Marginal land use changes for varying biofuels volumes

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Authors:
Harry Croezen
Geert Bergsma
Matthijs Otten

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Contents

Summary and introduction

General conclusions from studied information

The main conclusions drawn from the studied literature sources considered in this project are:

- The probable range of biofuels that will be applied in 2020 will probably consist of:
    - 6 – 8 Mtoe/a ethanol produced from primary agro commodities;
    - 7 – 13 Mtoe/a of waste based biofuels and renewable electricity (weighted contributions)
    - 12 – 18 Mtoe/a of biodiesel produced from primary agro commodities.

  Imports of biofuels will probably be limited to 2 Mtoe/a of bio-ethanol, 1.5 – 2.5 Mtoe of palm oil for HVO production and several Mtoe's/a of soy biodiesel and rape seed.
  Most of the ILUC studies commissioned by the EU consider a different mix.
- The probable range of the biofuels (and renewable electricity) mix will yield a GHG emission reduction of 6 – 17 Mtons CO2-eq/a. This reduction comes mainly from utilization of waste based biofuels and renewable electricity and to a lesser extent from sugar cane and cereals based bio-ethanol.
- In contrast, the utilization of oilseeds based biodiesel will probably give a net increase in GHG emissions due to indirect land use change related emissions of greenhouse gases.

Policy conclusions: feedstock specific policies and simulations for adjusted biofuel mix compositions

In the EU consultation document two questions – question 1 and 3 – in particular touch the contents of this report.

Considered biofuels mixes

Given the findings of this report our conclusion concerning question 1 would be that apart from the AGLINK simulation conducted by JRC-IES the four studies commissioned by the EU consider biofuels mixes with compositions and total volumes that significantly deviate from the prognosis given in the NAP's and in other literature sources.
It would be beneficial if the different computer model simulations for estimating the scale of ILUC related GHG emissions would be redone with a biofuels mix that is more in line with the probable ranges of the biofuels mix that will be applied in 2020.

Conclusions with respect to feedstock types

Considering the third question, the EU reports allow for conclusions with respect to feedstock type – if the biofuels specific ILUC emission factors given in IFPRI (2010) are considered credible.

The reports clearly indicate that waste derived biofuels and bio-ethanol from sugar crops (and renewable electricity) give a net GHG emission reduction, while utilization of oilseeds based biodiesel will probably cause an increase in

GHG emissions because of induced indirect land use changes. Cereals based bio-ethanol probably give a small reduction of greenhouse gas emissions.

In line with this conclusion, the EU might define separate ILUC factors for these three different categories of biofuels:

- Nil for waste derived biofuels – as long as the feedstock is truly waste[1];
- 15 – 20 g/MJ for bio-ethanol from sugar crops;
- ± 40 g/MJ for cereals based 1st generation based bio-ethanol;
- ± 60 g/MJ for 1st generation biodiesel – which will be primarily be soy and rape seed biodiesel.

The above conclusion could be a guide for adjusting EU biofuels policy and further specify this policy.
The EU might follow the example of the Swedish government who's biofuels policy focuses on utilization of biogas, bio-ethanol and waste based diesel substitutes such as DME and HVO produced from chemical pulp production by-products. Within this focus, the Swedish government stimulates penetration of flexfuel cars and the development of the infrastructure required for distribution of these fuels.
The ambitions concerning the role of 1st generation biodiesel in the 2020 biofuels mix will probably have to be reduced, not only in view of the anticipated ILUC emissions, but also because of the uncertainty if enough feedstock can be made available in the EU and on the global oilseeds market to realize the projected 1st generation biofuels volumes.

[1] This for example does not apply to tallow, a high value by-product of meat processing that competes with palm oil and palm kernel oil.

1 The fuel mix considered in IFPRI and other EU commissioned ILUC related repo

1.1 The overall figures

In Table 1 the volumes and compositions of the EU 2020 biofuels mix estimated in two authoritative ILUC studies commissioned by the EU are compared with biofuels mix volume and composition as estimated by EU member states in their National Action Plans (NAP's)

Table 1 Overview of prognosed and estimated biofuels mix volumes and compositions for 2020 (all figures in Mtoe/a)

	NAP's d.d. 1 Octobre	AGLINK	IFPRI BAU 5.6%	IFPRI FT 5.6%	IFPRI BAU 8.6%
Biofuels (Mtoe) consumption EU					
ethanol	6,1	7,9	8,0	8,0	13,4
- 1st gen EU	*3,9*	4,2	2,2	0,4	3,4
- imports	*1,8*	2,0	5,8	7,6	10,0
- waste based	*0,4*	*1,7*			
- 2nd gen EU					
biodiesel	18,7	20,7	9,8	9,8	13,8
- 1st gen EU	*11,8*	14,4	9,0	9,8	
- imports	*5,6*	2,9	0,8	0,0	
- waste based	*1,4*	*3,3*			
- FT diesel					
Hydrogen	0,0				
Electricity in rail	2,3				
Renewable elecricity in road transport	0,6				
Other (biogas, DME, .. ?)	0,6				
- biogas					
- HVO					
- methanol/DME					
Total weighted amount (second generation and waste counts double)	31,6	33,5	17,8	17,8	27,2

The presented figures are discussed in some detail below. Background information can be found in the appendices to this report.

1.2 Total volumes and biofuel mix composition

IFPRI study

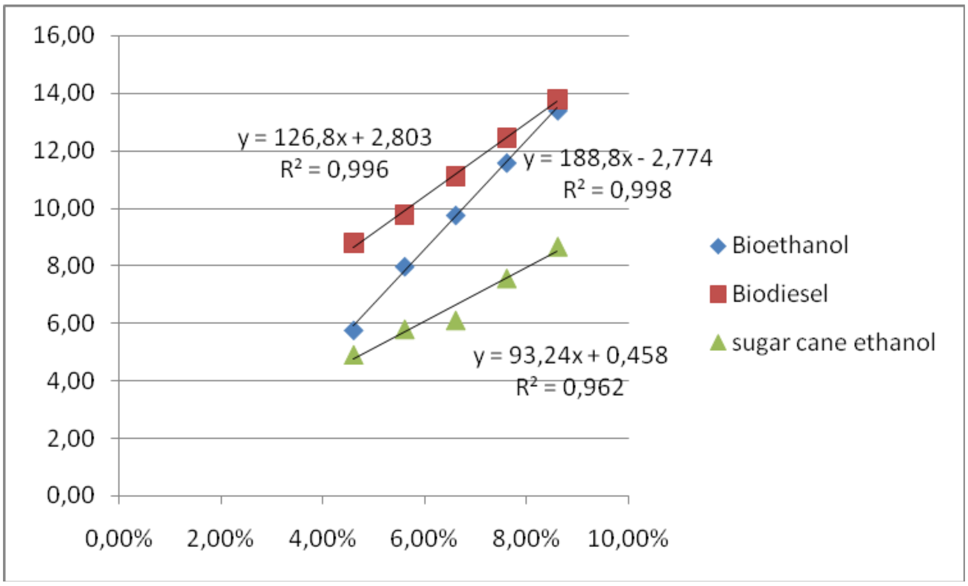
In the IFPRI study a 5.6% mandatory blending level (17.8 Mtoe) for 1st generation land requiring biofuels is considered, assuming a 45-55% split between bio-ethanol and biodiesel. Non land-using first generation biofuels such as recycled waste oil and animal fats are not included.
The 5.6% level is estimated as a function of the trade policy applied by the EU with regard to biofuels imports, for two different scenarios:

- a scenario based on current policy;
- a free trade policy .

