Local and global consequences of the EU renewable directive for biofuels

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Testing the sustainability criteria

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Rapport in het kort

Locale en mondiale gevolgen van de nieuwe Europese richtlijn voor hernieuwbare energie in de transportsector. Een eerste analyse van de voorgestelde duurzaamheidscriteria.

Dit rapport analyseert de effecten van het voorstel van de Europese Commissie voor een nieuwe richtlijn voor hernieuwbare energie. Hierbij wordt alleen ingegaan op het doel voor de transportsector, wat neerkomt op 10% hernieuwbare energie in 2020 ten opzichte van de totale energievraag. Zoals het doel is geformuleerd, zal dit bijna volledig moeten worden gehaald door biobrandstoffen.

De Europese Commissie stelt duurzaamheidscriteria voor waaraan de biobrandstoffen moeten voldoen als ze willen meetellen bij het 10%-doel. Deze criteria gelden voor de broeikasgasbalans en het tegengaan van ongewenste landgebruiksveranderingen en verlies van biodiversiteit. Andere effecten van biobrandstoffen, zoals hogere voedselprijzen, zijn niet in criteria vertaald.

Het doel van de Europese Commissie kan alleen worden gehaald door ook buiten de Europese Unie biobrandstoffen te telen. Hiervoor zal ook extra landbouwland nodig zijn. Het is onzeker of deze landconversies buiten de EU kunnen worden gedaan zonder extra broeikasgasemissies. Daarnaast is verlies van biodiversiteit onvermijdelijk op de korte termijn. De criteria van de Europese Commissie zijn onvoldoende om deze effecten mondiaal tegen te gaan.

Omdat het onzeker is of alle zogenaamde tweedegeneratiebiobrandstoffen betere resultaten zullen opleveren, is de vraag gerechtvaardigd of het voorgestelde doel van de Europese Commissie voor 2020 gehandhaafd moet worden. Aangezien er alternatieven voor de transportsector op de lange termijn aanwezig kunnen zijn, zou de Europese Commissie kunnen inzetten op stimulering van deze verschillende alternatieven. Het huidge voorstel doet dit in onvoldoende mate door de gekozen doelstelling.

Trefwoorden:

Biobrandstoffen, broeikasgassen, biodiversiteit, voedselzekerheid, energie, EU-richtlijn

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Summary

The European Union has set a target for an obligatory share of 10%, for energy from renewable sources in transport, to be reached in 2020. This applies to final energy consumption in transport within each Member State. This target for the transport sector is expected to be met, mainly by using biofuels, although other routes, like using electricity (plug-in technology), are also thinkable. In the proposal for the Directive (released 23 January 2008), the European Commission pays much attention to sustainability criteria for biofuels and bioliquids, following the debate on whether the negative aspects of biofuels outweigh their benefits as a renewable energy source. In this report, a first analysis is given on these sustainability criteria in the transport sector. The application of biomass in other sectors, such as the electricity and heating and cooling sectors, is not assessed.

Transport target can only be met by imports from outside the EU
Considering default projections, 10% of the European transport consumption in 2020 amounts to around 35 million tonnes of oil equivalent. When grown in Europe with existing technologies ('first generation'), an area of 20 to 30 million hectares is needed for the production of biofuels. This amount of land is not likely to become available within Europe. Studies that do show the availability of large amounts of land, usually assume full liberalisation of European agricultural policies, using a considerable amount of set-aside land and the diverting of existing land use. However, such a drastic reform of European agriculture is not likely to occur within a short time frame. It is also not likely that land which is best suited for large-scale biofuel production will become available when liberalisation will occur. Diversion of land use will not minimise total land use, globally. More importantly, when full liberalisation of Europe's agriculture will be applied, it will be almost impossible to steer foreign biofuel production with European policies. Studies that implemented Europe's 10%-target in 2020 in a fully liberalised world (the Eururalis-study), concluded that more than 50% of Europe's biofuel demand would be imported. Furthermore, the origin of biofuels grown inside the European Union (EU) is uncertain. Therefore, it remains unclear whether new Member States in Central Europe will benefit most from biofuel production. The European Commission assumes lower biofuel imports are needed to meet the 10%-target, than is suggested by the Eururalis study. This uncertainty is of great importance when the effectiveness of the proposed sustainability criteria is assessed. The results may change when new biofuel conversion techniques will enter the market, but large-scale applications before 2020 are unlikely.

Global land use will increase in the coming decades
The additional land demand for biofuels comes on top of default baseline developments as shown in this report. Even in a baseline where no explicit biofuel policies are assumed, total land use is projected to increase. The total area of wheat, maize, oilseeds and sugar cane is projected to grow by 10% between 2000 and 2020, already assuming substantial improvements in yield. With additional biofuel policies in the United States and the EU, an additional growth of 5% may be expected. This effect cannot be offset entirely by further yield growth. Therefore, the demand for biofuels will put additional pressure on land. This additional pressure on land, globally, asks for sustainability criteria. Criteria that can also be applied outside the EU. Even when most of the biofuels are grown within the EU (as concluded in the Commission's Impact Assessment), criteria need to address the displacement effect: food and feed will be grown elsewhere outside the EU because productive land will be occupied by biofuel crops.

Greenhouse gas reductions will not necessarily reach 35%

The Commission focuses on criteria which have to be met by individual economic operators. This means that criteria only apply to biomass which is produced at the level of each consignment. In this system, only criteria for greenhouse gas reductions and land use exclusion are addressed. For greenhouse gas reduction, individual operators have the choice between using default values or performing an elaborate analysis to calculate the reduction percentages of a specific biofuel production chain. By offering conservative default values for greenhouse gas reductions per biomass type, the current criteria can be applied very well, and offer some level of safety. Although these values are chosen with great care and the calculating methodology addresses most aspects of the life cycle, the default values are not necessarily met by 'real' production. Firstly, an excessive use of fertiliser may lead to additional N_2O emissions, leading to lower greenhouse gas reductions than presented by the default values. Secondly, economic operators may adjust the default greenhouse gas emissions in specific parts of the processing steps in the Commission's proposal. An adjustment in such a step may, theoretically, lead to better performances than the required 35% greenhouse gas reduction and, therefore, meeting the required sustainability criteria, but in reality this 35% reduction is not necessarily met. More importantly, even the most carefully selected default values will not cover all negative side effects of biofuel production. Through displacement effects and the loss of soil carbon by other agricultural practices, some production chains may indirectly lead to a negative impact of biofuels. These aspects cannot be covered by the default values for greenhouse gas reductions. Therefore, global displacement effects should play a more important role in the sustainability criteria than is currently the case in the proposal for a Renewable Directive.

