increase the LUC impact 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 fertiliser input, yields are reduced and thus, more land is needed to produce the same amount of energy (European Environment Agency Scientific Committee, 15 September 2011). This is only the case if sustainability verification were 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, but 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 an ex ante incentive to reduce fertiliser inputs.

After analysing the mechanism of the emisison saving threshold theoratically, the question remains whether economic models can help to evaluate how high the overall minimum emission saving threshold should be if the iLUC component were explicitly taken into account. To elaborate this question in the following section we discuss requirements for modelling iLUC.

## Modelling iLUC

The Laborde study cited above has given rise to a controversial discussion about the ability of economic models to display iLUC emissions.

ILUC is a global externality, which is driven by complex global market processes. Global market processes depend on global as well as regional demand and supply conditions, and also on regional support policies in the agricultural sector, local infrastructure conditions, and local markets as well as the geophysical suitability of areas for agricultural production. These factors simultaneously determine land use decisions. As a consequence, an appropriate causal attribution of the iLUC impact of the expansion of a particular feedstock for biofuels would require firstly, a site specific identification of which food and feed crop is replaced, secondly, an economic analysis of the global market responses to this replacement, and finally, a site specific identification of the areas of unused land that is converted into the production of the particular crop that has been replaced by biofuel feedstocks.

The Laborde study represents a sophisticated modelling approach in the field of CGE modelling. It gives important insides into the market mechanisms and direction of changes with respect to land use. Results clearly show that iLUC emissions are relevant even though the current modelling approaches are still subject to data shortcomings.

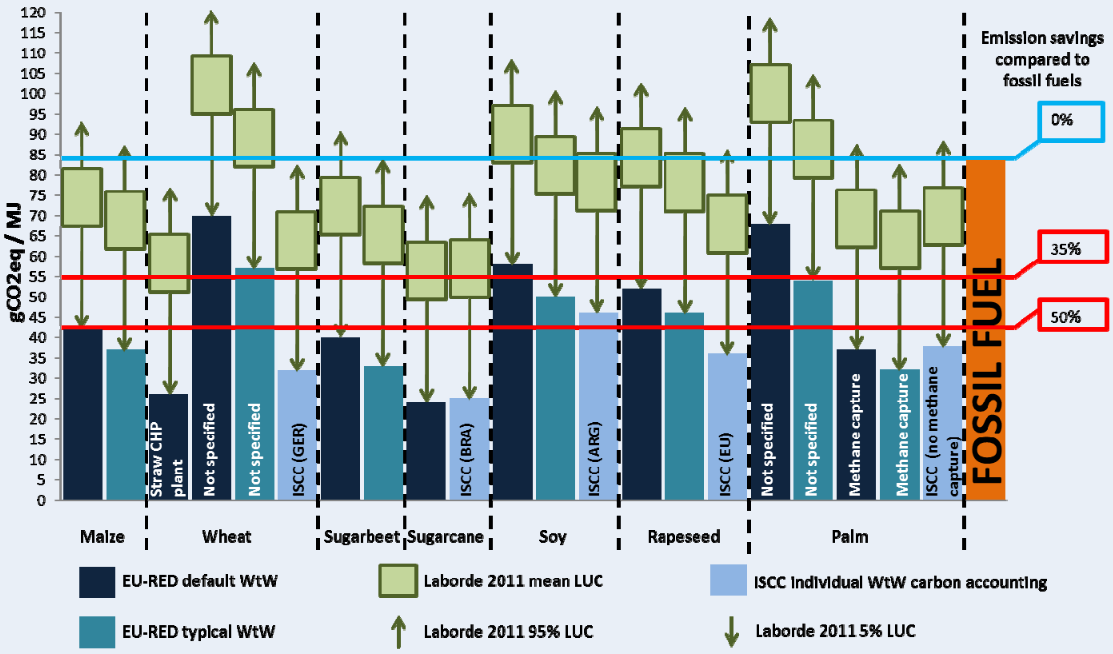
However, while the uncertainty range of results could be reduced by further research, due to generic shortcomings and assumptions made models will always produce an uncertainty range of results but not the one “true” iLUC factor. One of the major problems is the fact that models do not differentiate between dLUC and iLUC but only produce a total LUC factor. In addition, since markets clear simultaneously, land use change cannot be distinguished into crop specific effects. Having these problems in mind, in the next section we discuss how model results could nevertheless be helpful to evaluate iLUC policies if one assumes that the Laborde results come close to the real LUC emission values.