An 7.6% scenario and an 8.6% scenario are analyzed in the sensitivity analysis. These could be considered as comparable with the other estimates, prognoses and simulation results presented in the table. The split between biodiesel and bio-ethanol could be extracted from the report.

We deduced the formula of the consumed amounts of biodiesel, sugar cane ethanol and total bioethanol as a function of the total biofuels mandate based on IFPRI (2010) as presented in Figure 1.

Figure 1 Estimated progress of consumed amounts of biodiesel and bioethanol as a function of total biofuels mandate (y-axis in Mtoe/a)



Source: authors calculations, R^2 = level of consistentcy

Aglink simulation by JRC-IES

The AGLINK study considers a 5.75% increase in biofuels consumption up from current (2008) consumption level of 3.1% c.q. 9.75 Mtoe consumption level and assumes a 35-65% split between gasoline and diesel. The latter is in line with trends in the EU automotive transport fuel market, which shows an increase in the market share of diesel of approximately 1% per annum and is currently already at 63%[2].
The split taken in the JRC study is also in line with existing and future[3] production capacity for bio-ethanol and biodiesel in the EU. Current biodiesel production capacity already amounts to 19.5 Mt of biodiesel (17.3 Mtoe), while bio-ethanol production capacity is only 8.6 Mt (5.5 Mtoe).

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2 See http://ec.europa.eu/environment/air/transport/fuel_quality_monitoring.htm.

3 "Future" as being under construction or having been announced.

The National Action Plans (NAP's) prognoses

At the moment this report was written, National Action Plans (NAP's) for 21 member states had been published. One member state with a significant domestic biofuels production – Poland - had not published it's NAP, so that the figures included in this report should be considered as a minimum projection of total EU biofuels production and consumption.

The NAP's of the EU member states project a future biofuels mix, in which the total volume of biodiesel is thrice that of bio-ethanol.

The projected volume of waste based and 2^{nd} generation biofuels is small or marginal, less than 50% of the volume estimated in the AGLINK simulation. The NAP's also project a significant import of biodiesel.

Next to bio-ethanol and biodiesel the NAP's also include a number of energy carriers not considered – explicitly - in the two simulations discussed in this report, for example electricity.

1.3 Broad reality check of biofuel mix projections and consequences for implementation

Before discussing the GHG emissions related to the biofuels mixes estimated in IFPRI and AGLINK simulations and projected in the NAP's it is good to broadly check to what extent implementation of these projections could suffer from difficulties in practical realization. For example because of the requirement for adapted and/or additional cars and fuel distribution infrastructure. This avoids discussion about fuel mixes and associated GHG emissions that are rather unrealistic from a practical point of view.

Both the NAP's and AGLINK simulation and the IFPRI study assume a higher consumption of either biodiesel or bio-ethanol than the amounts allowed by the fuel quality standards. Realisation of the projected and simulated scenario's require creation of niche markets and adaption of car fleets by penetration of vehicles designed for biofuels consumption such as bio-ethanol flex fuel cars, biogas flex fuel cars or B30 and B100 lorries..
In this respect any of the considered biofuels mixes requires additional effort for practical implementation.

With respect to domestic production capacity, there probably is no practical bottleneck. Projected EU domestic biofuels production capacity could cover the biofuels volume in 2020 as projected in the NAP's and AGLINK and IFPRI simulation.

However, there could be practical problem concerning the availability of feedstocks for the volumes of biodiesel considered in the NAP's and in the AGLINK simulation.
As indicated in several sources the EU can produce more than enough feedstock to meet the amounts of bio-ethanol considered in the NAP's and in the AGLINK simulation[4]. Imports are therefore not necessary and can be limited by imports policies (see below). And as indicated in Annex D there may also be limitations to the volume of Brazilian sugar cane bio-ethanol that will actually be available for export to the EU.

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[4] With respect to feedstocks, EU agriculture could yield cereals and sugar beets for the production of approximately 12 Mtoe/a of bio-ethanol in 2020 on the same area as currently used, while at the same time being able to meet EU cereal feed and food demand.

For biodiesel on the other hand imports of large volumes of oilseeds, vegetable oil and/or biodiesel are required if volumes of 1st generation biodiesel of 17 – 18 Mtoe/a as projected in the NAP's and AGLINK simulation are to be realized. It is not certain the required volumes of rapeseed and soy oil[5] will become available (see text box).

Example: rapeseed for biodiesel

Because of fuel specification demands- the EU DIN EN 14214 standard - rapeseed biodiesel will have to make up at least 55% - 60% of the total applied 1st generation biodiesel. Taking the total 1st generation biodiesel volumes projected in the NAP's and AGLINK simulation as a starting point, approximately 9.5 - 10 Mtoe/a or 11 - 12 Mtons/a of rapeseed oil would be required.
Next to this, EU food consumption and other industrial applications require an additional 3 Mtons/a of rapeseed oil.

The maximum rapeseed area in the EU in 2020 will measure 6.5 Mha to 9 Mha according to different sources. These areas could yield 9.5 – 13 Mtons/a of oil. This would leave a potential gap of 1 – 5 Mtons of rapeseed oil or 2.5 – 13 Mtons of rapeseed.

According to MVO (2009) availability of rapeseed or derived oil is uncertain. Net exports of rapeseed and rapeseed oil from countries currently exporting to the EU (Canada, Ukraine, Russia, Kazakhstan) will increase, but the EU will have to compete with the markets in India and China for these increases.

A similar uncertainty concerns the availability of the required amount of soy oil, the other main component of 1st generation biodiesel.

The requirement for rapeseed and soy oil could in practice be lower as projected by the NAP's and the AGLINK simulation.
The NAP's and the AGLINK simulation could underestimate the future share of HVO, biogas and methanol/DME. In our expert view these biofuels will probably cover a significant share of the biofuel mandate in 2020. Both biogas and methanol/DME can be counted double under the RED and fuel quality directive as these fuels are waste or residue based. HVO is a superior fuel compared to biodiesel and conventional diesel, that can be blended with conventional diesel up to 20% – 30% levels and which gives a reduction of pipe tail emissions.
The projected consumption for these biofuels amounts to a range between 2.5 and 4 Mtoe/a – weighted contribution[6].

Stimulating the uptake of electric vehicles could also reduce the requirements for rapeseed and soy oil.

Reducing the requirement for oilseeds would also reduce the impact on the prices of these commodities and the derived vegetable oils. These prices are estimated to increase with 10% - 35% according to the AGLINK, CAPRI and ESIM simulations conducted by JRC.