Impacts on biodiversity can be negative in the short-term

The land exclusion criteria in the Commission's proposal are effectively targeted at several valuable land cover types, that either contain high soil carbon stocks or high biodiversity values. Categories of land which may be used for biofuel, are abandoned agricultural lands (from crop growth) and natural grasslands with low biodiversity values. Moderately degraded lands can also be used. Using abandoned intensively used agricultural lands and (moderately) degraded lands may be beneficial, as biofuel crop production can help to restore the biodiversity in these ecosystems. However, (semi-)natural and extensively used grasslands remain under further threat with the proposed land use criteria. Furthermore, a global analysis of available lands shows that the amount of abandoned areas, alone, will probably not be enough to meet the targets of the EU and the United States. This will add pressure to the global extent of natural and semi-natural grasslands. The exact meaning of the criterion 'high diverse grasslands' is not made clear in the current proposal, and is especially relevant for application outside Europe. Reducing greenhouse gas emissions is important to avoid future changes in biodiversity (through climate change). However, stimulating biofuel production does not contribute to this positive biodiversity effect, at least not within a time frame of several decades. An analysis with a 'biodiversity balance' indicator shows that, in most cases, the greenhouse gas reductions from biofuel production are not enough to compensate for biodiversity losses from land use change. This result will be even worse if soil carbon emissions from land use change are taken into account. In total, the European criteria are probably effective in preventing biodiversity loss within the European Union, as soon as a clear definition of highly biodiverse grasslands is given. Outside the EU, biodiversity loss cannot be ruled out, especially not in grassland areas. Moreover, through the displacement effect of current agricultural practices, biodiversity loss may even be aggravated due to the push for biofuels. Therefore, additional protection of valuable ecosystems may be needed in combination with the proposed sustainability criteria.

Macro monitoring needed to address the issue of food security

In the proposal, the issue of food security is only addressed by the European Commission's reporting obligations, starting in 2012. The proposed target for the use of biofuels will very likely lead to higher global food prices, especially if this target is combined with targets from other countries, such as the United States. Food exporting countries will benefit from higher food prices, whereas especially poorer food importing countries will suffer from higher food prices and to some extent benefit from cheaper oil prices. Since it is not possible to prevent the conceivably negative impacts on food security of biofuel policies with individual consignments, an adequate, global early warning system may be needed as part of the EU biofuel policy. Such an early warning system could help to timely signal increased risk on food security. This issue is of added importance since the EU has endorsed the Millennium Development Goals.

Future biofuels ('second generation') will also need land

For future application of biofuels, hopes are that upcoming techniques ('second generation') will perform much better than present agricultural crops. However, the report shows no clear difference between first and second generation, when all byproducts of first generation biofuels are considered and the amount of energy per hectare is regarded. Therefore, conclusions on first or second generation biofuels can only be drawn when the full production chain is considered and the total energy content of the production chain per hectare is considered. When soil emissions are excluded, most of the values of each production chain are emission reductions of between 5 and 15 tonnes of CO_2 equivalent per hectare per year, and 50 to 200 GJ per hectare. For biofuel production chains, which deliver byproducts such as animal feed, the energy values may be much larger when substitution of all byproducts is considered. Examples of these production chains are wheat and rapeseed. Applying the Commission's soil carbon contents, the potential soil emissions, following undesired land conversion, may reach a value of 18 tonnes of CO_2 equivalent per hectare per year, for a period of several decades. This conversion means that almost none of the biofuels can comply with the criterion of 35% reduction. Therefore, the results of land demanding biofuels are, in all cases, very dependent on the location of where they are grown. Future biofuels from woody and non-woody materials or whole grains will ask for land, as well. Theoretically, these so-called second generation biofuels are better suited for degraded lands and other idle land. However, the current Directive only excludes certain areas from being used, and it does not dictate that these biofuels should only be grown on degraded and idle lands. The conclusion is probably easier to draw when waste and residuals are used for biofuel production, but it is the expectation that these types of biofuel will not enter the transport market in large amounts, before 2020.

Incentives for alternatives for transport should be implemented

The advantage of biofuels is that they can easily be introduced in the present transport system, just by blending a certain percentage of them with fossil fuels. It seems that energy security is the most valid argument for promoting biofuels in the transport sector. The costs of first generation biofuels are not a real high barrier, especially with the present high oil prices. However, the potential to reduce greenhouse gas emissions in 2020 is quite low. Moreover, biodiversity losses cannot be excluded and impacts on food security through food price effects are likely. Since the proposed Directive will put an additional pressure on global land use, the mandatory 10%-target in 2020 is debatable. Alternatives for the transport sector do exist. The most important (new) driving technologies for vehicles are: steep increase of fuel efficiency of existing petrol and diesel engines, further stimulation of hybrids, plug-in hybrids and completely electric cars or fuel cell cars on hydrogen. The costs of the latter are still relatively high, because they are in the development phase. There are lots of uncertainties about their role in future. However, in a long-term transition process towards a new transport system, their potential seems high, although their impact depends on the sustainability of the hydrogen production and the generation of electricity. The proposed target in the Commission's proposal, weighted with final energy consumption, is not stimulating these alternatives routes. Although hydrogen and electricity are promising fuels for transport when the potential distance travelled per kilometre is assessed, further improvement of the performance of fuel-cells, batteries and cost reduction are necessary to make them realistic alternatives. There is no certainty that these improvements can be realised in time or at all. Therefore at this moment, it is best to support all alternatives for transport. This Commission's proposal does not.

