How to deal with indirect land-use change in the EU Renewable Energy Directive?

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Abstract

Greenhouse gas (GHG) emissions related to indirect land-use change (ILUC) for biofuels can be substantial, but there is and will be great uncertainty about the exact impact. The risk of an increase in greenhouse gas emissions is low if policymakers were to choose a high emission factor in the greenhouse gas balance, but this choice also would mean that no agricultural land could be used for growing biofuels. Even a relatively low emission factor could provide a barrier for many of the biofuels to enter the market.

Most biofuels with ILUC effects do not fit into a long-term perspective with an 80 to 95% reduction in greenhouse gas emissions. Other technical options, without ILUC effects, such as advanced biofuels and zero-emission vehicles, do. Especially for the last category the incentives in European policy can be strengthened.

This brief report was the reaction of PBL Netherlands Environmental Assessment Agency on the EU's Public consultation on indirect land use change and biofuels.

Introduction

As required by the EU Renewable Energy Directive (EU, 2009a) and the Fuel Quality Directive (EU, 2009b), by the end of the year the European Commission will submit a report to the European institutions, reviewing the impact of indirect land-use change (ILUC) on greenhouse gas (GHG) emissions and addressing ways to minimise that impact. In the build-up to the report, the European Commission has launched a public consultation seeking views of stakeholders and other interested parties. The issue especially draws the attention of scientific and business communities. Recently, various studies have been published on the impact of indirect land-use change and possible policy actions, both commissioned by the European Commission and initiated by other stakeholders.

The main role of the PBL Netherlands Environmental Assessment Agency is to support the policy process with information and assessments. In a series of reports, we have contributed to the debate on indirect land-use change by identifying the problem (Eickhout et al., 2008), framing the issue (Ros et al., 2010b) and elaborating scientifically on various aspects of this complex issue (Oorschot et al., 2010; Prins et al., 2010; Ros et al., 2010a; Stehfest et al., 2010). The objective of this brief report is to present background information for the policy decisions to be taken, as formulated in the consultation document, to address ILUC in the implementation of the EU Renewable Energy Directive.

The background information in this brief report especially deals with two aspects:
1. Incorporation of ILUC-emission factors in the calculation of greenhouse gas impacts of biofuels.
2. Stimulation of structural long-term technical options without ILUC effects.

1. ILUC emission factors in the greenhouse gas balance

An ILUC emission factor is fundamentally different from most other emission factors

An emission factor generally relates the emission of a specific substance linearly to the activity level from which the substance is emitted. The higher the production or the more a product is used, the higher the emission. Here, the emission factor is a characteristic of the process or the product. The producer or the user can be held responsible for these emissions. In many cases they have the opportunity and the means to reduce the emission factor.

The situation is different for emissions related to indirect land-use change (ILUC) that is caused by biofuel production. These emissions are the result of the dynamic interaction between the biofuel production chain and the global economic and physical system. The emissions depend on the state and development of these global systems in combination with the production process itself. In conclusion, ILUC emissions are not a characteristic of biofuel production alone. As such, there is no scientific ground for awarding a single value to the ILUC emission factor per specific biofuel.

Ranges of ILUC emission factors (in g CO_2 eq/MJ biofuel) for different types of biofuels from different world regions, based on a variety of studies* compared with maximum ILUC emission allowed in case of a 35% emission reduction target (direct + indirect emissions equal to 54 g CO_2 eq/MJ) **Table 1**

Type of biofuel	ILUC emission factor, based on several studies: Minimum values, Range (median)	ILUC emission factor, based on several studies: Maximum values, Range (median)	Default direct greenhouse gas emissions (RED)	Maximum ILUC emission permitted (35% reduction target for direct and ILUC emissions)
Biodiesel based on rapeseed from Europe	-33 -80 (22)	80-800 (180)	52	2
Biodiesel based on palm oil from South-East Asia	9-45 (19)	34-214 (160)	37**	17
Biodiesel based on soy from Latin America	13-67 (31)	75-1380 (196)	58	-4
Ethanol based on wheat from Europe	-79-37 (21)	-8-329 (154)	55***	-1
*Ethanol based on maize from Europe****	5-54 (22)	44-358 (68)	43****	11
Ethanol based on sugar cane from Latin America	6-48 (18)	19-95 (71)	24	30