[5] These two oilseeds will have to supply the bulk of the vegetable oil for biodiesel production because of biodiesel fuel specifications

[6] Means double counting

1.4 Resulting probable ranges of different biofuels volumes and 'the marginal biofuel'

Table 2 illustrates the probable range of the mix of biofuels and (renewable) electricity other than 1st generation applied in transports in the EU in 2020, based on the reflections described in previous paragraph.

As indicated in the table, several routes will very probably be implemented in the indicated production capacity, e.g. renewable electricity in rail transports, biogas, waste fats based biodiesel and HVO production.
Implementation of advanced and capital intensive technologies – e.g. FT diesel production – and fuels requiring a separate distribution infrastructure – e.g. DME – will probably be far more dependent on enabling governmental policy.

The remaining 'space' for 1st generation domestic production and imports amounts to 19 – 25 Mtoe/a, with the actual value being probably around 23.5 Mtoe/a.
Bio-ethanol and biodiesel imports will – according to the consulted sources – amount to approximately 2 Mtoe/a and an average of 3 Mtoe/a respectively.

Table 2 Probable contributions of other than 1st generation biofuels

	Weighed contributions other biofuel types + electricity				
	min		max	...and average	Most likely
Biofuels (Mtoe-eq/a) consumption EU					
ethanol					
- 1st gen EU					
- imports					
- waste based		0		0	0
- 2nd gen EU	0	-	1,0	0,5	0
biodiesel					
- 1st gen EU					
- imports					
- waste based	2,0	-	3,0	2,5	2,0
- FT diesel	0	-	1,0	0,5	0
Hydrogen					
Electricity in rail	2,3	-	2,3	2,3	2,3
Renewable elecricity in road transport	0	-	1,5	0,8	0,8
Other (biogas, DME, .. ?)					
- biogas	0,6	-	0,8	0,7	0,6
- HVO	1,5	-	2,5	2,0	2,0
- methanol/DME	0,2	-	0,8	0,5	0,5
Total weighted amount	6,6		12,9	9,7	8,1

Based on the E10 quality standard and the projected 2020 gasoline consumption, the implementable amount of ethanol would be approximately 6 Mtoe/a. A larger volume could be implemented depending on the level of penetration of flexi-fuel cars and the availability of E75/E85 distribution infrastructure. Sweden has the highest level of penetration with flexfuel cars making up 4% - 5% of total passenger cars and with approximately 1,500 refuelling stations per million inhabitants.

Given
- the current low availability of refuelling stations in other EU member states,
- the current intertwinement of ethanol implementation with ETBE production and E10 supply
- the emphasis on biodiesel implementation in large member states as France and Germany

the 2020 consumption level estimated in the AGLINK simulation would seem a representative estimate of the maximum level of bio-ethanol consumption in 2020.

The resulting ranges between which the composition of the 2020 would vary is given in Table 3.

Table 3 Probable contributions of 1st generation domestic production and imports

	Range			Current
Biofuels (Mtoe-eq/a) consumption EU				
ethanol				
- *1st gen EU*	4,0	-	3,5	1,5
- *imports*	*2,0*	-	2,0	0,6
biodiesel				
- *1st gen EU*	16,0	-	7,7	6,6
- *imports*	3,0	-	3,0	1,1
Other biofuels + electricity	6,6	-	12,9	0,6
Total weighted amount	31,6		31,6	*11,0*
share 1st gen, ex HVO	7,9%	-	5,9%	3,1%
ethanol ÷ biodiesel	24,1%	-	32,2%	

2 Biofuel mix volume and composition and ILUC emissions

2.1 Introduction

The policy discussion in Europe is not about the question if (first generation) biofuels will be supported in 2020. The discussion focuses on the question which percentage of biofuels has to be aimed at in 2020. Should it be 10% or a certain percentage higher or lower than 10%. For this policy question the question is what the marginal effect of 1 extra litre of biodiesel or bio-ethanol at this level. Therefore we focus on this marginal figures in this paragraph.

2.2 Net marginal GHG balances per specific biofuel

The net added value of different biofuels in reducing greenhouse gas emissions can be broadly assessed on the basis of (see Table 4):

- The typical direct greenhouse gas emission reductions compared with fossil fuels for individual biofuels as given in the RED;
- The specific marginal ILUC factors determined in the IFPRI study for a 5.6% contribution of 1st generation biofuels to total transport fuel consumption[7].

Though both the biofuel specific direct reduction figures and ILUC emission factors are uncertain up to different degrees , the comparison of direct emission savings and ILUC related emissions for a 5.6% biofuel share as estimated in the IFPRI study give an illustrative picture of the contributions of different individual biofuels to greenhouse gas emission reductions.

The estimated marginal ILUC emission figures used in this comparison can probably be best regarded as an indication of the actual potential ILUC emissions:

- First of all the applied marginal ILUC emission figures concern the emissions for marginal changes in a 1st generation biofuels share of approximately 5.6% while the NAP's for example project a share of 1st generation biofuels and HVO of 7.3%. A number of studies indicate that ILUC emission factors increase with increasing volume. This would imply that the marginal emission factors used in this assessment are lower than the actual emission factors for the considered 7.3% share biofuels may be higher than the factors applied in this assessment.
- On the other hand, the ILUC emission factors will in practice strongly depend on a large number of interlinked aspects, which can give a very large variation in the resulting factors[8].

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[7] This marginal ILUC factor which is reported for 5,6% is considerable higher than the average ILUC factor between 3,3% and 5,6%. Ideally for marginal calculations around 7-8% marginal ILUC factors should be used for the volume but IFRPI does not report these marginal ILUC factors. It is expected that these maginal ILUC factors are higher so the calculations in this report are and underestimation of the ILUC effect.

[8] For example, different basic assumptions about the effect of increased bio-ethanol from sugar cane production in Brazil on the number of cows per km^2 can yield ILUC factors ranging from 6 - 70 g CO_2/MJ, depending on whether increased bio-ethanol production results in an increase of the number of heads per km^2 from 3 to 4 or whether no increase occurs.

Because of these large uncertainties in ILUC emission factors, the comparison in Table 4 should be regarded more as an indication of the sensitivity of different biofuels feedstocks for ILUC emissions and the resulting sensitifity of the net GHG emission balances than as precise figures calculated with scientific precision.

The IFPRI estimated ILUC factors are comparable with ILUC emission factors estimated in other studies.