10% target should be reconsidered

Given all these considerations, the current obligatory target for transport in 2020 should be reconsidered. The presently proposed target and the sustainability criteria can not prevent important negative impacts on greenhouse gas emissions and global biodiversity. When biofuels are fully stimulated by the EU, compensating mechanisms such as payment for protection of biodiversity and support for food importing regions, should also be in place. Whether the total renewable target can be achieved without a mandatory target in the transport sector, should be part of further research. Obviously, biomass can still be used in other sectors, such as heating and cooling, electricity and bio-based products, although sustainability criteria have not been applied in these sectors, yet. For the transport sector, the impact on greenhouse gas reduction and energy security of other Directives, such as the Fuel Quality Directive and the CO_2 standards, should be investigated as well. The conclusion of that research may be that other mandatory targets, as currently proposed by the European Commission in the Renewable Directive, are not improving the outcome of greenhouse gas reduction and increase in energy security.

I Introduction

On the 23 January 2008, the European Commission released its climate and energy policy package, including European targets for greenhouse gas reductions and shares of renewables for all EU Member States in 2020 (EC, 2008a). This package contains proposals for Directives following initiatives by the European leaders in March 2007. At that time, the European Council agreed to put forward an ambitious climate and energy policy package, including targets for greenhouse gas emission reduction, energy savings and share of renewables in the total energy consumption (EU, 2007). This policy package is supposed to put the European Union's ambitious targets to mitigate climate change into operation.

While the European Commission was working on detailed proposals for Directives following these targets set by the European Council, a debate on the use of bioenergy and, in particular, biofuels developed in the course of 2007. The term 'biofuel' is used when bioenergy for the transport sector is meant. Bioenergy refers to all biomass used for energy production, including for transport, electricity and the heating and cooling sector.

From initial positive reactions (EurActiv, 2007), and even reactions that the targets were set too low (FOE, 2007a), the debate focussed more and more on the performance of biofuels with respect to sustainability. In 2007, the OECD published the report 'Biofuels: Is the cure worse than the disease?' [1] The report raised two fundamental questions:

1. 'Do the technical means exist to produce biofuels in ways that enable the world to meet demand for transportation energy in more secure and less harmful ways, on a meaningful scale and without compromising the ability to feed a growing population?
2. Do current national and international policies that promote the production of biofuels represent the most cost-effective means of using biomass and the best way forward for the transport sector?' (Doornbosch and Steenblik, 2007)

The report concluded that food shortages and damage to biodiversity are a possible consequence of a rush on energy crops, without clear benefits, since the claimed greenhouse gas reduction effects can be very small. Also in the scientific field questions were raised on the best use of available land with respect to biofuels. Righelato and Spracklen (2007) concluded that the carbon balance for reforestation is much better than for using first generation biofuels. The term first generation biofuels refers to fuels produced from (food) crops containing sugar, oil or starch that can be converted to biodiesel or bioethanol. The term second generation biofuels refers to fuels based on the process of converting all lignocellulosic (see section 3.1).

Very recently, Fargione et al. (2008) and Searchinger et al. (2008) concluded that biofuels are increasing global greenhouse gas emissions, through land-use emissions because of deforestation. In their analyses, special attention was paid to the displacement effect of biofuels: biofuels may occupy productive land and other agricultural practices are shifting towards newly formed arable land at the cost of existing ecosystems. The analyses in both studies quantified these displacement effects, assuming a worst-case scenario where all displacement leads to soil carbon emissions.

1 OECD claimed this report was not representing an official view of the OECD, but nevertheless the outreach of this report certainly benefited from OECD's trademark.

Additionally, in 2007, environmental non-governmental organisations (NGOs) also published critical reports on biofuels (FOE, 2007b). World Wide Funds (WWF) published its 'position paper' on biofuels, stating that 'WWF will only support bioenergy that is environmentally, socially and economically sustainable and considers that effective measures are needed to address issues like food security, protection of permanent grasslands, natural and semi-natural forests and other high conservation value areas, a fair level playing field for small producers and a positive greenhouse gas balance over fossil fuels' (WWF, 2007). Just before the publication of the European Commission's proposal, a group of environmental NGOs demanded the introduction of much tougher standards for biofuel production, or to abandon mandatory transport biofuel targets altogether (De Clerck et al., 2008).

The discussion on biofuels steered towards the question of how different biofuels can be distinguished. This discussion is reflected in the implementation of sustainability criteria that are conditional for allowing specific biofuels on the market. Different Member States produced several reports in which sustainable criteria were introduced (see chapter 3). The European Parliament also participated in the process of approving the new Fuel Quality Directive (EP, 2007). In the new proposal for an updated Fuel Quality Directive, the European Commission proposed a minimal reduction of 1% of greenhouse gas emissions per year from road transport fuels and non-road mobile machinery, starting in 2010 (EC, 2007a). This emission target is stimulating biofuels in the transport sector and, therefore, the European Parliament added sustainability criteria to this proposal. Currently, it is unclear where the sustainability criteria will be positioned: in the Fuel Quality Directive or in the Renewable Energy Directive. Clearly, the criteria in both Directives should be consistent, which, currently, is not the case.

This report gives a first analysis of the proposal for the Renewable Energy Directive by the European Commission, focussing on biofuels in the transport sector and the sustainability criteria as proposed by the Commission. The full title of the EC's proposal is '*Proposal for a Directive of the European Parliament and of the Council on the promotion of the use of energy from renewable sources*' (EC, 2008a). The broader intention of the Directive is to set a binding target to increase the level of renewable energy in the EU energy mix to 20% by 2020. The European Commission acknowledges that an integrated approach to climate and energy policy is needed, given that energy production and use are primary sources for greenhouse gas emissions. However, climate change is not the only reason to stimulate renewables in the EU. As the European Commission states '*the European Union's increasing dependence on energy imports threatens its security of supply and implies higher prices. In contrast, boosting investment in energy efficiency, renewable energy and new technologies has wide-reaching benefits and contributes to the EU's strategy for growth and jobs*' (EC, 2008a). The targets for renewables within the EU27 should be considered in this broader setting.

Specifically for the transport sector, the European Commission proposes a binding target of 10% of renewables compared to the final consumption of energy in the transport sector for each Member State in 2020. This 10%-target can only be met by biofuels that fulfil the sustainability criteria as proposed by the Commission. In combination with the different aspects of biofuel production, the following questions are addressed in the next sections:

1. To what extent are the sustainability criteria - as formulated by the European Commission - sufficient to assure the desired outcome, based on the initial reason for proposing these criteria?