## Where to Put the Right Threshold? – Are Model Results of Any Help?

In the following section we discuss what models are able to contribute about the iLUC risk involved. Therefore, in figure 1 we compare carbon balances of different biofuel options with the respective fossil fuel emissions, using Laborde’s LUC data and different well to wheel (WtW) data.

Figure 1 shows resulting carbon balances in gCO2eq per MJ of different biofuel pathways. The dark blue bars represent WtW emission values 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 typical EU-RED WtW emission values. Furthermore, where available, we consider values calculated in practice by the biomass certification system ISCC (International Sustainability and Carbon Certification) that was recognized by the Commission to perform individual carbon accounting in order to verify compliance with the EU-RED criteria.

***Figure 1:***
**Full Carbon Balances of Different Biofuel Options**




***Source:*** **EU-RED (2008); Laborde (2011); ISCC.**

The green rectangle with the arrows represents iLUC emission values of the Laborde Monte Carlo study which he has performed to assess the uncertainty range of his LUC emission results. Here we assume that there are no dLUC emissions, which corresponds to assuming that all biofuel feedstocks are planted on areas already used for crop production. Due to the sustainability requirements concerning dLUC this assumption is quite realistic. Consequently, we assume that the whole LUC effect of the mandate is covered by the iLUC effect. It thus represents the worst case in terms of iLUC emissions.

Therefore, we use the average (and not crop specific) LUC emission value by Laborde and treat them as pure iLUC emissions. The lower arrow indicates the lower 5% percentile level, the lower arrow plus the rectangle the mean value and adding up the upper arrow represents the 95% percentile level of the Monte Carlo study. Thus, the upper arrow represents the upper range of the model results taking into account part of the uncertainty in model assumptions.

Figure 1 is to be interpreted in the following way:

The blue bar plus the green iLUC bar represents the total carbon balance of a certain biofuel including WTW and LUC emissions. These emissions need to be compared to fossil fuel emissions (orange bar) in order to elaborate whether the biofuel options still cause less emissions than the fossil alternative and thus contribute to climate mitigation. The value, in which fossil fuel emissions and biofuel carbon emissions are equal (83,8 gCO2eq/MJ fuel = 0% emission savings) is highlighted in figure 1 with a light blue line. Thus, if the whole bar (blue WtW part and green iLUC part) surpasses the blue line, the biofuel causes more emissions than the fossil alternative.

Therefore, a functional minimum emission saving threshold should rule out all biofuel options which, when considering a possible iLUC risk, exceed 83,8 gCO2eq/MJ (blue line) for the whole carbon balance in order to avoid options which are harmful to the climate. When one considers the Laborde LUC values a specific biofuel could cause WtW emissions without dLUC of 45,4 gCO2eq/MJ for the mean LUC value (and 33,4 gCO2eq/MJ for the 95% limit or 58,9 gCO2eq/MJ for the 5% limit respectfully) and then cause exactly as many emissions than contained in the fossil alternative.

In figure 1 two proposed emission saving thresholds are represented by red lines. Since minimum emission saving thresholds are only applied for dLUC and the process emissions, in figure 1 it is only the blue WtW bar that has to be compared to the red threshold line. We have included the current emission saving threshold of 35% and a possible increase to 50% in order to represent the risk of a larger iLUC. We come back again to this policy option in the next section. In order to be eligible under a certain threshold, the WtW bar of a biofuel must not exceed the respective red threshold line depending on which regulation will be adopted by the EU.