Table 4 **Overview of direct emission savings and ILUC related emissions for several individual biofuels**

	Direct GHG Reductions (g CO_2/MJ)	Marginal ILUC emission factors (g CO_2/MJ) at 5,6% level in the IFPRI model)		Net GHG balance (g CO_2/MJ)		Net GHG emission reduction	
		Current trade policy	Liberal Trade policy	Current trade policy	Liberal Trade Policy	Current trade policy	Liberal Trade policy
ethanol from straw	-73	0		-73	-73	-87%	-87%
biogas from manure	-71	0		-71	-71	-85%	-85%
waste fats based biodiesel	-74	0		-74	-74	-88%	-88%
FT diesel from waste wood	-79	0		-79	-79	-95%	-95%
Ethanol from agro commodities							
SugarBeet ethanol	-51	16	65	-35	14	-42%	17%
SugarCane	-59	18	19	-42	-41	-50%	-49%
Maize	-47	54	79	7	32	9%	39%
Wheat	-44	37	16	-7	-28	-9%	-34%
Biodiesel from agro commodities							
Palm	-52	50	48	-2	-4	-2%	-4%
Rapeseed	-42	54	51	12	9	14%	11%
Soybean	-34	75	68	42	34	50%	41%
Sunflower	-48	61	57	12	8	14%	10%

Sources: RED and IFPRI (2010)
A negative percentage means a net reduction of GHG emissions

In general four different categories can be distinguished:
- Waste derived biofuels and electricity;
- Bio-ethanol produced from sugar crops – for sugar beet apparently only under current EU trade policy;
- Bio-ethanol from cereals;
- Biodiesel produced from primary agrocommodities (oli seeds).

As indicated by the presented percentages, only waste based biofuels and sugar crops based bio-ethanol can meet the RED 2017 net GHG reduction target of 50%.

Waste derived biofuels give a large net reduction in greenhouse gas emissions because of the absence of ILUC emissions.

Sugar crops require little area per unit of biofuel, because of the high specific crop yield.
For biodiesel on the other hand the marginal negative ILUC effect is larger than the positive direct GHG reduction effect. This means that the net marginal effect of an extra litre biodiesel at the 5,6% to 10% level is negative on GHG reduction.

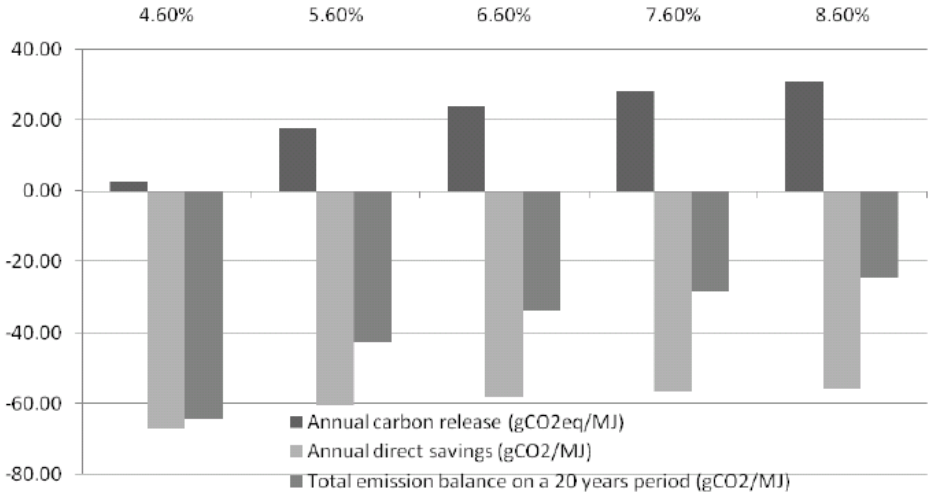
Agro commodity trade policies are assessed to have an effect on the actual ILUC emission factor, especially for wheat and wheat . Given the developments in EU biofuels policies concerning imports of biofuels, the ILUC factors for current trade policy are more representative

2.3 Resulting general mechanisms affecting EU biofuels policy effectiveness for GHG emission reduction

A clear discrepancy exists between the IFPRI study and the results and prognosis in AGLINK simulation and NAP's concerning the ethanol ÷ biodiesel split of the biofuels mix that will be applied in 2020.

According to the IFPRI study average ILUC emissions will be limited, mainly because of the large volume of Brazilian sugar cane bio-ethanol import, both at a 5.6% mandate level and a 8.6% mandate level of 1st generation biofuels.

Figure 2 Indirect land use emissions and direct savings for different mandate levels, No change in trade policy (y-axis values in g CO_2/MJ)



Source: IFPRI (2010)

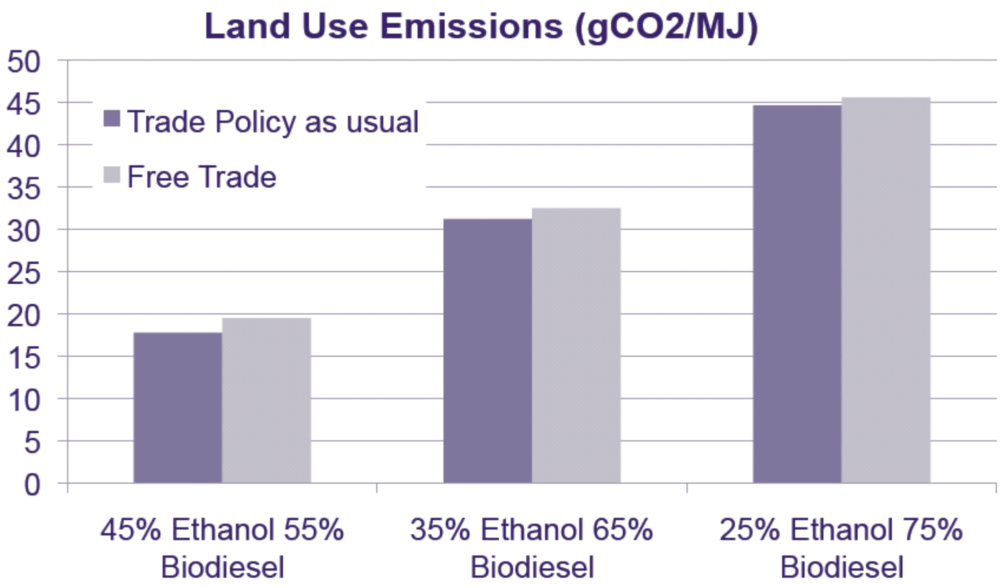
The NAP's prognosis, the AGLINK study and the other sources considered in this study on the other hand indicate that there is a significant possibility that biodiesel rather than bio-ethanol will make up the bulk of the total biofuels mix. Both sources indicate that total biodiesel volume will account for a share of approximately 65% - 75% of all 1st generation in 2020.

According to the IFPRI report the ILUC related specific emissions at a 25% ÷ 75% bio-ethanol to biodiesel ratio is double that for a 45% ÷ 55%, when considering a 5.6% 1st generation biofuels mandate level (see).

At this mandate level of 5.6% and for the considered bio-ethanol ÷ biodiesel split the annual direct savings of the biofuel mix calculated in the IFPRI analysis would be comparable with c.q. somewhat smaller compared with the

ILUC emissions mentioned in Table 4. Any net GHG emission reduction would be realized only by the volume of article 21.1 fuels.