2. Which biomass production chain meets best with the proposed criteria, and what are the geographical consequences of these criteria (domestic production versus import from different regions)?
3. Which considerations could be added to improve the use of renewables in the transport sector?

This analysis encompasses a first reaction to the proposed sustainability criteria and addresses a number of sustainability aspects, ranging from greenhouse gas reductions and biodiversity concerns to other aspects like food security. These aspects are an issue at a local level in the production chain but also at a national and even global level. The conclusions on biofuels in the transport sector are not necessarily applicable to other uses of bioenergy in the electricity and heating and cooling sectors.

Chapter 2 gives a summary of the proposal by the European Commission. A general discussion on sustainability criteria is summarised in chapter 3. In chapter 4, the discussion focuses on the global impacts of the 10%-target. Thereafter, three sections are addressing the following sustainability concerns: greenhouse gas reductions, biodiversity, and food security. In chapter 8, the report concludes with considerations for improving the scope of the current proposal by the European Commission.

2 Proposal by the European Commission

The proposal for a Directive by the European Parliament and the Council on the promotion of the use of energy from renewable sources, is intended to replace earlier directives on renewables and biofuels and to introduce binding targets for all Member States of the European Community (EC, 2008a). A specific target for renewables in the transport sector is set in Article 3(3): '*Each Member State shall ensure that its share of energy from renewable sources in transport in 2020 is at least 10% of final consumption of energy in transport in that Member State*.' To calculate the total energy consumed in transport, it is stated that "*petroleum other than petrol and diesel shall not be taken into account*". In other words, the use of LPG is not considered in determining the total energy demand in the transport sector. Whether biofuels themselves need to be considered in the total energy use in 2020 is unclear.

In its communication the European Commission pays much attention to tackling the oil dependence of the transport sector as one of the most serious issues affecting the security of the energy supply in the EU. Therefore, the 10% target for the transport sector should not only be seen from an environmental, climatic point of view.

The 10%-target is expanded in Article 5(1) where the sustainability criteria are introduced: '*Biofuels and other bioliquids that do not fulfil the environmental sustainability criteria in Article 15 shall not be taken into account*.' This specific focus on biofuels and bioliquids is of the utmost importance for the transport sector, since most of the bioliquids will be applied in this sector. In other sectors, solid biomass can be applied. At this stage, no sustainability criteria are introduced for this topic. By 31 December 2010, the European Commission will report on requirements for a sustainability scheme for other possible uses of biomass (Article 15 (7)).

It is possible to use other renewable sources than biofuels in the transport sector, although '*gas, electricity and hydrogen from renewable energy sources shall only be considered once in either the electricity sector, use for heating and cooling or the transport sector for calculating the share of final consumption of energy from renewable sources*' (Article 5(1)). In other words, other routes than liquid or gaseous biofuels are possible for the transport sector, but double counting of renewable energy (like wind power) to meet the target in both the electric power and transport sector, is prevented.

Article 15 states the environmental sustainability criteria. Article 15(2) indicates '*the greenhouse gas saving from the use of biofuels and other bioliquids taken into account for the purposes referred to shall be at least 35%*'. This reduction is reached by applying the mix of renewables, not by individual raw materials. Article 16 supplies further detail on how producers must prove the biofuels' sustainability, including mass balance considerations of the biofuel mix. In Article 16 it is not entirely clear whether raw materials that do not meet the 35% greenhouse gas reduction may be considered as sustainable renewable. This part of the proposal could be clarified further. In Section 5 of this report, details are given on the proposed calculating procedure, as stated in Article 17 and Annexes of the proposal.

The biodiversity criteria are applicable to the raw materials produced (for each consignment). In Article 15(3), it is stated that '*biofuels and other bioliquids taken into account for the purposes referred to shall not be made from raw material obtained from land with recognised high biodi-*

versity value, that is to say land that had one of the following statuses in or after January 2008, whether or not the land still has this status:
(a) forest undisturbed by significant human activity, that is to say, forest where there has been no known significant human intervention or where the last significant human intervention was sufficiently long ago to have allowed the natural species composition and processes to have become re-established;
(b) areas designated for nature protection purposes, unless evidence is provided that the production of that raw material did not interfere with those purposes.
(c) highly biodiverse grassland, that is to say grassland that is species-rich, not fertilised and not degraded.'

And Article 15(4) adds '*Biofuels and other bioliquids taken into account for the purposes referred to shall not be made from raw material obtained from land with high carbon stock, that is to say land that had one of the following statuses in January 2008 and no longer has this status:*
(a) wetlands, that is to say land that is covered with or saturated by water permanently or for a significant part of the year, including pristine peatland;
(b) continuously forested areas, that is to say land spanning more than 1 hectare with trees higher than 5 metres and a canopy cover of more than 30%, or trees able to reach these thresholds in situ.'

The difference between Articles 15(3) and 15(4) lies in the fact that ecosystems in Article 15(3) are not allowed to be touched at all as biodiversity concern, whereas the ecosystems in Article 15(4) may be used for biomass production, if the status of these ecosystems remains unchanged. So the gathering of wood residue and straw is allowed, but further encroaching of these ecosystems is not allowed. Fuels in Article 15(4) are therefore only extractable as second generation biofuels.

The definition of highly biodiverse grasslands is unclear. The Commission states that identification of these grasslands will occur in future comitology, although it is unclear whether these definitions will encompass all grasslands globally. This issue will be elaborated upon in section 6.

At this stage, other criteria - for example on food security - are not set. Even more important, '*Member States shall not refuse to take into account biofuel and other bioliquids obtained in compliance with this Article, on other grounds of sustainability*' (Article 15(6)).

Other impacts of biofuels which are applied in the transport sector, are covered in obligatory reports, as set out in Article 19: '*Member States shall submit a report to the Commission on progress in the promotion and use of energy from renewable sources by 30 June 2011 at the latest, and every 2 years thereafter*'. In their report Member States must report '*commodity price and land use changes within the Member State associated with its increased use of biomass and other forms of energy from renewable sources*', '*the development and share of biofuels made from wastes, residues, grasses, straw and ligno-cellulosic material*' and '*the estimated impact of biofuel production on biodiversity, water resources, water quality and soil quality*'.

