

## Biofuels: indirect land use change and climate impact - summary

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### Introduction

One of the main reasons cited for introduction of the mandatory 2020 target of 10% renewable energy (mainly biofuels) in Europe's road transport sector is the reduction of greenhouse gas emissions.

Until a few years ago biofuels were considered a robust option for reducing CO<sub>2</sub> emissions. The thinking went as follows. Biofuels displace fossil fuels, mainly oil, in the transport sector. Although biofuels have roughly the same tailpipe carbon emissions as fossil fuels, this carbon was previously absorbed from the atmosphere when the biofuel feedstock was grown. Net carbon emissions do occur, though, because biofuels production and feedstock cultivation require inputs in terms of fertilizer application, use of diesel for agricultural machinery, energy in processing the feedstock to fuels, etc. The use and/or production of these inputs generate greenhouse gas emissions, too. Overall, though, biofuels would by and large reduce emissions compared with fossil fuels.

It was largely this thinking that was reflected in the sustainability criteria for biofuels that were put in place in the renewable energy directive (RED). Among other things, the Directive requires that the greenhouse gas emissions associated with production and use of biofuels are at least 35% and from 2017 at least 50% lower than those associated with production and use of conventional petrol and diesel. The RED requires that the whole production chain from cultivation of the feedstock up to use of the biofuels is considered, including direct conversion of land to grow biofuels feedstock.

However, over the past few years much evidence has emerged that this thinking is only part of the story and that it does not capture the full climate impact of biofuels. In particular, the RED does not take into account the potential indirect effects of biofuels production. When biofuels are grown on existing arable land, indirect land use change (ILUC) will ensue, since current demand for food and animal feed will push these production activities into new areas such as forests or grasslands. Conversion of forest or grassland to agricultural land can lead to very significant releases of carbon to the atmosphere.

Studies show that emissions resulting from ILUC are so significant that they could sway the climate effects of biofuels from positive to negative, compared with fossil fuels. As yet, however, the most recent range of studies have not been systematically compared and summarized.

## Objective of this study

The objective of this study is to:

- Compile the available recent literature on ILUC emissions.
- Compare these emissions with the assumed gains of biofuels.
- Assess how ILUC changes the carbon balance of using biofuels.
- Formulate policies to avoid these extra emissions associated with ILUC.

## Trends in land use, with and without biofuels

All the studies on global agricultural markets reviewed predict that new arable land will be required to meet future global demand for food and feed.

Although there will be increased productivity on current arable land (intensification), food and feed demand will probably grow faster, which means that mobilization of new land is likely to occur. Biofuels produced from crops (the current mainstream practice) will add extra demand for crops like wheat, rice, maize, rapeseed and palm oil. This will increase prices for these crops (as well as for land) and lead to two impacts: intensification of agricultural production and conversion of forests and grasslands to arable land.

## Assessing indirect land use change from growing biofuels: two approaches

We identified two possible approaches to assessing the risks vis-à-vis ILUC-related GHG emissions due to biofuels.

The first approach is to use agro-economic models which simulate global agricultural markets, trade, intensification, possible crop replacements and so on. These models can predict the land use effect of using particular crops for biofuels. In this research project we compared the results of seven different modelling approaches (IIASA, LCFS, EPA, Banse, JRC AGLink, IFPRI GTAP and IFPRI FT). Although the results of the models differ (because of different assumptions) several clear general trends emerge:

- Extra intensification caused by higher commodity prices will reduce the ILUC effect of biofuels (if achieved without additional fertilizer input that leads to higher N<sub>2</sub>O emissions), but will not nullify it.
- For all crops the models predict a minimum, a maximum and an average ILUC effect.
- ILUC effects vary, depending on the type of biofuel and crop concerned, but in general for many crops an average effect of 60 gram CO<sub>2</sub>/MJ biofuel is indicated. This is roughly two-thirds of the total carbon footprint of petrol and diesel.

The second approach to examining ILUC is to adopt a 'one-for-one' strategy, whereby every extra hectare of land used for biofuels is assumed to lead to one hectare of grassland or forest being converted to new farmland. This approach leads to 'worst case' estimates of ILUC emissions, because gains from intensification as described above are ignored. The Dutch 'Corbey' advisory commission and the WGBU (German Advisory Council on Global Change) choose this option and arrive at a higher figure of 120 to 500 gram CO<sub>2</sub>/MJ biofuels for ILUC emissions (a correction of 140 to 590% points in the GHG emission calculation). This is roughly two to six times the carbon footprint of petrol and diesel.

## ILUC estimates

Table 1 summarizes the estimates of ILUC-related CO<sub>2</sub> emissions calculated with the seven selected models.



Table 1 CO<sub>2</sub> emissions due to ILUC, based on the models considered (Econometrica, E4tech, LCFS II, EPA, AGLINK, IIASA, IFPRI BAU, IFPRI FT), expressed as g CO<sub>2</sub>/MJ biofuel and percentage of carbon emissions of fuel replaced