Figure 3 **Indirect land use emissions as a function of bio-ethanol ÷ biodiesel ratio**



Source: IFPRI (2010)

2.4 Net GHG emission estimations based on probable ranges of biofuels mix

Taking the probable composition ranges of the 2020 biofuels mix estimated in previous chapter as a starting point (see Table 2 and Table 3), net direct GHG emission reductions and ILUC related emissions for the whole biofuels mix can be estimated (see).

Using the typical direct GHG reduction percentages given in the RED and the biofuels specific ILUC emission factors given in the IFPRI analysis for a 5.6% biofuels volume the net GHG emission reduction realized with the probable composition of the 2020 biofuels mix can be estimated as ranging between 6 and 17 Mtons/a.
This net saving is generated by utilization of waste derived biofuels, electricity and to some extent by utilization of ethanol from sugar cane and cereals. The large volume of oilseeds and palm oil based biodiesel however largely mitigates these savings – as indicated by the balance of average ILUC emissions and average direct savings for 1st generation biofuels and HVO.

	Range		Direct savings		ILUC factor
			g CO2/MJ	perc	g CO2-eq/MJ
Biofuels (Mtoe) consumption EU					
ethanol					
- *1st gen EU (as wheat)*	4,0 -	6,0	-44	53%	37,3
- *imports (sugar cane)*	2,0 -	2,0	-59	71%	17,8
- *waste based*	-				
- *2nd gen EU (straw)*	-	0,5	-73	87%	
biodiesel					
- *1st gen EU (as rape)*	16,0 -	7,7	-42	50%	53,7
- *imports (as soy)*	3,0 -	3,0	-34	40%	75,4
- *waste based*	1,0 -	1,5	-74	88%	
- FT diesel (waste wood)	-	0,5	-80	95%	
Hydrogen					
Electricity in rail	2,3 -	2,3	-84	100%	
Renewable elecricity in road transport	-	0,6	-84	100%	
Other (biogas, DME, .. ?)					
- biogas (manure)	0,3 -	0,4	-71	85%	
- HVO (as palm oil)	1,5 -	2,5	-57	68%	50,1
- methanol/DME	0,1 -	0,4	-80	95%	
Avoided direct emissions (Mtons CO2/a)			-60,6		-60,3
ILUC emissions (Mtons CO2/a)			56,3		42,9
net			-4,3		-17,4
average ILUC primary + HVO (g CO2-eq/MJ)			50,8		48,3
average avoided primary + HVO (g CO2-eq/MJ)			-43,5		-44,9

Source: authors calculations.

A negative percentage means a net reduction of GHG emissions

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Annex A Broad reality check of considered biofuel mixes

Car fleet composition and specifications and probability of uptake of 1st generation biofuels

Projected transport fuel consumption in road transport in 2020 amounts to approximately 316 Mtoe, divided over gasoline and diesel and over different types of vehicles as indicated in Table 5.
In these projections effects of the recently implemented Fuel Quality Directive – which will probably give further transport fuel savings - have not yet been taken into account.

Table 5 Projected fuel consumption and car fleet composition for 2020

	Transport mode	Energy consumption (Mtoe/ year)	Energy consumption (Mtoe/ year)	Share in energy consumption road
Diesel	Car	119,0	209,7	66,4%
	Van	15,8		
	Bus	9,2		
	LDV	3,3		
	HDV <16 ton	12,3		
	HDV > 16 ton	50,1		
Gasoline	Moped	1,1	101,6	32,2%
	Motorcycle	3,2		
	Car	93,9		
	Van	2,4		
	LDV	1,0		
CNG	Car	0,0	2,7	0,9%
	Bus	2,7		
LPG	Car	2,0	2,0	0,6%
Total	**Total**	**316**	**316**	**100%**

Source: adapted from TREMOVE 3.3, TML (TREMOVE figures have been adapted to a total of 316 Mtoe; TREMOVE gives 297 Mtoe in 2020)

Current fuel quality standards allow for a 10% volume based addition of ethanol and a 7% volume based addition of biodiesel to conventional transport fuels. In terms of energy these percentages amount to 7% and 6.4% of the blend, which means that the projected demand for gasoline and diesel will allow for blending in of 7 Mtoe/a of bio-ethanol and 13 Mtoe/a of biodiesel.

Both the NAP's and AGLINK simulation and the IFPRI study assume a higher consumption of either biodiesel or bio-ethanol than the amounts allowed by the fuel quality standards. Realisation of the projected and simulated scenario's require creation of niche markets and adaption of car fleets by penetration of vehicles designed for biofuels consumption such as bio-ethanol flex fuel cars, biogas flex fuel cars or B30 and B100 lorries. These different vehicle types have all been developed, which means that both the NAP's and AGLINK simulation and the IFPRI study are comparably realizable.

Level of penetration of adapted vehicles will very much depend on the direction of the applied national and EU policies. The development in Sweden illustrates the effects that policy can have: since the government started stimulating introduction of E85/E75 flexfuel cars in 2000, their share of the fleet of private cars has risen to more than 4% and there are now more than 1,400 E75/E85 refuelling stations per million inhabitants. A more recently introduced stimulation of biogas vehicles has resulted in their share increasing to 1% of the fleet of private cars.

EU domestic 1st generation biofuels production volume and capacity

Current production capacity in the EU for bio-ethanol and biodiesel amount to 4.5 and 17.5 Mtoe/a respectively. Additional capacity announced or under construction will increase bio-ethanol production capacity to 5.5 Mtoe/a.
The domestic bio-ethanol and biodiesel production projected and calculated in the NAP's and AGLINK simulation therefore are realizable.

The NAP's prognosis and the AGLINK scenario results indicate a reasonable utilization of existing and projected production capacity, the IFPRI simulation would mean a less than 50% utilization of this capacity.
Current utilization rate of EU bio-ethanol and biodiesel production of 35% and 40% respectively is in line with the IFPRI study results.

Summarizing, projected EU domestic biofuels production capacity could cover the larger part of the required biofuels volume in 2020 as projected in the NAP's and AGLINK simulation. But current practice illustrates that existence of capacity does not necessarily mean that biofuels demand would not be covered to a large extent by imports.

First generation biofuels imports possibilities

The IFPRI calculations and the NAP's assume imports of significant volumes of respectively sugar cane bio-ethanol from respectively Brazil and unspecified biodiesel from unspecified countries and feedstocks.

Comparing feedstock availability and production capacity, the EU would be able to generate more than enough feedstock for existing and projected bio-ethanol production capacity. As indicated in several sources the EU can produce more than enough feedstock to meet the amounts of bio-ethanol considered in the NAP's and in the AGLINK simulation[9]. Projected bio-ethanol production capacity is also larger than the projected domestically produced volumes. Imports are therefore not necessary and can be limited by imports policies (see below). And as indicated in Annex D there may also be limitations to the volume of Brazilian sugar cane bio-ethanol that will actually be available for export to the EU.

For biodiesel on the other hand imports of large volumes of oilseeds, vegetable oil and/or biodiesel are required if volumes of 1st generation biodiesel of 17 – 18 Mtoe/a as projected in the NAP's and AGLINK simulation are to be realized. It is not certain these volumes will become available.