In the following section we discuss the four policy options of the EU concerning iLUC on the basis of the following intermediate conclusions:

- The range of model results indicates that if WtW emissions are sufficiently low, several biofuels actually contribute to climate mitigation even if direct and/or indirect land use change takes place.
- Increasing the threshold introduces incentives to become more efficient in the production process and to prove that in the certification process. In such cases default values would usually exclude such biofuel options.
- As models are not able to calculate a crop and location specific iLUC factor, the question which threshold is appropriate for making sure that producing biofuels without emission savings is unlikely to take place essentially depends on the risk that would be accepted for violating the positive GHG balance of certain biofuels. A risk adverse approach would suggest a high threshold.

## Analysis of Policy Options

Four options are discussed which try to take into account the impact of iLUC on the GHG balance of biofuels. The first option consists of staying at the 35% threshold under the presumption that the 35% is sufficient to take account of the iLUC effect. If this is not believed to be the case, an increase to 50% could be seen as option two. In the third option it is proposed to use model results that then can be integrated into the default values of the GHG balance. Finally, it has been suggested to use additional sustainability indicators in order to control iLUC. We discuss those in turn.

**Increase the minimum emission saving threshold to 50% or leave it at 35%**

With policy option 1, the threshold remains at the 35% level until 2017 and is then increased to 50%. Under policy option 2, the minimum emission saving threshold is increased to 50% at an earlier stage.

If the 35% emission saving threshold is maintained it would not capture all cases in which the overall GHG balance including LUC would be negative. According to the sum of the average LUC emissions as computed by Laborde and the default values of the EU-RED only sugar beet, sugar cane, and maize would have a positive GHG balance. However, the 35% threshold would not identify rapeseed as having a negative overall GHG balance. If instead the typical emissions values according to the EU-RED were used, biofuels based on palm without methane capture, rapeseed, soy, or wheat would meet the requirements under the 35% threshold despite having a negative GHG balance.

For the 50% emission saving threshold (option 2), under default values only bioethanol from wheat out of straw CHP (combined heat and power) plants, from sugar beet and from sugar cane would be eligible for certification. Palm oil from methane capture production would be the only eligible biodiesel option. Option 2 actually would be able to exclude all biofuel activities which show a negative overall GHG balance when the computed average LUC values are used.

Figure 1 also illustrates that the LUC emissions have a large variance such that the use of average LUC values may exclude some biofuels even though they may not show a negative GHG balance. Suppose we use the 5% confidence interval to illustrate whether the threshold might exclude some biofuels that possibly have a positive GHG balance. In this case only ethanol based on wheat under default WtW emission values and biodiesel based on palm without methane capture would actually show a negative balance. However, the 50% threshold would also exclude soy, rapeseed, and palm without methane capture from passing the threshold.

These results illustrate the role of risk when specific thresholds are chosen. The 50% threshold essentially makes sure that there is a high likelihood that in fact the biofuels that pass this threshold actually have a positive GHG balance. On the other hand, it excludes several biofuel options although they have some probability of showing a positive GHG balance. The 35% threshold, to the contrary, may accept some biofuel options that probably do not show a positive GHG balance. The choice between the two options therefore comes down to a choice between two errors, that of excluding some biofuel processes despite their showing a positive GHG balance and including some having a negative GHG balance.

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

The advantage of both options is that they build upon the sustainability regulation already in place, especially the certification schemes approved by the EC. Schemes like ISCC provide an individual carbon accounting along the supply chain which can be used to pass the thresholds and at the same time prove a positive overall GHG balance according to the available LUC emission values. Thus, if potential iLUC emissions should be implemented through an increased minimum emission saving threshold, such a regulation could be implemented immediately.

**ILUC Factor Based on Models**

The third policy option consists of adding an iLUC emission factor to the carbon balance of the different biofuel options which is based upon results derived from models that compute LUC. The mechanism of this approach is similar to the increase of the emissions saving threshold as in options 1 and 2. If iLUC emissions are added to the WtW carbon balance and the dLUC emissions several problems need to be resolved:

- The current models only compute LUC values and not iLUC, i.e. they can only identify the net effect of dLUC and iLUC. Hence, the computation of dLUC as done in the current GHG balance according to EU-RED would need to be dropped. Otherwise there would be a double counting of LUC emissions.
- If one could actually compute crop specific iLUC emissions there is strictly speaking no need for an emission saving threshold or at least for such a high threshold. Already the default emission factors of the EU-RED make sure that there is some safety built in the procedures against violating the carbon balance.
- Recent results of directly computed carbon balances within the certification process indicate that a well run biofuel process can have significantly lower emissions than suggested by the default values. As a consequence, there should be an incentive to actually perform a location specific carbon balance instead of relying on the default values.