* (ADEME, 2010; Al-Riffai et al., 2010; CARB, 2009a; CARB, 2009b; E4tech, 2010; JRC-IE, 2010; Overmars et al., submitted; Ros et al., 2010b)
** Process with methane capture at oil mill
*** Natural gas as process fuel in conventional boiler (ILUC figures from US cases)
**** Natural gas as process fuel in cogeneration plant

Global systems are complicated to describe in models, and predictions about the future are surrounded by uncertainty. However, these kinds of studies are not completely black boxes. Therefore, some conclusions can be drawn. Many studies show that ILUC emissions are very likely to be occurring. Some studies suggest these emissions are relatively low, others find very significant emissions, which in some cases are even higher than those from fossil fuels. Based on many studies with different approaches, the potential order of magnitude of ILUC emissions has been established. We present the results from a variety of studies in the form of a range (Table 1). This range is partly caused by a lack of scientific knowledge about the complex processes in the global system and partly caused by uncertainties surrounding future developments of this dynamic system.

Based on the nature of the system and the state of science in this field, any ILUC emission factor is ultimately a policy choice. How this policy choice is made depends on the various objectives that are at the basis of the policy.

ILUC policy as risk management

Because of the fundamental uncertainties about the effects, ILUC-related policy can be regarded as a form of risk management. The model results could be used to establish a policy factor for ILUC emissions as part of the sustainability criteria for biofuels. On the one hand, a low factor would carry the risk that the actual amount of greenhouse gases that is emitted indirectly is higher than this factor would suggest, while it would allow for a relatively high market potential of biofuels. A high factor, on the other hand, would carry the risk that a contribution from biofuels using agricultural land in order to realise the targets of the EU Renewable Energy Directive and the Fuel Quality Directive is low, but would prevent ILUC emissions quite effectively.

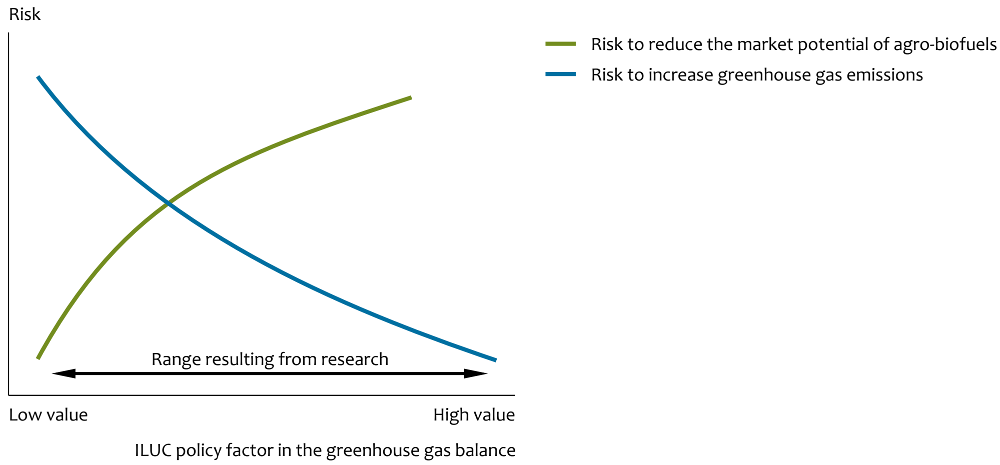
For our analysis, we assumed that the 35% reduction target applies to emissions from direct sources (as currently in the sustainability criteria) as well as indirect sources. It implies a maximum of 54 g CO_2-eq/MJ biofuel for direct plus indirect emissions. This assumption is not yet set in the criteria of the Renewable Energy Directive. Table 1 shows that if policymakers take a safe stance on greenhouse gas emissions by applying an emission factor that is near the average of the maximum values in the studies mentioned, an overall emission reduction target of 35% (including ILUC emissions) would provide a big barrier for biofuels being grown on agricultural land (see also Figure 1). Even the application of a relatively low emission factor (the average of the minimum values for indirect emissions found in the studies) would not fulfill the criteria for most biofuels, with the exception of sugar cane ethanol.

In case only a few of the biofuels grown on agricultural land would be accepted, their demand is likely to increase. Because ILUC emissions are not necessarily linearly related to biofuel use (IFPRI 2010), there is a risk that the ILUC effects of these biofuels will be different from those predicted in current model results.