[9] With respect to feedstocks, EU agriculture could yield cereals and sugar beets for the production of approximately 12 Mtoe/a of bio-ethanol in 2020 on the same area as currently used, while at the same time being able to meet EU cereal feed and food demand.

Example: rapeseed for biodiesel

Because of fuel specification demands- the EU DIN EN 14214 standard - rapeseed biodiesel will have to make up at least 55% - 60% of the total applied 1st generation biodiesel. Taking the total 1st generation biodiesel volumes projected in the NAP's and AGLINK simulation as a starting point, approximately 9.5 - 10 Mtoe/a or 11 - 12 Mtons/a of rapeseed oil would be required.
Next to this, EU food consumption and other industrial applications require an additional 3 Mtons/a of rapeseed oil.

The maximum rapeseed area in the EU in 2020 will measure 6.5 Mha to 9 Mha according to different sources. These areas could yield 9.5 – 13 Mtons/a of oil. This would leave a potential gap of 1 – 5 Mtons of rapeseed oil or 2.5 – 13 Mtons of rapeseed.

According to MVO (2009) availability of rapeseed or derived oil is uncertain. Net exports of rapeseed and rapeseed oil from countries currently exporting to the EU (Canada, Ukraine, Russia, Kazakhstan) will increase, but the EU will have to compete with the markets in India and China for these increases.

A similar uncertainty concerns the availability of the required amount of soy oil, the other main component of 1st generation biodiesel.

On the demand site the EU is increasingly protecting its domestic biofuels by import fees, anti dumping legislation and in future probably also by definition of maximum import allowances.[10]

Article 21.2 fuels

The NAP's and the AGLINK simulation conducted by JRC-IES project c.q. calculate different volumes of so-called article 21.1 fuels: waste based biofuels and so-called 2nd generation biofuels (lignocellulosic ethanol and FT-diesel).
The information found in other literature sources and on the internet suggests that the NAP projections are significantly more realistic than the calculation results of the AGLINK simulations:

- EU potential for waste based biofuels is estimated at 1 – 2 Mtoe (see EU (2010));
- No plans for realization of commercial scale 2nd generation plants in the EU exist and compulsory legal US targets for 2nd generation fuels from 2012 on make it more likely that 2nd generation technology will be launched in the USA and not in the EU. This makes it unlikely that 2nd generation biofuels will give a significant contribution to total biofuels mix.

Electricity

The projections for renewable electricity included in the NAP's is in line with estimates made in other sources. The projection for renewable electricity in road transport included in the NAP's lies within the range considered realistic for the penetration of plug in vehicles and the vehicle kilometres driven by these vehicles.

[10] Soy oil production in the EU amounts to approximately 2.4 Mtons/a (FAPRI, 2010), of which 1.2 Mton is used for biodiesel production. Biodiesel exports to the EU from Argentina may

Other biofuels

Both the NAP's and the two considered simulation studies do not consider biofuels like HVO, biogas and methanol/DME.

In our expert view these biofuels will cover a significant share of the biofuel mandate in 2020. Both biogas and methanol/DME can be counted double under the RED and fuel quality directive as these fuels are waste or residue based. Methanol production capacity already amounts to 0.1 Mtoe/a and has a directly realizable potential for expansion to a volume of 0.4 Mtoe/a. DME production may amount to 0.1 Mtoe/a in 2020;
Biogas targets in Sweden, Germany and France amount to a total contribution of approximately 0.3 Mtoe/a. Since this application is highly related to public functions such as waste collection and public transport it seems realistic that these targets will be realized.

HVO is a superior fuel compared to biodiesel and conventional diesel, that can be blended with conventional diesel up to 20% – 30% levels and which gives a reduction of pipe tail emissions. The high percentage that can be blended into diesel poses a solution for the problem identified in the first subparagraph in this paragraph: the inability of the current fleet of diesel cars to absorb the amount of biodiesel required for meeting the EU blending target. Another advantages of HVO production – for the refinery sector - is the possibility of integrating production at existing refineries, either by co-processing of vegetable oils in existing hydrotreaters or by co-siting of a separate production unit at the refinery. This allows refiners to keep the whole transport fuels system into their own hands.
Neste and ENI/UOP have in operation, under construction or planned a total of 6 industrial scale installations with a production capacity of approximately 2 Mtoe. Co-processing potential and targets are not known, but PREEM Göteborg alone already produces 0.1 Mtoe/a of HVO from pulp production residues.

Annex B Fuel mix prognoses

B.1 The prognosed future EU road transport fuel consumption

Projected transport fuel consumption in road transport in 2020 amounts to approximately 316 Mtoe, divided over gasoline and diesel and over different types of vehicles as indicated in Table 6.
In these projections effects of the recently implemented Fuel Quality Directive – which will probably give further transport fuel savings - have not yet been taken into account.

Table 6 Projected fuel consumption and car fleet composition for 2020

	Transport mode	Energy consumption (Mtoe/ year)	Energy consumption (Mtoe/ year)	Share in energy consumption road
Diesel	Car	119,0	209,7	66,4%
	Van	15,8		
	Bus	9,2		
	LDV	3,3		
	HDV <16 ton	12,3		
	HDV > 16 ton	50,1		
Gasoline	Moped	1,1	101,6	32,2%
	Motorcycle	3,2		
	Car	93,9		
	Van	2,4		
	LDV	1,0		
CNG	Car	0,0	2,7	0,9%
	Bus	2,7		
LPG	Car	2,0	2,0	0,6%
Total	**Total**	**316**	**316**	**100%**

Source: adapted from TREMOVE 3.3, TML (TREMOVE figures have been adapted to a total of 316 Mtoe; TREMOVE gives 297 Mtoe in 2020)

Current fuel quality standards allow for a 10% volume based addition of ethanol and a 7% volume based addition of biodiesel to conventional transport fuels. In terms of energy these percentages amount to 7% and 6.4% of the blend, which means that the projected demand for gasoline and diesel will allow for blending in of 7 Mtoe/a of bio-ethanol and 13 Mtoe/a of biodiesel.

The EU automotive transport fuel market shows a trend of increase in the market share of diesel of approximately 1% per annum. Current diesel market share is currently already at 63%[11].Future gasoline share will probably be somewhere around 25% - 30% (TREMOVE simulation and simple extrapolation). For comparison, the amounts of bio-ethanol and biodiesel required for meeting the mandatory 10% blending target are projected. These amount to respectively 21.5 - 24 Mtoe/a and 8 – 9.5 Mtoe/a.

Comparing RED specific greenhouse gas emission reduction targets (see) with the typical emission reduction percentages for individual biofuels mentioned in the RED indicates that the probability that soy bean biodiesel can be applied in the 2020 biofuels mix is limited.