In addition, the discussion about using crop specific iLUC factors (and not the average iLUC factor) is against the definition of iLUC as a global market effect where markets clear simultaneously. Thus, crop specific iLUC effects would introduce even more conceptual problems than the use of average LUC values.

**Introduce Additional Sustainability Requirements on Certain Categories of Biofuels**

Addressing the fourth option, additional sustainability criteria in the certification process can only be introduced about aspects concerning dLUC because only dLUC is directly related to a particular biofuel production process that is subject to a certification. As the dLUC criteria in place already result in a production of biofuel predominantly on land already in crop production, additional sustainability criteria will not change such choices of production areas. And, more importantly, they would not change the iLUC impacts since they do not reduce the pressure on crop land. In addition, sustainability criteria can not affect iLUC because they do not influence the price mechanisms for agricultural products on the world markets nor LUC decisions for crops other than biofuel feedstocks.

There is only one sustainability criterion that could influence the iLUC effect. If there were a requirement to allow feedstock production for biofuels only on degraded land, it would effectively eliminate iLUC. However, there is no consensus about the location, amount and productivity of degraded areas, hence such a rule could hardly implemented. Even if it could be established, it is doubtful whether production on such areas would be profitable.

## Conclusions

With current modelling approaches, it is impossible to calculate iLUC effects of different biofuel options. Even conceptually there is no way of causally linking iLUC to a particular biofuel activity. Nor can it be linked to a specific group of activities in a particular region or a particular feedstock. This is due to the fact that iLUC is driven by price effects on international markets which are themselves determined by the complex interplay of many market forces, on the supply as well as on the demand side. Allocating crop and region specific iLUC factors has therefore no defendable scientific or conceptual base.

We argue that an increase in the emission saving threshold is the only feasible and effective policy option of those currently under discussion. This would be equivalent to imposing a general iLUC emission factor on all biofuels. As a consequence, only the most efficient biofuel feedstocks in terms of emission savings could meet the sustainability requirement of the EU-RED. In this way the risk of allowing biofuels with a high risk of having an overall negative GHG balance would be avoided. However, decisions about the appropriate increase of the emission threshold depend on the desired probability with which biofuels with a potentially negative GHG balance will be kept out of the market and the probability with which it should be avoided that biofuels with a positive GHG balance are not allowed to enter the market.

We compute the WtW process emissions and add to those the emissions that are likely to come from the global LUC effects, i.e. dLUC and iLUC together, by using the Laborde model results. If the 35% threshold is maintained those biofuels that have the highest default WtW emissions and thus a likely negative overall carbon balance are effectively prohibited from entering the market. However, there are several biofuel pathways which would pass the 35% threshold but are still likely to have a negative carbon balance when iLUC emissions are added.

To the contrary, an increase of the threshold to 50% would make sure that no biofuel pathways with a negative carbon balance would enter the market. However, the results show that there is also in some cases a possibility that they would be prohibited from entering the market although they might have a positive carbon balance.

These results are computed with the help of the Laborde model results. It was shown that there can still be considerable improvement in the modelling of land use change. Both empirical parameters and assumptions about certain unknown parameters, but also the model architecture can be improved upon. This might change the size of the LUC effects in such models. However, it will not influence the fact that crop and region specific iLUC factors cannot be computed. The only way to really tackle iLUC is by requiring that all agricultural production becomes subject to sustainability assessments, especially a carbon balance. The problem of iLUC is only a problem of an incomplete carbon accounting of land use practices where only biofuel activities are subject to such an accounting, but food production and other bioenergy uses are neglected. If, in contrast, all land use practices (forestry, animal grazing, food, fodder and bioenergy production) were subject to a carbon accounting system, the burden of LUC would always be imposed on the activity that has replaced the previous type of land use. All considerations about accounting for iLUC would then become meaningless.

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