Consequences for Third World countries (especially regarding changes in commodity prices and negative effects on food security) will be reported on by the European Commission, in 2012 and every two years thereafter (as mentioned in Article 20). The Commission will base its report on those from Member States, and on reports from relevant third countries, intergovernmental organisations and other scientific and relevant pieces of work. In its report, the Commission '*shall, if appropriate, propose corrective action*' (Article 20(5)).

To stimulate innovation, the Commission states in Article 18(4) that '*for the purposes of demonstrating compliance with national renewable energy obligations placed on operators, the contribution made by biofuels produced from wastes, residues, non-food cellulosic material, and ligno-cellulosic material shall be considered to be twice that made by other biofuels*.' This intention, together with the high greenhouse gas reduction percentages as assumed in Annex VII B and E, give a clear incentive for second generation biofuels. The question remains, whether these new biofuels are available before 2020 and whether their supposed environmental benefits can really be obtained. This uncertainty will be addressed in chapter 8.

This short overview gives an insight in the basics of the Commission's proposal on biofuels in the transport sector. Chapter 5 supplies more details on the counting procedure for greenhouse gas reduction, as proposed by the Commission. Since a certain percentage of greenhouse gas reduction needs to be obtained by using a mixture of biofuels, fuel suppliers can mix different biofuel production chains. For reporting reasons we focus on results per raw material. Chapter 6 elaborates on the consequences of the biodiversity criteria. And chapter 7 addresses the issue of food security.

3 Biofuels and the sustainability criteria

As described in chapter 2, the European Commission proposes sustainability criteria for two concrete issues: greenhouse gas reductions and biodiversity (EC, 2008a). Other issues are addressed in obligatory reports by Member States (Article 19) and obligatory reports by the European Commission itself, starting in 2012 (Article 20). Moreover, the Commission clearly stimulates the use of new biofuels by double counting (in Article 18) and sets higher greenhouse gas reductions in Appendix VII B. This chapter generally discusses the different biofuel production chains and the sustainability criteria, as proposed by different political entities.

3.1 Different types of biofuels

Two main products for biofuels in transport can be distinguished: bioethanol and biodiesel. Both bioliquids can be used in the European transport market, replacing petrol and diesel respectively. Europe consumes more diesel than petrol. In projections, 55% of the consumption of transport fuels consists of diesel (EC, 2007b). The share of vegetable oil - used directly in cars with adjusted engines - is decreasing quickly. Biogases, like biomethane, biohydrogen or biodimethylether, are expected to enter only small niche markets up to 2020.

Biodiesel

The three main routes of producing biodiesel:

- Vegetable oils can be directly obtained from certain crops and converted into biodiesel through 'transesterification', a well-known and rather simple process. Examples of crops containing oil are rapeseed, sunflower and palm, oil from the latter of which cannot be produced efficiently inside the European Community. This type of biodiesel is suitable for blending with fossil diesel. Byproducts of this production, like glycerine, can be used in other applications.
- Vegetable oils can be treated with hydrogen (hydrogenation). This new process produces a better quality biodiesel than is produced by esterification. This biodiesel can be used without blending.
- All kinds of biomasses, including wood, straw or other lignocellulosic products, are initially treated in a gasification process. In a second step the gases are then converted by the Fischer-Tropsch (FT) process into biodiesel, which can be used without blending. This FT process is a well established, but rather complex, technology. Currently, this technology is only available on a small scale. The process can be used to produce other substances as well, like methanol or hydrogen.

Bioethanol

Bioethanol is produced through biological fermentation of sugars (applied mostly in Brazil) and starches (maize and wheat; respectively most applied in the United States and in Europe). Bioethanol can be mixed with petrol in low percentages. For high blends (like E85) flexifuel cars are necessary. Most of the bioethanol in Europe is converted into additives like ETBE, which can be mixed with petrol more easily. The production of bioethanol from lignocellulose is not yet well established, however, several demonstration sites already exist. The most important issues for cost reduction are hydrolysis (costs for cellulase) and improving the efficiency of converting C5-sugars.

Table 3.1 Sustainability criteria as proposed by the British LowCVP (2006)

Topics to be considered	Aspects per topic
Conservation of carbon stocks	Protection of above ground carbon Protection of soil carbon
Conservation of biodiversity	Conservation of important ecosystems and species Basic good biodiversity practice
Sustainable use of water resources	Efficient water use in water critical areas Avoidance of diffuse water pollution
Maintenance of soil fertility	Protection of soil structure and avoidance of erosion Maintain nutrient status Good fertiliser practice
Agricultural practice	Use of inputs complies with relevant legislation Use of inputs justified by documented problem Safe handling of materials
Waste management	Compliance with relevant legislation Safe storage and segregation of waste

This report will use the term 'second generation' (as it is most often used) to refer to biofuels (both biodiesel and bioethanol) based on lignocellulosic material (wood, straw, grass etc.). However, in many cases, because the so-called 'first generation' biofuels are being improved step by step, producers call their improved products 'second generation' as well. Therefore, these names might be somewhat confusing in discussions on biofuels in general.

3.2 Sustainability criteria

The Commission's focus on greenhouse gas reductions and biodiversity aspects is justified by the fact that other criteria cannot be set at a consignment level (EC, 2008c). This approach is different from initiatives on sustainability criteria in several Member States (most concrete in United Kingdom, Germany and the Netherlands) and from proposals by the European Parliament as was done for the Fuel Quality Directive (see chapter 1).

In the United Kingdom, the Low Carbon Vehicle Partnership has proposed sustainability criteria on several additional topics (Table 3.1). In its analysis, LowCVP pays most attention to the impacts of biofuels on the greenhouse gas balance, including soil carbon, and other environmental impacts.

The Cramer Committee[1] in the Netherlands composed a similar list of sustainability indicators, but with greater focus towards global effects on local communities in Third World countries. The topics addressed are (Cramer et al., 2007):

- Greenhouse gas balance: measured over the complete production chain, a greenhouse gas reduction of 30%, compared to use of fossil fuels, must be met in the transport sector.
- Competition with food and other local applications: production of biomass may not endanger the food production and other applications (for medicines et cetera).
- Biodiversity: biomass production may not affect protected or vulnerable biodiversity.
- Environment: quality of soil, air and water must be sustained.
- Welfare: production of biomass must contribute to local welfare.

