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REVIEW OF EU'S IMPACT ASSESSMENT OF 10% BIOFUELS ON LAND USE CHANGE

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Content

Abstract

In the proposal for a Renewable Energy Directive, the Commission proposes a 10% target for renewable energy in the transport sector which is expected to consist mainly of biofuels. From the moment the proposal was made, an increasing number of parties have expressed their concern on the sustainability of this biofuel target with the main area of concern being the potential negative consequences of land use change (LUC). These potential consequences include the loss of biodiversity, significant greenhouse gas emissions as well as land tenure conflicts.

The proposal for a 10% target is based on several Impact Assessments that assess the environmental consequences of certain biofuel targets. However, as this paper shows, the Impact Assessments that lay at the base of the proposed 10% biofuel target do not permit a conclusion that such a 10% target will not cause significant negative consequences resulting from land use change. The main reasons for this are:

- ***The Impact Assessments do not analyse or recognize the land use effects outside the EU. Such land use requirements for biofuels outside the EU are likely because of:***
  - ***EU imports of biofuels and/or biofuel feedstocks***
  - ***Displacement of food/feed/material production from the EU to other regions as EU arable land will shift to biofuel feedstocks production.***
- ***The Impact Assessments conclude there is no need for additional sustainability criteria on indirect LUC. However, the reasoning behind this important conclusion is incorrect.***
- ***The Impact Assessments do analyse the likely land requirements within the EU for certain biofuel targets, but they do not analyse the GHG emissions from LUC, which will result from this and which could be significant. As LUC outside the EU is not considered at all, GHG emissions from LUC outside the EU have also not been include.***

These findings mean that it can not be concluded based on the Impact Assessments underlying the 10% target that a 10% biofuel target will not cause significant negative consequences resulting from land use change.
Furthermore our analysis on the outcomes of the Impact Assessments shows that about 50% of total LUC caused by a 10% biofuel target is likely to take place outside the EU.

How to read this report

As the Impact Assessment (IA) of the RED refers to several other papers for some parts of the actual impact assessment of a 10% biofuel target Chapter 1 first gives an overview of the most relevant papers and how they refer to each other.

Chapter 2 briefly reviews the IA's finding on the biomass potential and concludes that the sustainable biomass potential is indeed sufficient for a 10% biofuel target in 2020.

However, the fact that this sustainable biomass potential exists, does not mean that the market will fill in the 10% target with this sustainable potential. Chapter 3 therefore discusses the analyses made on the mix of biofuels and feedstocks that will enter the market in 2020 to achieve certain biofuel targets. It will be shown that while the analysis itself seems robust, the outcomes of the IA in terms of land use and land use change have not been used to assess the risk of LUC outside the EU.

While Chapter 3 will show that the IA omits to assess the risk of LUC outside the EU, Chapter 0 analyses the statements made in the IA on the need for additional criteria on indirect LUC. It will be shown that these statements are based on incorrect reasoning and that the risk of indirect LUC remains high.

Finally Chapter 5 discusses how the IA has come to the conclusion that the 10% biofuel target will lead to significant GHG emission savings and will show that this analysis does not take into account the emissions from LUC.

1 Overview of EU papers on biofuel target and its land use impacts

The actual assessment of the impacts of a 10% biofuel target is not fully included in the impact assessment which accompanies the proposal for a RED. In stead reference is made to several other documents, which in turn refer to other documents, etc. The figure below shows the main reports that are referred to for the proposed 10% biofuel target and how these documents refer to each other.

RED

Proposal for RED[1] | Impact assessment[2] | Annex to Impact Assessment[3]

- The documents do *not* analyse impact of 10% target but refer to Roadmap
- The Annex discusses the need for additional LU criteria for indirect land use change

↓

Roadmap

Renewable Energy Road Map[4] | Impact assessment[5]

- Documents assess the *feasibility* of 10% target in terms of biomass availability
- Documents argue for domestic production to prevent unwanted LUC -> disregards indirect LUC

↓

Biofuel Progress report 2006

Commission Staff working document accompanying Biofuels Progress report[6]

- Analysis of likely crop mix and land requirements in EU for 7 and 14% target
- Analysis of GHG benefits, *excluding emissions from LUC*
- No analysis of LUC outside EU as result of
  - Import of biofuel or biofuel feedstock
  - Displacement EU food/feed production

EEA study

EEA: How much Bioenergy can Europe produce without harming the environment?[7]

- *Potential* for sustainable EU biomass production.
- No analysis of LUC outside EU as result of
  - Import of biofuel or biofuel feedstock (this import potential was not included in the study)
  - Displacement EU food/feed production

DG-Agri

Impact Assessment of the Renewable Energy Roadmap[8]

- Analysis of likely crop mix and land requirements in EU for 10% target
- No analysis of LUC outside EU as result of
  - Import of biofuel or biofuel feedstock
  - Displacement EU food/feed production

References:
1) EC 2008a
2) EC 2008b
3) EC 2008c
4) EC 2006a
5) EC 2006b
6) EC 2006c
7) EEA 2006
8) EC 2007

2 Biomass potential

In two of the reviewed documents, an analysis is made of the biofuel production potential within the EU:

- The EEA study: How much biomass can Europe produce without harming the environment? (EEA 2006)
- The Impact Assessment accompanying the Renewable Energy Roadmap (EC 2006b).