11 See http://ec.europa.eu/environment/air/transport/fuel_quality_monitoring.htm.

Biofuel production pathway	Typical greenhouse gas emission saving
sugar beet ethanol	61%
wheat ethanol (natural gas as process fuel in CHP plant)	53%
wheat ethanol (straw as process fuel in CHP plant)	69%
corn (maize) ethanol, Community produced (natural gas as process fuel in CHP plant)	56%
sugar cane ethanol	71%
sunflower biodiesel	58%
soybean biodiesel	**40%**
palm oil biodiesel (process with methane capture at oil mill)	62%
waste vegetable or animal (*) oil biodiesel	88%
hydrotreated vegetable oil from rape seed	51%
hydrotreated vegetable oil from sunflower	65%
hydrotreated vegetable oil from palm oil (process with methane capture at oil mill)	68%
pure vegetable oil from rape seed	58%
biogas from municipal organic waste as compressed natural gas	80%
biogas from wet manure as compressed natural gas	84%
biogas from dry manure as compressed natural gas	86%
wheat straw ethanol	87%
waste wood ethanol	80%
farmed wood ethanol	76%
waste wood Fischer-Tropsch diesel	95%
farmed wood Fischer-Tropsch diesel	93%
waste wood dimethylether (DME)	95%

farmed wood DME	92%
waste wood methanol	94%
farmed wood methanol	91%

Annex C EU biofuels production

C.1 Current production capacity

Biofuels consumption in the EU in 2009 amounted to Mtoe, divided along the various biofuels types and applied feedstocks in Table 7.

Table 7 Current EU biofuels production, divided according to feedstocks

	2006	2007	2008	2009
Biodiesel	4,11	5,90	7,16	8,17
a) imports	0,05	0,79	2,11	1,12
b) domestic production	0,00	0,00	0,00	0,00
Rapeseed Oil	2,92	3,75	3,69	4,98
Soybean oil	0,64	0,77	0,75	0,95
Palm oil	0,13	0,26	0,26	0,39
Sunflower	0,15	0,17	0,17	0,26
Other and not attributed	0,09	0,02	0,03	0,04
Recycled Vegetable Oil	0,10	0,12	0,17	0,34
Animal Fats	0,01	0,03	0,11	0,14
Pure Vegetable oil	0,92	0,66	0,37	0,10
Soybean oil	0,42	0,21	0,08	0,02
Rapeseed Oil	0,50	0,45	0,29	0,08
Bioethanol	0,88	1,38	1,79	2,07
a) imports	0,11	0,49	0,52	0,56
b) domestic production				
Wheat	0,42	0,45	0,57	0,72
Corn	0,10	0,13	0,28	0,33
Barley & Rye	0,08	0,05	0,09	0,09
Sugar*	0,16	0,26	0,33	0,37
Total, including double count	6,02	8,09	9,60	10,82

Current production and imports amount to approximately 35% for biodiesel and approximately 25% for bio-ethanol, compared to the EU 2020 targets.

Imports of biodiesel largely came from the USA. These imports have recently been halted by ant dumping duties. Bio-ethanol is reported to be imported from Brazil, Argentina, Costa Rica, Venezuela, Peru and Guatemala at Rotterdam port.

The applied amounts of palm oil and sunflower oil are limited because of quality issues and price respectively.

Current EU biodiesel production capacity already stands at almost 22 Mtons/a or almost 20 Mtoe[12], already largely comparable with the 21.5 - 24 Mtoe of biodiesel required for a 10% percentage of biofuels blending.

12 http://www.biofuelstp.eu/news/EBB_2009_prod_2010_capacity.pdf

For ethanol existing capacity amounts to approximately 6.5 Mtons/a or approximately 4.5 Mtoe/a[13], of which approximately 1/6 is based on sugar beet/sugar juice and another 1/6 is based on raw alcohol.

C.2 Future EU production capacity

First generation biodiesel and bio-ethanol production

For biodiesel production capacity no projections have been found.

For ethanol announced capacity expansion amounts to approximately 1.7 Mtons/a or approximately 1.1 Mtoe/a[14], the majority of which will be grains based.

HVO production

The EU 2020 stand alone production capacity of hydrogenated vegetable oil (HVO) amounts to 2 Mtoe/a, taking into account all existing capacity and capcity under construction or announced. Main technology suppliers are Neste (NexBtl technology) and the ENI/UOP combination.

Additional HVO production capacity potential exists in the shape of existing diesel hydrotreaters at existing refineries. Vegetable oils are coprocessed together with diesel and can potentially replace up to 20% of diesel production. Most prominent example of the potential of this adaption of existing refineries is PREEN's Göteborg refinery where 0.1 Mtoe of fatty acids byproduct of chemical pulping substitutes approximately 20% of convential diesel.

Second generation capacity

The contribution of 2nd generation bio-ethanol and FT-diesel to the EU 2020 biofuel mix will probably be small, in part because of the insufficient pace of technological development and in part because of the US legislation under the the US Renewable Fuels Standard which requires an increasing volume of 2nd generation biofuels being the marketed from 2012 onwards (see textbox).

The main achievements of development of 2nd generation bio-ethanol and FT-diesel technology in the EU thus far are the CHOREN 45 MW_{in} beta plant in Germany and a 5,000 tonnes/a Abengoa bio-ethanol plant in Spain.

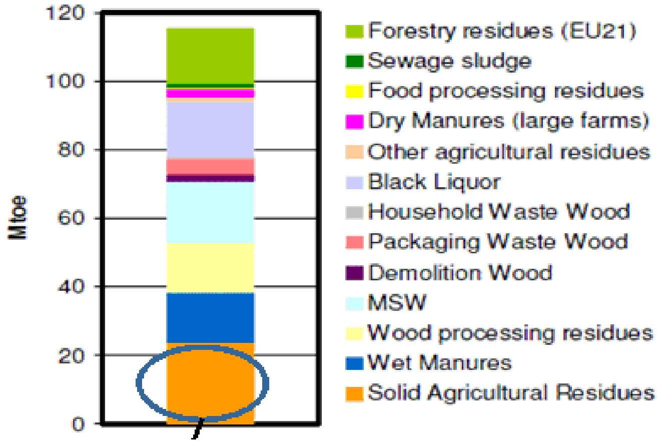
> The first commercial-scale 2nd generation technology bio-ethanol and FT-diesel plants will not commence operation before 2012 and will not be situated in the EU but in the USA.
> This firstly implies that production capacity will be limited at best. It will take some years before these first of a kind installations have been debottlenecked and designs for further plants can be produced and these next plants can be realized.
> Next to this, the driving force for 2nd generation bio-ethanol and FT-diesel is more focussed on the US market than on the EU market. A European company as Abengoa too is focussing on realization of their first commercial scale 2nd generation biofuels production plants in the USA, rather than in the EU. As a consequence production capacity for 2nd generation biofuels in the EU in 2020 will probably be marginal compared with the 10% blending target.

[13] http://www.ebio.org/statistics.php?id=6

As a result the further development of the Abengoa technology is focussed on the US market, where Abengoa is constructing a first of a kind commercial scale lingo-cellulosic ethanol plant.
The CHOREN technology will be applied next in another 45 MW_{in} FT diesel plant in France. The 200 kton/a gamma plant previously planned at Schwedt refinery seems to have been abandoned.
On the other hand, the volume of residues readily available and collectable as biofuels feedstock and thus the potential volume of associated biofuels is limited (see Figure 4).