1 The Committee was led by Jacqueline Cramer who became Minister of Environment in February 2007.

- Well-being: production of biomass must contribute to the well-being of employees and local population.

In its report on the Fuel Quality Directive (EC, 2007a), the European Parliament has proposed amendments to include sustainability criteria, which are very similar to the Cramer topics. Most important is the amendment that 'biofuels should show a greenhouse gas reduction of at least 50%, compared to fossil fuels, in order to offset the negative effects of growing fuel crops, such as negative environmental effects, increased competition for land, water and food, and increased pressure on natural forests and local communities' (EP, 2007). But in its amendments, the European Parliament also introduced further criteria that need to be met before subsidies may be granted to specific production chains. These criteria demand that 'international conventions and regulations are complied with, in particular relevant International Labour Organisation (ILO) standards and United Nations conventions for the protection of indigenous people', 'no significant effect on water resources occur due to biofuels production', 'air, water and soil quality is not adversely affected by extraction of fuel feedstock production' and 'no deforestation or net loss of other carbon stocks above or below ground occurs due to fuel feedstock production' (EP, 2007).

Clearly, the amount of greenhouse gas (GHG) reduction that is required is one of the most important issues on the table. However, the methodology used to calculate the amount of reduction that can be achieved by using biofuels, is a strong determining factor in such a calculation. Therefore, a clear methodology for the counting of greenhouse gas reductions is essential before production chains can be assessed. This issue is discussed in chapter 5.

The areas that are covered by these criteria in the United Kingdom, the Netherlands and the European Parliament are very much related. This is also the case for the German government in its first response to the Fuel Quality Directive. In its first response to the Fuel Quality Directive, Germany also mentioned several issues that need to be considered for the production of biofuels. Issues mentioned are emissions that may cause acidification or eutrophication or ozone destruction, impacts on soil functions or soil fertility, impacts on water quality or water supply and an environmentally sound use of fertiliser and pesticide. The discussion within the proposal of the European Commission seems to focus on how the greenhouse gas reduction should be counted and how criteria in other fields can be implemented at the production level (per consignment).

The addition in the proposal of the European Commission, saying that '*Member States shall not refuse to take into account biofuel and other bioliquids obtained in compliance with this Article, on other grounds of sustainability*' (Article 15(6)) is logical, from the perspective of producers and fuel suppliers. Otherwise, fuel suppliers would need to consider different criteria per Member State. However, it is unclear to what extent this Article allows different Member States to apply different subsidy regimes per production chain. Clearly, this Article is no incentive for Member States to continue with initiatives on proposing additional sustainability criteria in the Member States.

4 Global effects of a 10% target

Before focussing on individual sustainability aspects, it is crucial to determine to what extent the 10% biofuel target can be produced within the European Union and to what its impact will be on regions outside the EU. This chapter gives an analysis of the global effects of the 10% target. These aspects are also analysed by the European Commission in its Impacts Assessments (EC, 2006b; EC, 2008b). This chapter starts with a short overview of these Impact Assessments.

4.1 Commission's Impact Assessment

The European Commission's proposal for a Directive on renewables (EC, 2008a) is accompanied by an Impact Assessment (EC, 2008b). This assessment does not explicitly address the transport target, since this issue was covered extensively in the Commission's Renewable Energy Roadmap (EC, 2006a). The Impact Assessment mentions the transport target as a 10% biofuel target only, although other routes for transport are thinkable as well. The main conclusion in the Impact Assessment states that the 10% biofuel target '*would incur significant additional costs but result in a significant reduction of oil imports, generate extra employment and reduce greenhouse gas emissions*' (EC, 2008b). In the provisional annex to the Impact Assessment some more detail on the transport target is given. In this annex it is stated that '*it is not the function of the present impact assessment to repeat the investigation of whether such a [10%] target is appropriate. The issue to be addressed here is how to design a legislative proposal that will ensure that the 10% target is achieved in an optimal way'* (EC, 2008c).

In the annex, the Commission also clearly states that criteria on other aspects than greenhouse gas reductions and biodiversity cannot be covered by criteria on individual consignments of biofuels. On food security the Commission concludes that '*it is recommended that assessment of positive and negative food security impacts should be an important element in the regular monitoring of the implementation of the policy*' (EC, 2008c). This conclusion is further discussed in section 7. On the question of whether the 10% target will lead to additional land use, the Commission concludes that '*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*' (EC, 2008c). This conclusion is poorly documented. Further on, the Commission concludes that land-use change can only be penalised when it is caused by individual consignments.

In earlier analyses, the European Commission also paid attention to the issue of biofuels. The Impact Assessment of the Renewable Energy Roadmap (EC, 2006b) is often referred to, although its accompanying document *the Biofuels Progress Report* (EC, 2006c) contains the most valuable information. In this document the consequences of a 7% and 14% biofuel target are assessed. The arable land that is needed for these targets is 7.6 or 18.3 million hectares, respectively (EC, 2006c). In both cases about 25% of biofuels is assumed to be imported from outside the European Union. The share of 'second generation' biofuels is assumed to be between 20% and almost 40%, respectively. Within the European Union, land which is set-aside is considered to be available for biofuel production, as is some of the abandoned land. Some arable land will be re-orientated from export production to biofuel production. However, the consequences for land use outside the European Union are not addressed. On the basis of this analysis, the 10% target has been set to follow a middle path between both analysed targets of 7 and 14%.