In our opinion the assumptions made in these studies are in general realistic and take sustainability of production into account. We generally agree with the conclusion of these papers that there is sufficient *sustainable potential* to produce a significant amount of the 10% biofuel target within the EU, also if biomass demand for heat and power production is taken into account. However, while both studies assume part of EU agricultural land can be reoriented towards biofuel feedstock production, neither mentions the indirect LUC this may cause outside the EU. A more detailed discussion on the two papers can be found in the Annex.

While the sustainable *potential* does exist, its mere existence does not guarantee its utilisation. On the base of the sustainability criteria that will be set for biofuels in the EU, market players will decide how they fill in their targets and this will in turn determine what types of LUC will occur. In doing so, economics is likely to be their main driver, again, within the framework of the sustainability requirements for biofuels in the EU.

Therefore, in order to assess the risk of LUC from an EU 10% biofuel target, an estimation is needed of how the market will fill in the 10% target. Such an analysis has been done as part of the Impact Assessment of the 10% target and this analysis is reviewed in the next section.

3 Land use change within and *outside* the EU

The Annex to the biofuel progress report is referred to (indirectly) in the proposal for a RED and analyses the likely land requirements *within the EU* of a 7% and 14% biofuel target. In addition, the Impact Assessment of the 10% biofuel target performed by DG-Agri, also studies the likely land requirements within the EU. This latter study is not actually referred to directly or indirectly by the proposal for a RED, but it contains important findings and being a paper from the EU it has been included in this review nonetheless.

As with the biofuel potential studies, the two studies on the land requirements of a certain biofuel target generally build on plausible assumptions, although conversion efficiency numbers for Biomass to Liquid technologies were found to be very high in the biofuel progress report. Nonetheless, both studies give a useful overview of land requirements in the EU.

However, both studies contain insufficient information to draw a conclusion on the risks of land use change caused by a 10% biofuel target. Specifically the studies do not include:

- Analysis of LUC outside the EU as a result of:
    - Land requirements to produce biofuel feedstock for exports to the EU (either as biofuel feedstock or as biofuel). Both studies do find that part of the target will be met through imports.
    - Land requirements to compensate for a reduced production of food and feed in the EU as part of the arable land in the EU is shifted from food or feed production to biofuel feedstock production. These are the so called displacement effects.
- Analysis of the GHG effect of the LUC that results from the land use requirements, both inside and outside the EU.

In the following paragraphs, the main assumptions and outcomes of the two studies are summarised. Based on the outcomes an estimation will be made of the amount of land use change, both within the EU and outside the EU, that can be expected from the analysed biofuel targets.

3.1 Annex to Biofuel Progress Report: EU land requirements for 7% and 14% biofuels in 2020

In this study, the European Simulation Model (ESIM), used by the Commission for agricultural commodity projections and policy simulations, was used to estimate the mix of biofuels likely to enter the market if a 7% or 14% share is achieved.

Assumptions

The main assumptions used in this study are included in the table below.

Table 3-1 Main assumptions in land requirement analysis of 7% and 14% biofuel target in Annex to Biofuel Progress report.

Parameter	Assumption	Comment
Scope	EU-25	
Crop yield development	0.8% annual growth in yield	The report states: *"As in the past decade, technical progress in European agriculture will be used mainly to reduce costs and fertilizer use per ton produced rather than to increase yields per hectare."*
Fraction second generation biofuels	20% in 7% target 37% in 14% target	Fraction assumed to be equal for ethanol and biodiesel BTL from wood and straw Ethanol from straw only
Availability of straw for biofuels	15.5 Mtoe primary energy	This takes into account straw needed as natural soil improver. No source given, but matches well with (EEA 2006) which reports sustainable potential of solid agricultural residues of more than 20 Mtoe in EU-25 in 2020. This does imply that the heat and power sector would make only limited use of straw.
Biodiesel: ethanol	55:45	In line with forecasted ratio diesel: gasoline consumption in EU-27 in 2020
Feedstock mix biodiesel	Model outcome, with rapeseed > 50% Remainder from Palm and soy	For fuel quality reasons rapeseed was set at >50% in the study
Conversion efficiency second generation (energy basis)	Straw -> BTL = 48% based on energy content Straw -> ethanol = ?	Not given in report, but BTL yield calculated based on total straw availability (15.5 Mtoe) and total BTL produced from this (7.5 Mtoe). This seems high. Hamelinck (2004) reports yields of less than 30%. E4tech (2008) give yields of around 30% on energy basis
Imports	Model Outcome	

Results

The main results of the study are shown in the two tables below.

Table 3-2 Biofuel production (Mtoe) in different scenarios, taken from the Annex of Biofuel Progress report.