Indirect land-use change cannot be monitored directly

It is impossible to directly relate the replacement of food crops by energy crops at a specific location to any form of land-use change elsewhere in this world. Therefore, indirect land-use change cannot be monitored directly. An assessment of past ILUC emissions could be made with the help of a series of monitoring data. Especially data on direct land use for biofuels (including the role of by-products) and data on land-use change in different world regions are important. However, to link these two types of data, important assumptions have to be made and models have to be used. Additional key data are: agricultural yields and their development in different world regions, and nitrogen use efficiency and its development in different world regions.

Balance between risk of greenhouse gas emissions and market potential of agro-biofuels **Figure 1**



A policy factor for indirect land-use change emissions in the greenhouse gas balance of the sustainability criteria: Risk management

Knowledge about indirect land-use change can be improved, but uncertainties will remain

As discussed above, indirect land-use change is an effect of the interaction between a (new) biofuel production chain and the complex and dynamic global economic and physical systems. An assessment of future ILUC emissions is done with the help of integrated modelling. These models vary from relatively simple ones that are used in combination with major assumptions on the process of interaction, to very complex models that include most of these interaction processes and, therefore, also include all of the related uncertainties.

In this context, it can be argued that there is a need for more research. The uncertainty about ILUC effects could be reduced, but substantial improvement of the models and the supporting monitoring systems is not easy, will take many years, and is unlikely to produce the perfect model. Furthermore, improvement of models does not take away uncertainties about future global developments. Consequently, ILUC emissions vary over time and between world regions.

Because the large range in the results from different model calculations is partly based on scenario assumptions, another way to reduce this range would be to take fixed values (i.e. on yields) to apply in model calculations of ILUC factors, carried out for policy reasons. Alternatively, an agreement could be made on using one model, instead of a fixed value. In fact, this approach lies in between the attempts to get a science-based emission factor and a policy that imposes a factor. However, general agreement on the most important assumptions, or the selection of a model, is a challenging process as well, and would subsequently become political.

Indirect land-use change has negative impact on biodiversity

Indirect land-use change implies a short-term loss of natural land. Even if biofuels from energy crops provide a net emission reduction and a long-term benefit in the form of reduced impact on climate change, it would take hundreds of years to compensate for the short-term losses (Oorschot et al., 2010) and some losses are irreversible. Therefore, these losses cannot be regarded as temporary. Stimulating options that exclude any ILUC effect would prevent this loss of biodiversity.

2. Stimulating technology options that will not result in ILUC emissions

Most biofuels that cause ILUC emissions do not fit into the long-term perspective

One of the important issues of sustainable development is to have an energy system that guarantees the supply of affordable energy without harming the environment, both in the short and long term. Innovations in the energy system are necessary to realise a goal of at least 80% reduction in greenhouse gas emissions by 2050.

Although not all sectors have the same potential for reducing emissions, they all should contribute substantially. Pursuing a reduction target of 80 to 95% is a good starting point for each sector, when exploring possibilities. With an expected increase in transport volumes, vehicle emissions have to be 5 to 30 g CO_2 eq/km by 2050. At present, average emissions from private passenger vehicles are about 160 g CO_2 eq/km.

What would be the long-term technological options for achieving such large emission cuts in road traffic? And to what extent is the use of biofuels that cause ILUC emissions unavoidable, in the transition time? There are many technical options available, the most promising for private passenger vehicles are listed in Table 2 (in practice plug-in hybrids are also possible, but they are a combination of the technologies mentioned).

In order to achieve large emission cuts in transport, a mix of technologies listed in Table 2 will be necessary. Inevitably, a sustainable transport system in 2050 will use high shares of low-emission biofuels, electric and/or fuel-cell vehicles. Some of these low-emission biofuels without an ILUC effect are

Indicative emission factors for passenger vehicles in 2050 (PBL assessments) **Table 2**

Technological option	Emission passenger vehicles (long term) g CO_2 eq/km (indicative target 5-30) Driving	Fuel production	Total
Hybrid vehicles on fossil fuels	70 – 90	5 – 10	75 – 100
Hybrid vehicles on biofuels from crops cultivated in Europe	70 – 90	30 – 60 * (CO_2 sink 70-90)	30 – 60
Hybrid vehicles on liquid biofuels or biogas from grasses obtained from low-quality land or residues and wastes	70 - 90	10 – 25 (CO_2 sink 70-90)	10 – 25
Electric vehicles	0	5 – 15 **	5 – 15
Fuel-cell vehicles on hydrogen	0	10 – 25 **	10 – 25