|  | Highest value (1) | General value (2) | Average (3) | Highest value (1) | General value (2) | Average (3) |
|--|-------------------|-------------------|-------------|-------------------|-------------------|-------------|
| 1 <sup>st</sup> gen. ethanol           | 60                | 60                | 29          | 72%               | 72%               | 34%         |
| Sugar beet ethanol                     | 65                | 60                | 42          | 78%               | 72%               | 50%         |
| Wheat ethanol                          | 60                | 60                | 35          | 72%               | 72%               | 42%         |
| Maize ethanol                          | 79                | 60                | 55          | 94%               | 72%               | 65%         |
| Sugar cane ethanol                     | 69                | 60                | 38          | 82%               | 72%               | 45%         |
| 2 <sup>nd</sup> gen. ethanol, residues | 0                 | 0                 | 0           | 0%                | 0%                | 0%          |
| 2 <sup>nd</sup> gen. ethanol, crops    | ?                 | ?                 | ?           | ?                 | ?                 | ?           |
| 1 <sup>st</sup> gen. biodiesel         | 60                | 60                | 47          | 72%               | 72%               | 56%         |
| Rapeseed biodiesel                     | 60                | 60                | 36          | 72%               | 72%               | 43%         |
| Soybean biodiesel                      | 68                | 60                | 54          | 81%               | 72%               | 64%         |
| Sunflower biodiesel                    | 75                | 60                | 64          | 89%               | 72%               | 76%         |
| Palm oil biodiesel                     | 74                | 60                | 55          | 88%               | 72%               | 66%         |
| Waste oil biodiesel                    | 0                 | 0                 | 0           | 0%                | 0%                | 0%          |
| HFO Palm                               | 74                | 60                | 57          | 88%               | 72%               | 68%         |

Notes:

- Highest value: highest ILUC emission per MJ biofuel as calculated with the respective model.
- General value: indicative average ILUC emission factor of the ILUC emissions per MJ biofuel, averaged over all the biofuels considered.
- Average: arithmetic average of the ILUC emissions per MJ biofuel as calculated with the respective model, for a specific crop.

The ILUC effect of second generation crops is not predicted in the models considered and requires further evaluation.

### ILUC policies

We conclude that at the moment the only way to prevent ILUC is to introduce a so-called 'ILUC factor', i.e. an additional CO<sub>2</sub>/MJ figure, in the GHG rules for biofuels, with several clearly defined exemptions.

We see four possible approaches to an ILUC factor:

#### A: Minimum ILUC risk: Use maximum ILUC factors from models

To assure that any ILUC risk is eliminated, the maximum calculated ILUC factor from model calculations for the different individual crops can be taken as representative. This would mean an ILUC factor of between 60 and 79 gram CO<sub>2</sub>/MJ biofuel (72 tot 94% would then have to be added to the GHG calculation).

#### B: Low ILUC risk: Use an average and general ILUC factor

Using one or a selected number of models, an average ILUC factor for the complete biofuel policy target is estimated. Given the results of the simulations considered in this study, an average value of 60 gram CO<sub>2</sub>/MJ biofuel seems a good first estimate. Alternatively, an average factor for diesel substitutes and for petrol substitutes could be applied. In that case 60 gram CO<sub>2</sub>/MJ biodiesel and 40 gram CO<sub>2</sub>/MJ bio-ethanol (see Figure 7) could be applied as an initial estimate.



### **C: Medium ILUC risk: Use crop-specific average ILUC factors**

If a certain level of ILUC risk is deemed acceptable in biofuel policies and model simulations are considered sufficiently accurate, one could conclude that the average crop-specific ILUC emissions calculated with model simulation(s) are a reasonable prediction of the ILUC effect. This approach will lower the ILUC risk but will not completely eliminate it, because actual ILUC may be higher if the more pessimistic models prove to be more representative for real-world effects. With this approach the ILUC factor for the crops will be between 35 and 64 gram CO<sub>2</sub>/MJ, depending on the biofuel feedstock (42 to 76%).

### **D: Eliminate any ILUC risk: Do not apply model simulations but use a direct link between biofuels and land use**

If the model simulations are not considered sufficiently accurate, a 'risk adder' approach as suggested by the Dutch Corbey Commission or applied in the WBGU advice to the German government could be applied. These approaches are often intended as a stop-gap until more reliable models become available. As previously indicated, in these approaches a maximum-risk scenario is applied in which the basic assumption is that each hectare of land used to produce biofuels leads to conversion of one hectare of natural forest to new farmland. In the Corbey Advice, for the associated loss of carbon sinks a globally averaged factor is applied, 105 tonnes/ha (= 120 to 500 gram CO<sub>2</sub>/MJ biofuels).

### **Exceptions**

All four approaches to an ILUC factor require exemptions for:

1. Use of marginal, severely degraded or abandoned land which has not been used for food production in the last 5 years; in such cases only direct land use-related GHG emissions would need to be reported.
2. Intensification of production over and above the 2% per year required for food output (over an average period of 5 years); in such cases there would be an exemption for the additional yield.
3. Use of wastes and residues, as defined in the EU's waste framework directive and in compliance with the waste hierarchy defined in there. This means materials for which there is no alternative more beneficial use such as for material purposes or as soil improver.

A combination of the described approaches could potentially result in almost or completely ILUC-free biofuels for Europe, but this will require a substantial modification of current policies.

### **CO<sub>2</sub> emissions in 2020**

For 2020 the models predict a direct (i.e. excluding ILUC) GHG reduction for the EU biofuels programme of around 70 Mt CO<sub>2</sub> per year. With the maximum risk approach of the Corbey Commission, biofuel policies would lead to additional, ILUC-related emissions of approximately 270 Mt, hence a net extra emission of 200 Mt a year (the same as the annual emission of a country like Belgium). With the modelling approach (including extra intensification caused by higher prices) the ILUC effect is estimated as about the same as the direct gain and the net result of the policy on GHG emissions would be approximately zero.

To conclude, by properly accounting for the emissions associated with indirect land use change a real reduction of 70 Mt CO<sub>2</sub>-eq per year seems possible.

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