	7% share of biofuels	14% share of biofuels
Domestic production		
Biodiesel from rape	4.7	3.9
BTL from farmed wood	-	10.5
BTL from straw	2.5	0.5
ethanol from sugar beet	0.6	0.8
ethanol from wheat	5.6	11.2
ethanod from maize	1.3	1.5
cellulosic ethanol from straw	2.1	5.0
Imports		
rape for biodiesel	2.4	2.6
palm for biodiesel	0.4	2.9
soy for biodiesel	2.6	3.2
ethanol from sugar cane	0.8	0.9
Total	**23.1**	**43.1**
share of imports	23%	*22%*
share of diesel replacers	55%	*55%*
share of second-generation	20%	*37%*

Table 3-3 EU 25 arable land use in 2020 (million hectares), taken from the Annex of Biofuel Progress report.

	"no biofuel" scenario	7% share of biofuels	14% share of biofuels
rape for biodiesel	0	2.7	2.6
cereals for bioethanol	0	4.6	8.3
sugar beet for bioethanol	0	0.3	0.5
farmed wood for BTL [16]	0	0	6.9
TOTAL LAND FOR BIOFUEL PRODUCTION	0	7.6	18.3
non-biofuel arable production	87.6	84.8	80.8
idle arable land (set-aside)	10.8	7.7	3.4
TOTAL ARABLE LAND	98.4	100.1	102.5

An interesting aspect of this study is that it also studies the situation without biofuels. This allows for an actual comparison of this situation *without* biofuels to situations *with* biofuels. On the land use impacts of increasing the biofuel target the report concludes:

"This modelling work suggests that for each additional 1 million hectares needed in the EU to produce raw material for biofuels, land use will change as follows:

- *370 000 hectares of arable land will be re-orientated from exports to domestic production;*
- *400 000 hectares will be taken out of set-aside;*
- *220 000 hectares of land that would otherwise have fallen into other uses will remain in arable use."*

Answering the LUC question

The above LU results from the study together with the fraction of imports (outcome of the study), have been used to estimate the following critical parameters: *the amount of LUC* *that occurs both inside and outside the EU as a result of a 7% and 14% biofuel target compared to a situation without biofuels.* The results are show in the table below.

Table 3-4 Estimation of the differences in land use in both a 7% and 14% biofuel scenario compared to a situation without biofuels, based on the outcomes of the analysis made in the Annex to the biofuel progress report.

. **Cause of LUC**	**Type and location of LUC (ceteris paribus)**[1]	**Biofuel area in 7% target (Mha)**	**Biofuel area in 14% target (Mha)**
Area taken out of set-aside	Direct LUC in EU: set-aside -> productive cropland	3.1[2]	7.4
Additional area kept in production[3]	Direct LUC in EU: non-arable land -> cropland	1.7[4]	4.1
Imports[5]	(In)direct LUC outside EU: non arable land -> cropland	2.1	3.2
Area re-oriented from exports to domestic biofuel feedstock production[6]	Indirect LUC outside EU: non-arable land -> cropland	2.8	6.8
Total estimated LUC in EU		4.8	11.5
Total estimated LUC outside EU		4.9	10.0

Based on this analysis it is estimated that a 7% target will result in an additional 4.8 Mha of arable land in the EU and an additional 4.9 Mha of arable land outside the EU. For a 14% target the area within the EU increases to 11.5 Mha while the area outside the EU increases to 10.0 Mha.
The outcomes of this study therefore suggest that roughly half the land use change will occur within the EU and the other half will occur outside the EU.

3.2 DG-Agri: The impact of a minimum 10% obligation for biofuel use in the EU-27 in 2020 on agricultural markets

This study also uses ESIM as a model to estimates the feedstock mix used for a biofuel target: only it assesses the 10% biofuel target in stead of 7% and 14%. Again, the study only analyses the land requirements for feedstock production *within the EU*.

[1] This analysis assumes that in a scenario with biofuels, agricultural yields, food consumption, and internal losses in the food/feed production system are the same as in a scenario without biofuels. See final part of this section for more elaborate discussion on this assumption.
[2] See Table 3-3: Set-aside in scenario without biofuels (10.8 Mha) – set-aside area in scenario with 7% biofuels (7.7 Mha).
[3] Note that while this is not a LUC compared to today, it is a LUC compared to a scenario in 2020 without biofuels.
[4] See Table 3-3: Total arable land in scenario with 7% biofuels (100.1 Mha) - Total arable land in scenario without biofuels (98.4 Mha).
[5] Assuming a yield of 3 Mtoe per hectare. This is a rather high yield for European standards but can easily be achieved with oil palm and sugar cane in more tropical regions.
[6] For the displaced exports it is assumed that the land required outside the EU to produce this displaced amount, is equal to the amount of land that was needed for this in the EU. In other words, yields are assumed to be similar.

Assumptions

The main assumptions used in this study are included in the table below. The assumptions that are given are plausible although 30% second generation biofuels coincides with the 'high second generation scenario' in the scenarios analysed in the review of the 10% biofuel target in the UK of which this paper forms a part – see E4tech (2008). 30% second generation biofuels can thus be considered optimistic.
Details are not given on second generation feedstock types or conversion efficiencies.