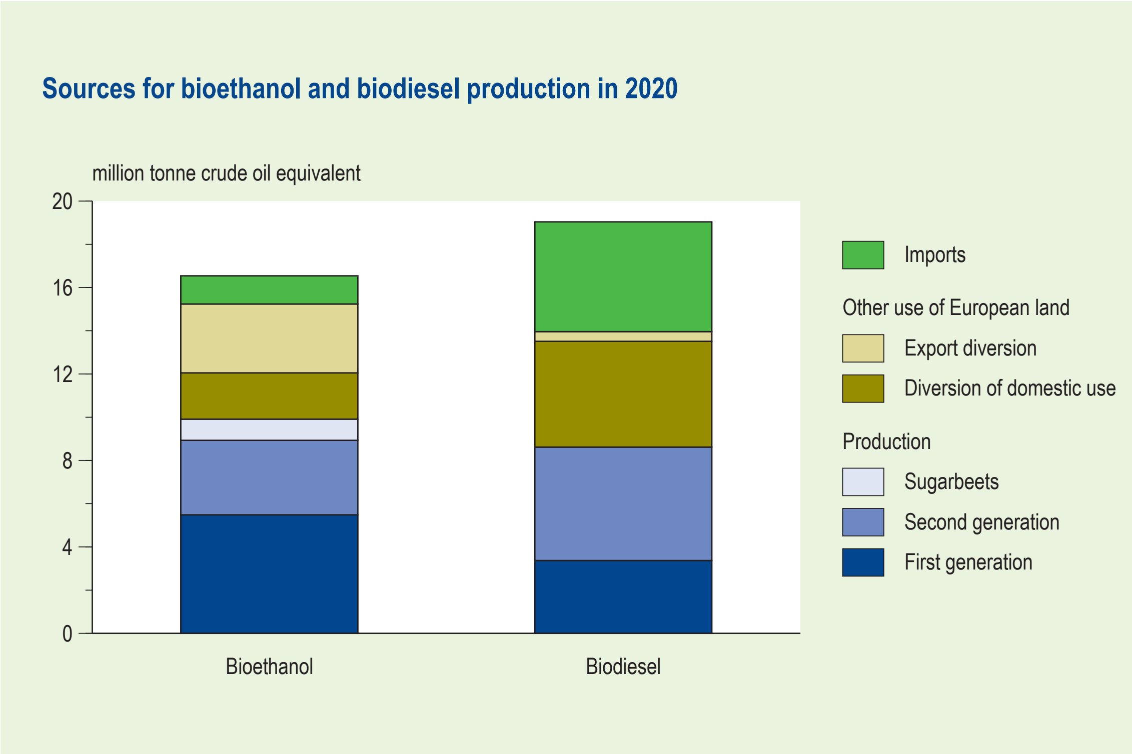

Figure 4.1 Sources of feedstocks for bioethanol and biodiesel production in 2020 in crude oil equivalent (Mtoe; EC, 2007b).

The Directorate-General for Agriculture and Rural Development also published their own analysis on the 10% biofuel target (Figure 4.1; EC, 2007b). In it is concluded that '*the 10% scenario does not overly stretch the land availability nor does it lead to a significant increase of intensities of production because of the limited pressure on markets. The long term until 2020 and the relatively small increase in cereal feed use in the EU over that time would leave enough possibilities for European farmers to support this new market outlet without a danger of returning to fertiliser and pesticide input patterns seen until the late 1980s. Farm employment could be expected to decline less than under a scenario without biofuel and additional jobs would be created in the downstream activities and processing of biofuel*' (EC, 2007b). This conclusion is built on the following assumptions: land, currently set-aside, will be used for production of biofuels, a fair amount of domestic use of agricultural products will be diverted, export of crops will be lowered, more 'second generation' biofuels will be readily available (30% of the total biofuel demand) and 18% of the biofuel demand will be imported (Figure 4.1). The impact of these changing trade regimes on countries outside the EU is not considered in the above analysis. The sensitivity analysis shows that the land-use results and the amount of imported biofuels are very much dependent on assumptions of availability of 'second generation' biofuels. When second generation biofuels contribute 20% to the biofuel demand, imports to the EU will account for 30% of the total biofuel demand and when no second generation biofuels are available, around 50% of the biofuels will be imported (EC, 2007b).

These Impact Assessments show the most crucial uncertainties when global impacts are considered: 1) how much land will be available within the European Union and 2) how much in biofuels will be imported. Both results are dependent on the availability of new techniques by 2020. Both aspects are elaborated upon in the next subsections. Section 4.2 addresses the context of global land use (also for food and feed).

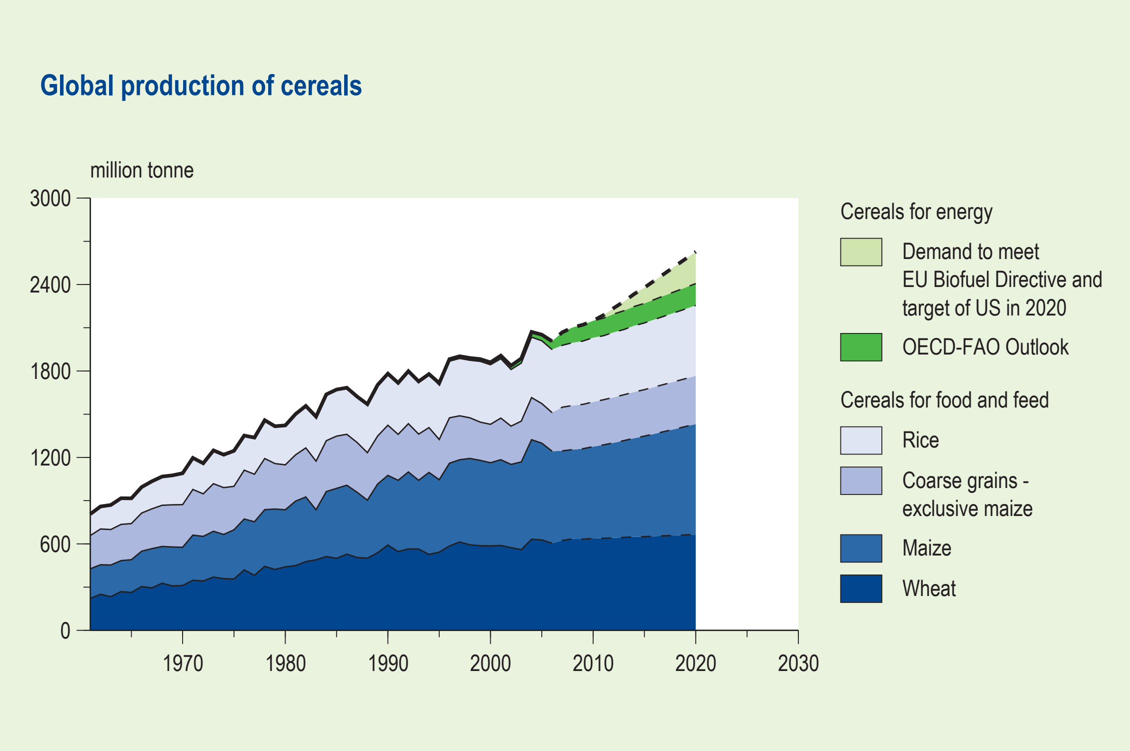

Figure 4.2 Global production of all cereal products from 1961 to 2020, including implementation of biofuel policies by the EU and US. Food and feed projection is based on OECD-FAO Outlook (2007).