Availability of residues for FT diesel and lignocellulosic ethanol are expected to be limited.

Figure 4 Availability of residues in the EU

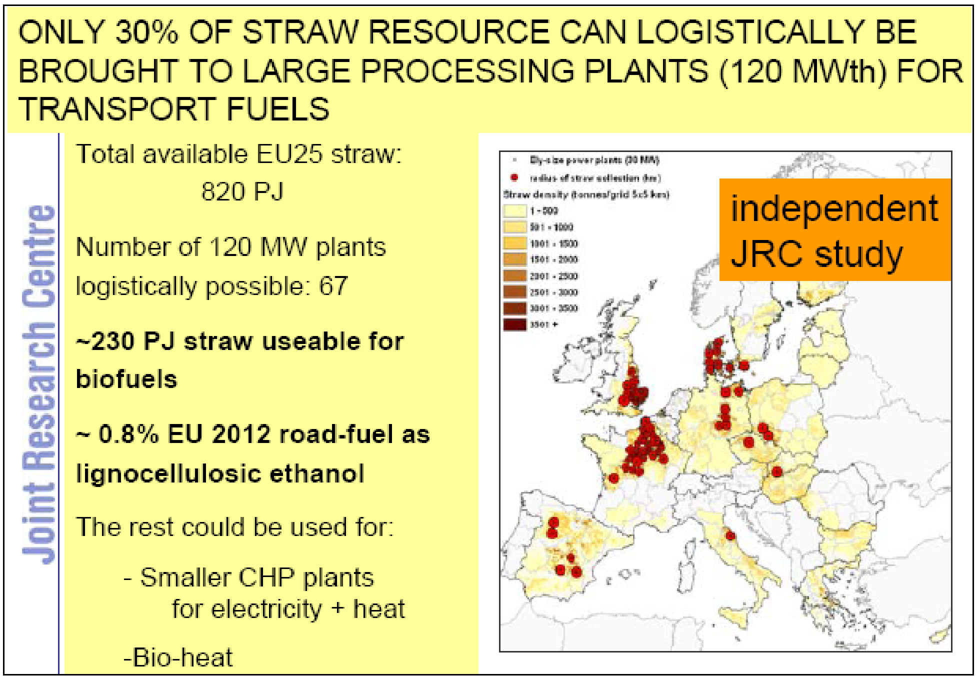


Source: Ecofys, 2008.

Both technologies compete with application of residuesfor electricity and heat generation and have a disadvantage compared with these alternative applications because of scale of size. According to (JRC, 2007) FT diesel and lignocellulosic production technologies can be implemented only in regions where feedstocks are available in large quantities in a limited area, for otherwise the costs of feedstock collection and transportation will become prohibitive (see Figure 5, for example).

[14] http://www.ebio.org/statistics.php?id=6

Figure 5 Illustration of the limited amount of residues potentially available for biofuels production



Source: JRC, 2008.

Production capacity of other 2nd generation biofuels – bio-methanol and DME – on the other hand is developing at a faster pace:

- The recently opened BioMCN in Delfzijl in the Netherlands has a production capacity of 200 ktonnes/a which can be extended potentially to 800 ktonnes/a. The BioMCN plant is a second beginning of the former 2 x 500 ktonnes/a natural gas based methanol production plant which has been redesigned for applying crude glycerine as feedstock;
- Chemrec in Sweden has realized a 4 tonnes/day DME plant based on black liquor gasification and has designed a 100 ktonnes/a commercial scale plant.

In both cases gasification is applied for converting the feedstock into a processible feedstock and in both cases the applied feedstock is a by-product c.q. residue of another chemical production process, biodiesel production and chemical pulp production respectively. Both pathways can be integrated, as DME is the ether of methanol.

Waste derived first generation biofuels

Certain residues are already being used for biofuels production:

- Biodiesel from residual frying oil and low-quality residual fats from slaughterhouse waste already amounts to approximately 0.5 Mt of biodiesel (USDA, 2009).
- Biogas from residues, manure and dedicatedly cultivated substrate crops is increasingly being used in transportation in the EU (see Biogasmax, Madagascar and Biogas highway programmes).

The production potential for biodiesel from spent cooking oil and animal residues is estimated to be between 1 and 2.2 Mtoe/a (EU, 2010).
The production capacity of biomethane depends on the availability of manure and digestible organic wastes from households and food industries. In JRC (2007) the maximum potential production capacity for compressed biomethane is estimated at 200 PJ/a or 4.8 Mtoe.

Annex D Potential for imports of feedstock and biofuels

D.1 Sugar cane ethanol imports from Brazil

Authoritative studies such as the FAO-OECD 2009–2018 Outlook, EU Agri 2009–2015 Outlook and EU AGRI EIA for EU biofuels policy all project imports of between 1.5 and 2.5 Mtoe per year.
In these studies, imports are assumed to remain limited because of the anticipated rapid rise in domestic consumption in Brazil. In all these studies the volume available for exports is assumed to be limited in view of the fact that sugar cane ethanol in Brazil is cheaper than petrol. Production costs are expected to become ever lower as the costs of both sugar cane cultivation and ethanol production are steadily declining. In addition, recent car sales in Brazil have shown a sharp increase in flex-fuel cars, allowing a high share of ethanol in transport fuel consumption. Thirdly, the USA seems a more attractive export market, with two-thirds of Brazilian exports going to that country.

D.2 Soy and rapeseed imports and biodiesel imports

In addition, the USDA and EU reports indicate a growing supply of rapeseed and rape oil from Canada and Ukraine to the EU. Total contribution of soy oil to the EU demand for biodiesel feedstock is anticipated to be significantly higher than 0.5 Mton. Most forecasts predict exports of soy oil or derived biodiesel to the EU as in excess of 3 Mtons/year.

At the same time demand for vegetable cooking oil is expected to keep rising in Asian countries, most notably in India and China. This means that soy oil is likely to be diverted from the cooking oil market to biodiesel production[15].

The expected future rise in demand will be partially met by increased vegetable oil and oilseed imports, as India and especially China have limited opportunities for increasing the area for oilseed because of competition with other crops particularly cereals. As a result, the significant expected increase is expected to be met partially by imports of vegetable oils (with some increase in yield also possible). These imports are likely to be soy oil and palm oil.

Rape oil, produced in former Soviet states and in Canada, is expected to be exported to the EU for use as biodiesel feedstock. The Ukraine for example is implementing rape seed cultivation aimed at supplying the EU biodiesel market with 1 Mton/year of rape oil. Rape oil is also becoming more important for the EU market because of its favorable fatty acid composition. There is currently no market for sunflower oil in China and a limited market in India. This leaves palm oil and soy oil as available export oils.

[15] See e.g. http://www.mvo.nl/Portals/0/statistiek/nieuws/2009/MVO_Factsheet_Soy_2009.pdf.