Table 3-5 Main assumptions in land requirement analysis of a 10% EU biofuel target performed by DG-Agri (EC 2007).

Parameter	**Assumption**	**Comment**
Scope	EU-27	Inclusion of Romania and Bulgaria
Crop yield development	Cereals: 1% Oilseeds: almost 2% Sugar beet: slightly higher than 2%	Yields are assumed to continue their moderate path.
Fraction second generation biofuels	30%	Fraction assumed to be equal for ethanol and biodiesel BTL from wood and straw Ethanol from straw only
Availability of straw for biofuels	Not stated	
Biodiesel: ethanol	55:45	In line with forecasted ratio diesel: gasoline consumption in EU-27 in 2020
Feedstock mix biodiesel	Model outcome	
Conversion efficiency second generation (energy basis)	Not stated	
Imports	1st generation: model outcome 2nd generation: 25% (wood chips)	

Results

The results of the study in terms of the feedstock used to produce 10% biofuels in 2020 are shown in Figure 3-1 below.

Figure 3-1 Sources of feedstock for ethanol and biodiesel production in 2020 (Mtoe), taken from DG-Agri's impact assessment of a 10% biofuel target in 2020.

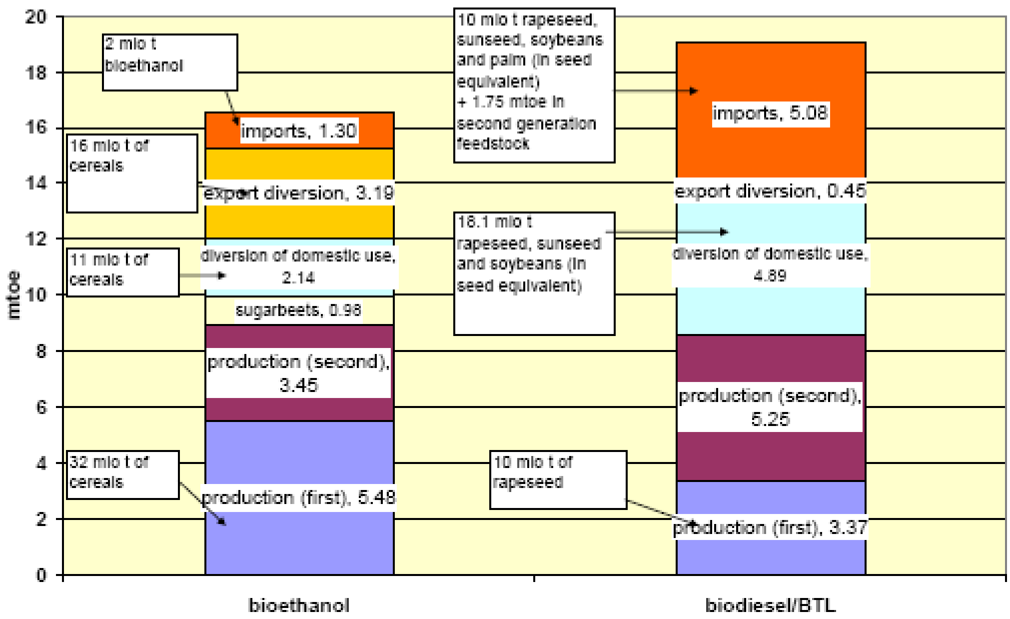

Table 3-6 EU land use under 10% biofuel target in the EU-27 in 2020 (Mha), taken from DG-Agri's impact assessment on a 10% biofuel target in 2020.

		2006		2020	
		1.2% share in total area		10% share in total area	
Area bioethanol		1.0	1%	12.9	11%
Area biodiesel		2.1	2%	4.6	4%
Total area biofuels		**3.1**	**3%**	**17.5**	**15%**
Cereal area		59	52%	62.5	55%
of which					
	bioethanol (1st gen.)	0.9	1%	7.1	6%
	bioethanol (2nd gen.)	n.a.		5.2	5%
oilseed area		8.8	8%	8.2	8%
of which					
	biodiesel (1st gen.)	2.1	2%	2.9	3%
BTL		n.a.		1.7	1%
sugar beets		1.9	2%	1.43	1%
of which					
	bioethanol	0.1	0%	0.6	1%
idle arable area	(idle + non used mandatory set aside)	7.2	6%	4.7	4%
Other		36.9	32%	36.6	32%
Total arable land		**113.8**	**100%**	**113.8**	**100%**
* including Bulgaria and Romania which joined during the campaign year 2006/2007					

After consultation with DG-Agri, we interpreted the results shown in
Table 3-6 as follows:

- "Export diversion" refers to products that were previously used for exports but are now used for domestic biofuel purposes.
- "Diversion of domestic use" refers to products that were previously used for other domestic purposes such as food and feed, which are now used for biofuel purposes. This causes a need for additional imports to cover EU food and feed demands.
- "Production first" is produced from additional feedstock production in the EU that have become available through either yield increases or taking into production of set-aside land.
- No feedstocks are mentioned for second generation biofuels but in the land use results, land use is included for BTL and we therefore assume BTL is produced from farmed wood in this study.
- For 2nd generation ethanol a cereal area of 5.2 Mha is mentioned. However, the ethanol is produced from straw which is considered a residue. We therefore did not include this area in the land requirements for biofuels.
- "Imports" clearly refers to imports of feedstock (biodiesel) or straight ethanol
- The totals in the results presented above add up to 35.58 Mtoe biofuels while the same document states that a 10% target requires only 34.6 Mtoe biofuels. The difference is caused by EU biofuel production for exports of 0.98 Mtoe. These should actually not be included in the analysis because they are not required for the EU biofuel target analysed. However DG-Agri kept this number in the results to reduce the complexity of the analysis. Because of the relative small amount of biofuels produced for exports and to avoid additional complexities we have not compensated for this.

Answering the LUC question

The study itself does not analyse the amount of LUC outside the EU that will occur as a result of a 10% biofuel target. Nonetheless, with the above interpretations, the results can be translated in an estimation of where the LUC takes place to produce these biofuels and whether this is a direct or an indirect LUC, see table below.

Table 3-7 Estimation of the % of biofuels causing land use change as a result of biofuel feedstock production which takes place within and outside the EU, based on (EC 2007).

Feedstock source	Type and location of LUC	Ethanol (Mtoe)	Biodiesel (Mtoe)	Total (Mtoe)	Total (%)
EU production first generation	Direct LUC within EU	5.48	3.37	8.85	26%
EU production second generation crops	Direct LUC within EU		5.25	5.25	15%
EU production second generation residues	Zero	3.45		3.45	10%
Imports first generation	(In)direct LUC outside EU: non-arable land -> cropland	1.3	3.33	4.63	13%
Imports second generation	Zero	0	1.75	1.75	5%
Export diversion	Indirect LUC outside EU	3.19	0.45	3.64	11%
Domestis use diversion	Indirect LUC outside EU	2.14	4.89	7.03	20%
Total		*15.56*	*19.04*	*34.6*	*100%*
Total from residues		*3.45*	*7*	*5.2*	*15%*
Total causing LUC (=ex residues)		*12.11*	*12.04*	*29.4*	*85%*
Total causing LUC inside EU		*5.48*	*3.37*	*14.1*	*41%*
Total causing LUC outside EU		*6.63*	*8.67*	*15.3*	*44%*

3.3 Conclusions and LUC implications

The table below compares the main assumptions and results of the two studies. It shows that most of the assumptions made in the two studies are comparable. One important difference is that the biofuel progress report is based on the EU-25, which may explain the relatively higher import shares compared to the DG-Agri study which is based on the EU-27[7]

The main conclusions that can be drawn in terms of LUC are:

- The results of both studies suggest that more than 80% of biofuels will be produced from energy crops, with less than 20% from residues.
- Furthermore, our analysis of the share of imports and diversion of existing EU-production to biofuels suggests that more than half the biofuel production from energy crops will lead to LUC outside the EU.

Table 3-8 Comparison of main assumptions and conclusions drawn from the results of the studies performed by DG-Agri and the Biofuel progress report on how certain biofuel targets will be met.

	DG-Agri	**Biofuel progress report (7% target)**	**(14% target)**
Model	ESIM	ESIM	ESIM
Main assumptions			
Target	10%	7%	14%
Scope	EU-27	EU-25	
Annual yield increase in agriculture	0.8%	1-2%	
Fraction second generation biofuels	30%	20%	37%
Availability of straw for biofuels	Not stated	15 Mtoe	
Biodiesel: ethanol	55:45	55:45	
Feedstock mix biodiesel	Model outcome	Model outcome	
Conversion efficiency second generation (energy basis)	Not stated	BTL: 48% Ethanol: ?	
Main conclusions drawn from results			
Imports (% of total EU consumed biofuels)	18.4%	27%	22%
Land required within EU (Mha)	17.5	7.6	18.6
% of biofuel causing LUC (ex residues)	85%	80%[8]	87%
% of biofuel causing LUC outside EU	44%	47%[9]	52%

[7] The EU-27 includes both Romania and Bulgaria which

[8] This excludes biofuels from residues as these do not cause LUC: ethanol from straw and BTL from straw. In the 14% scenario, BTL is partly produced from farmed wood, which also requires land. BTL from farmed wood is therefore included in this number.

[9] This consists of:

- 27% imports which do not include residues and thus cause LUC
- 37% of the fraction that is grown on EU arable land. The fraction grown on EU arable land is equal to: 100% - 27% (imports) – 20% (residues). The 37% refers to the statement in the report that for each 1 Mha needed in the EU to produce biofuel feedstock, 370.000 ha will be reoriented from exports to domestic production.