* ILUC emissions excluded;
** emission factor electricity 25-100 g CO_2/kWh; production H_2 is assumed to be based on electrolysis

To some extent, electricity and hydrogen could also be regarded as biofuels, if they are produced from biomass. Earlier studies already showed that the use of wood in the production of electricity on which electric vehicles are subsequently run, is more efficient than operating combustion engines on liquid fuel produced from the same wood (Eickhout et al., 2008). Biomass used in electricity or hydrogen production also requires sustainability criteria to prevent ILUC emissions.

already on the market: biodiesel based on waste oil or biogas based on household and industrial waste or manure. The potential supply of these low-emission biofuels is yet limited. Other such low-emission biofuels are still too costly; these are biofuels produced from agricultural and forest residues, grasses or wood cultivated on land not suitable for food production and with low ecological value.

At this moment electric and fuel-cell vehicles are costly technologies as well. These innovative technologies still need more development and market implementation for further cost reduction. Industries need a predictable and reliable policy framework that facilitates this transition process. In the context of the discussion on indirect land-use change, it is important that the ILUC emissions related to these technologies are low (see box) or even zero.

Current policy targets for 2020 not an optimal incentive for zero emission vehicles

What would be the best way to stimulate producers to bring these new technologies on the market? When policy formulates general targets or standards, the most cost-efficient options are likely to be chosen, in the short term. One of such options is the introduction of more fuel-efficient cars (especially for meeting the CO_2 standards for passenger vehicles). In itself, this is a good development but it does not stimulate a transition to innovative and clean transport technologies required to achieve large emission cuts by 2050.

The use of biofuels based on sugar, starch or vegetable oil appears a cost effective option for realising the targets in the EU Renewable Energy Directive and the Fuel Quality Directive. However, considerably high ILUC emissions over the coming decades make many of these traditional (first generation) biofuels less preferable, nor do they contribute to the transition towards an energy system required to make large emission cuts (see Table 2). The short-term introduction of high shares of first-generation biofuels creates new production chains and production volumes, which can form new barriers for the necessary, long-term system innovation. In the Renewable Energy Directive the most important incentive is that of counting the contribution of advanced biofuels twice, but there are no specific incentives for zero-emission vehicles.

A transition towards electric vehicles (EV or plug-in versions) or fuel-cell vehicles (FC) is more complicated than just substituting liquid fossil fuels by other energy carriers. Electric or hydrogen-powered driving requires not only suitable vehicles, but also new distribution systems and the clean production of electricity or hydrogen. This all takes time. In the short term, the contribution from electric or hydrogen-powered driving to a reduction in greenhouse gas emissions or to an increase in renewable energy will be limited because of this interdependence.

System innovation that requires new technologies in different parts of the system is not effectively stimulated, if the success of the introduction, in the short term, is also dependent on the simultaneous introduction of other technologies.

Suggestions for stronger incentives in the Directives

If the targets in the Renewable Energy Directive and the Fuel Quality Directive for 2020 are regarded as steps towards a long-term (2050) low-emission system innovation in road traffic, the impact of the Directives can be improved. There are a few options for stimulating system innovation under this existing legislation:

- In the Renewable Energy Directive, double counting of the preferred options – as is done for the preferred biofuels – can be extended to electric and fuel-cell vehicles (besides the factor of 2.5 in the directive, which is now to correct for the difference in energy efficiency for electric vehicles).
- In calculating of the contribution of electric and fuel-cell vehicles to the targets of the Directives, low values for the CO_2-emission factor per kWh and a high share of

Short-term results are more difficult to realise on a system level

Example 1: A share of 10% (kilometres driven) of electric vehicles, in combination with an emission under the present system of electricity production of 400 to 800 g CO_2 eq/kWh, would result in a reduction in greenhouse gas emissions from traffic of 0 to 5%.

Example 2: With an actual share of 10 to 40% of renewable electricity in most of the countries, the same 10% share of EVs would lead to a 1 to 4% share of renewable energy in traffic.

renewable electricity might be used that are based on long-term expectations of electricity production. In case a reduction of 80 to 95% in greenhouse gas emissions would be a policy target for traffic, the same reduction or even more could be expected in the production of electricity.

- A third option could be a specific target for the share of zero-emission vehicles.

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