4 Will indirect LUC occur on a large scale?

The Annex to the RED-IA argues that indirect LUC is unlikely to occur on a large scale and that therefore no additional land use criteria are needed. In the words of the report:

> "*Some commentators imply that each hectare of land devoted to the cultivation of crops for the biofuel market will have to be offset by finding a hectare of land, somewhere else, to produce the food that would (it is suggested) otherwise have been produced on the biofuel-producing land.*
> *However, citing the UN Food and Agricultural Organisation, "Yield increases and increased cropping intensity but not arable land expansion form the lion's share of sources of growth in LDC crop production from 1960 to 2005, and are expected to dominate growth from 2005 to 2030." There is a clear link between demand for agricultural commodities, their prices, investment in agriculture and agricultural productivity. Thus, it can be expected that the main impact of increased biofuel demand will be a further increase in productivity, not an increase in the quantity of land used for agriculture.*"

It is indeed true that most increase in crop production stems from increasing yields as well as increasing intensity (e.g. shorter fallow periods and double cropping). However, these sources of production growth alone have not been enough in the past to keep up with increases in demand and expansion of agricultural land has been necessary. Also for the period 2007-2020 WoodMackenzie (Patridge 2008) predicts an expansion of arable land in addition to continuing yield increases. In a less recent outlook the OECD/FAO predicted that in the period 1997-99 to 2030, arable land will expand by 120 Mha in developing countries, more than 80% of which is expected to take place in sub-Saharan Africa and Latin America (OECD/FAO 2002).

The point is that additional production from 'normal' yield increases is already consumed by the growth in demand in traditional markets (e.g. food and feed) and an expansion of arable land is already needed to meet the growing demand of these traditional markets. Ceteris paribus, any *additional* demand from biofuels will therefore come from a further expansion of arable land.

However, there are three possible reasons why an additional demand from biofuels would *not* lead to a (further) increase in arable land:

1. The *additional* demand for biofuels leads to *additional* yield increases.
2. The *additional* demand for biofuels leads to *less* consumption in other markets (e.g. food and feed).
3. The *additional* demand for biofuels leads to a more efficient system in which less is wasted in the supply chain before it reaches its point of consumption.

While all three are possible in theory, the RED-IA does not make plausible any of these three options. The document does *state* that there is a clear link between demand, prices and productivity, thereby effectively arguing that the additional demand for biofuels will lead to additional yield increases. While this is possible in theory, no proof is given for this and the very same point is actually contradicted in the one document which forms the heart of the Impact Assessment of a 10% biofuel target: the document accompanying the biofuel progress report in 2006. In its Impact Assessment of a 7% and 14% biofuel target it states:

> *"Despite price increases for agricultural commodities, the intensity of agricultural production per hectare is not forecast to vary significantly between the scenarios. The main reason is that farmers are modelled as maximising profit, not yields. This leads to a careful scrutiny of the value of the inputs that can be used to increase yields, and an optimisation of their use.* "

Furthermore, Searchinger et al (2008a) conclude that "*studies of the impact of higher prices on crop yields generally conclude that the impact is small*. [….] *Because of these studies the Economic Research Service of the U.S. Department of Agriculture incorporates low yield elasticity responses to prices (Lin et al. 2000)."*

The possibility that biofuels lead to less food consumption through higher food prices may be more realistic. But the desirability of this effect can be debated from a food security point of view. Furthermore, food has a very low price-elasticity and the effect of reduced food consumption is very small compared to the additional biofuel feedstock demand (Searchinger 2008b).

In summary there is little evidence that higher prices of agricultural commodities, caused by biofuel demand, will lead to sufficient yield increases needed to prevent an further expansion of arable land. Furthermore, neither the effects of biofuels on reduced food consumption or the effects of biofuels on losses in the supply chain have been made plausible by the impact assessment of a 10% biofuel target. While this does not prove that displacement effects are likely, it does prove that *it is currently not possible to conclude with reasonable certainty that displacement effects are unlikely to occur*.

5 GHG-emissions from land use change

Of all papers reviewed for this study the GHG-emission savings from biofuels are only studied in the Annex to the biofuel progress report.

On the GHG emission savings from biofuels, the roadmap document refers to the impact assessment done on a 7% and 14% biofuel target in the Annex of the biofuel progress report. It concludes that both targets will have a positive GHG effect and that the positive effects of a 14% target are larger than those of a 7% target.

However, the Annex of the biofuel progress report explicitly states that GHG emissions from LUC can be large but have not been taken into account. It can therefore *not* be concluded that the impact of biofuels in GHG-emissions, including LUC, will be positive.

In short the conclusion made in the roadmap that the GHG emissions savings from biofuels will be positive is premature as it does not include GHG emissions from LUC.

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Annex A Reviewed biomass potential studies

A.1 EEA: How much Bioenergy can Europe produce without harming the environment?

This study analysed the sustainable biomass potential of the EU-25 up until 2030.

Sustainability

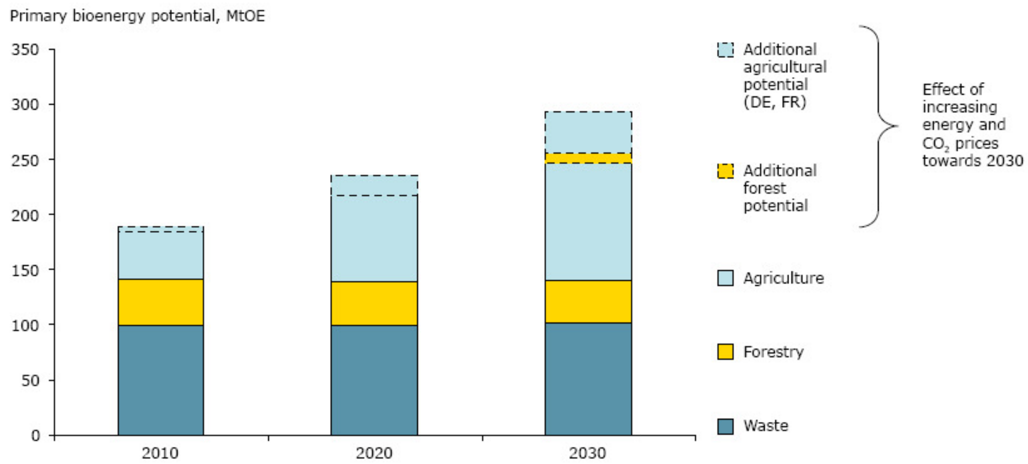
Sustainability has been incorporated in the study through inclusion of criteria, see Box A-1.

Box A-1 Environmental assumptions used in the EEA study.

- At least 30 % of the agricultural land is dedicated to 'environmentally-oriented farming' in 2030 in every Member State (except for Belgium, Luxembourg, Malta, the Netherlands, where 20 % was assumed).
- Extensively cultivated agricultural areas are maintained: grassland, olive groves and dehesas are not transformed into arable land.
- Approximately 3 % of the intensively cultivated agricultural land is set aside for establishing ecological compensation areas by 2030.
- Bioenergy crops with low environmental pressures are used.
- Current protected forest areas are maintained; residue removal or complementary fellings are excluded in these areas.
- The forest residue removal rate is adapted to local site suitability. Foliage and roots are not removed at all.
- Complementary fellings are restricted by an increased share of protected forest areas and deadwood.
- Ambitious waste minimisation strategies are applied.

Biomass potential

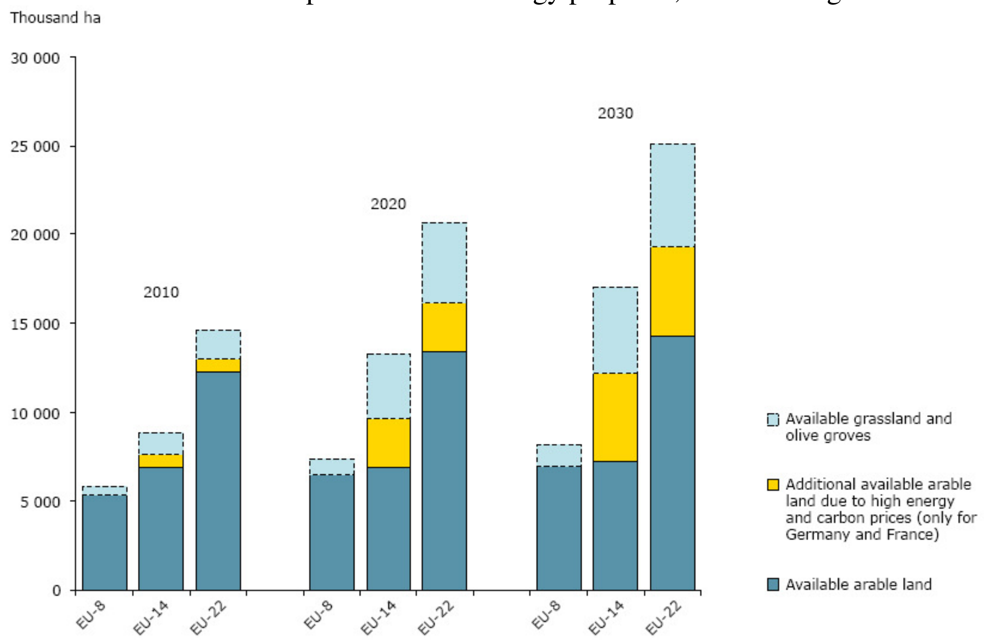
The study distinguishes the potential from three sectors, as shown in Figure A-5-1 below. The environmentally compatible primary biomass potential increases from around 190 Mtoe in 2010 to around 295 Mtoe in 2030.



Note: The agricultural potential comprises dedicated bioenergy crops plus cuttings from grassland and was calculated for EU-25 without Cyprus, Luxembourg and Malta. Agricultural residues, such as straw and manures, are included in the category 'waste' (covering all EU-25 Member States). The forestry potential was calculated for EU-25 except Cyprus, Greece, Luxembourg and Malta. It consists of residues from fellings and complementary fellings. The additional forestry potential takes into account the reductions in the black liquor potential as a result of wood redirected from pulp and paper to energy production. It strongly depends on the assumed carbon permit and oil price. The additional agricultural potential due to higher prices paid for bioenergy was modeled only for Germany (DE), France (FR).

Figure A-5-1 Environmentally compatible bioenergy potential in the EU. Taken from (EEA 2006).

As most biofuels in 2020 are expected to be produced from energy crops this review has focussed on the agricultural potential. This is largely determined by the amount of available land for biomass production for energy purposes, shown in Figure A-5-2 below.



Note: No data for Cyprus, Luxembourg and Malta. The additional available land due to bioenergy prices being above the food commodity prices was calculated for Germany and France with the HEKTOR model. For all other countries, the available land area was calculated with the CAPSIM model.

Figure A-5-2 Land available for biomass production for energy. Taken from EEA (2006).

Excluding available grassland and olive groves the study finds that the environmentally compatible available arable land increases from 13 million ha in 2010 to 19.3 million ha in 2030. However, the study does not analyse the direct and indirect land use change that results from the utilisation of this land for bioenergy purposes.

Based on the report and additional consultation with the authors we draw the following conclusions with respect to land use change:

1. The largest category is "available arable land", blue in Figure A-5-2. This category consists of three subcategories:
   - Set-aside land
   - Land taken out of food/feed production as a result of CAP-reform.
   - Land made available through yield increases

   The authors of the report were not able in the short time available for this review to indicate the size of each of these three subcategories. However, a large part of the 12.5 million ha 'available arable land' in 2010 must stem from CAP-reform as at the time of the study the amount of set-aside land amounted to 3.9 million ha (EC 2007), and the potential for yield increases between 2006 and 2010 is limited.

   In terms of LUC, land freed up in the EU because of CAP-reform is likely to lead to an indirect LUC as the decline in food/feed production in the EU will need to be compensated outside the EU. An important point here is that it is the CAP-reform which drives this indirect LUC, not the bioenergy market.

   Taking into production land from set-aside and land freed up from yield increases does not displace EU-production but leads to a direct LUC within the EU. The environmental and GHG-effects of such a LUC will depend strongly on the choice of crop and agricultural practices.
2. The category 'additional available arable land due to high energy and carbon prices (only for Germany and France)', yellow in Figure A-5-2, is formed by land which is reoriented from food/feed production to energy crop production.

   In terms of LUC this potential also displaces existing EU food/feed production and will therefore also lead to indirect LUC outside the EU. As opposed to indirect LUC caused by the CAP reform, this displacement effect and indirect LUC is caused by the bioenergy/carbon-market.

In summary, while the environmentally compatible agricultural potential may indeed exist in the EU as found by the study, a significant part of the future available EU-land for energy crop cultivation will displace existing EU-food/feed production. This displacement effect is likely to lead to indirect LUC outside the EU. However, it must be noted that a large part of the potential found by the study is a result of anticipated CAP-reform: in this case it is not bioenergy which is driving the displacement effect but the CAP-reform. On the other hand, the bioenergy market can be held responsible for the indirect LUC caused by European farmers switching from food/feed production to bioenergy crop production as a result of higher energy and carbon prices. Especially in 2030 this makes up a significant part of the total potential of 19.3 million ha, see Figure A-5-2.

A.2 The Impact Assessment accompanying the Renewable Energy Roadmap

The IA accompanying the Renewable Energy Roadmap (EC 2006b), also states numbers on the EU-biomass potential. The numbers stated in this document are shown in Figure A-3 below. These numbers are taken from the Forrest 2020 study (Ragwitz M. et. al. (2005). The Forrest 2020 study analyses the renewable energy supply potential for the EU. However this study is outside the scope of this review and the numbers have therefore not been reviewed within the scope of this review.

From a comparison with EEA (2006) it appears that the total biomass potential coincides well but large differences do exist between the different categories. EEA (2006) finds an agricultural potential (excluding residues) of more than 100 Mtoe in 2020 compared to around 75 Mtoe in Forrest 2020. For the forestry sector EEA (2006) finds a total potential of around 55Mtoe in 2020 compared to about 100 Mtoe in Forrest 2020.

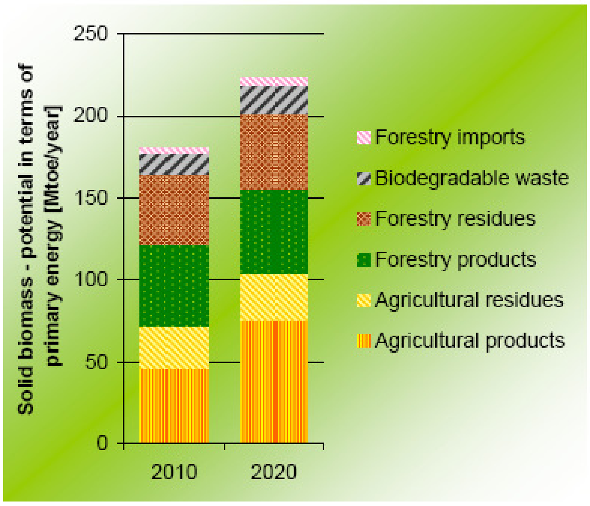


Figure A-3 Biomass potential as stated in the impact assessment accompanying the Renewable Energy Roadmap (EC 2006b).