4.2 Impacts on land use

The impact of a 10%-target on land use can only be considered when other global developments are also taken into account. The assumption that 10% of the European transport consumption is provided by biofuels in 2020, demands for a biofuel production that is equivalent to 34.6 Mtoe or 1.45 EJ (Figure 4.1; EC, 2007b). As the share of diesel in Europe is higher compared to petrol, the biodiesel production is 19 Mtoe and the bioethanol production 15.6 Mtoe. Expressed in litres of fuel this equals 22.9 billion litres of biodiesel and 29.2 billion litres of bioethanol, although another ratio might be possible.

Increasing crop production

This demand for biofuels has to be met in a world where other land-demanding commodities are also asked for. To take global developments into consideration, the OECD-FAO Outlook 2006-2016 (OECD/FAO, 2007) is taken as the basic source of future developments in agriculture. The required data on production and land demand are taken from this Outlook, for the most relevant food/feed and fuel crops, and extrapolated to 2020. The growth in production demand is based on the development up to 2016 and the yearly yield increase is based on the development over the last 5 years of this period. The data also reflect a presumed yearly yield increase, which is assumed to occur as the result of improved management and better crop varieties. For example, the presumed yield increase in EU27 in 2020 (compared to the yield of 2006) is 21% for wheat, 18% for maize and 38% for oilseeds.

In the baseline scenario until 2020 (OECD/FAO, 2007), a global increase in the production of different crops is expected, even without additional policies on biofuels. This increase is due to

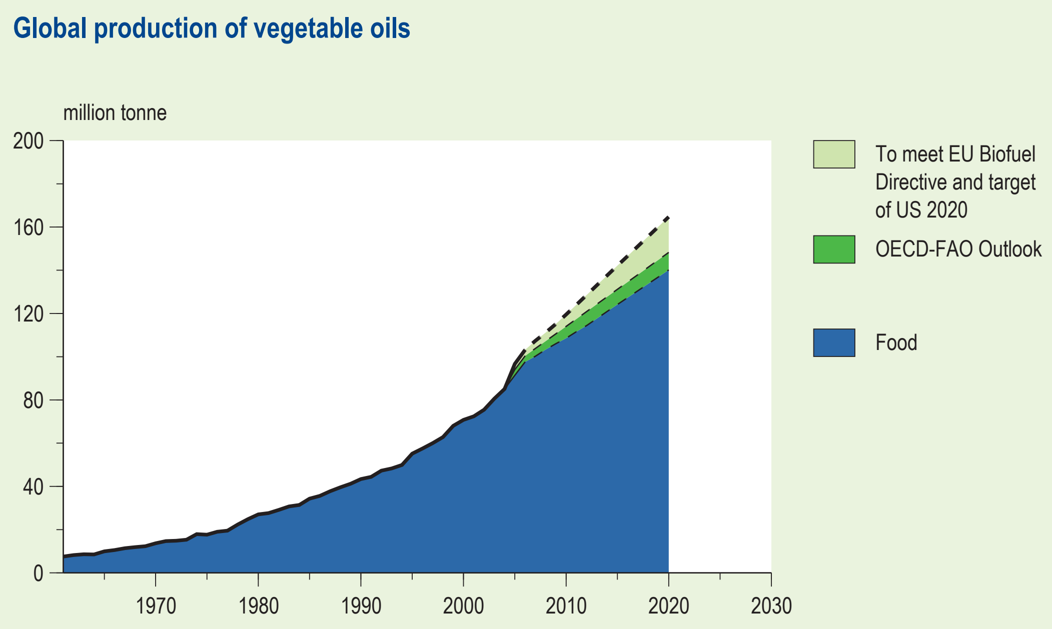

Figure 4.3 Global production of vegetable oil products from 1961 to 2020, including implementation of biofuel policies by the EU and US. Food and feed projection is based on OECD-FAO Outlook (2007).

further development in global consumption and to a shift towards more protein rich food, mainly caused by population increase and economic growth. The demand for biofuels is expected to increase, too, because of improved competitiveness of biofuels compared to fossil fuels. Figures 4.2 and 4.3 show the expected increase of global cereal production (wheat, maize, rice and other grains) and global vegetable oil production, respectively for food and feed and for biofuels, according to OECD/FAO (2007). On top of these reference developments, additional biofuel policies are implemented. Since the proposal by the European Commission is not the only proposal on biofuels, the impact of the United States (US) policies is also included. The US are aiming at a production of 132.6 billion litres of bioethanol in 2017 (35 billion gallons). In the US, the main crop used for energy is corn (maize), which is used for the production of bioethanol. In the EU, the main energy crops are oil crops, cultivated for the 23 billion litres of biodiesel (rapeseed, sunflower) and the 30 billion litres of bioethanol (wheat, maize and sugar beet). The required production of these crops is added in Figures 4.2 and 4.3. This shows that the global cereal and vegetable oil production needs to increase further until 2020.

Impacts on land use

These tonnes of crops make a demand on land. The demand in land use is dependent of (crop) productivities, the biomass product and the considered type of land. Therefore, all these aspects need to be taken into account using a scenario study. Here, the OECD/FAO Outlook (OECD/FAO, 2007) is used. No additional biofuel policies are applied in this Outlook.

First, global land use of all arable land is considered. When all cereals are regarded (wheat, rice, maize et cetera), OECD-FAO expects an increase of arable cereal land of 3.4% between 2006 and

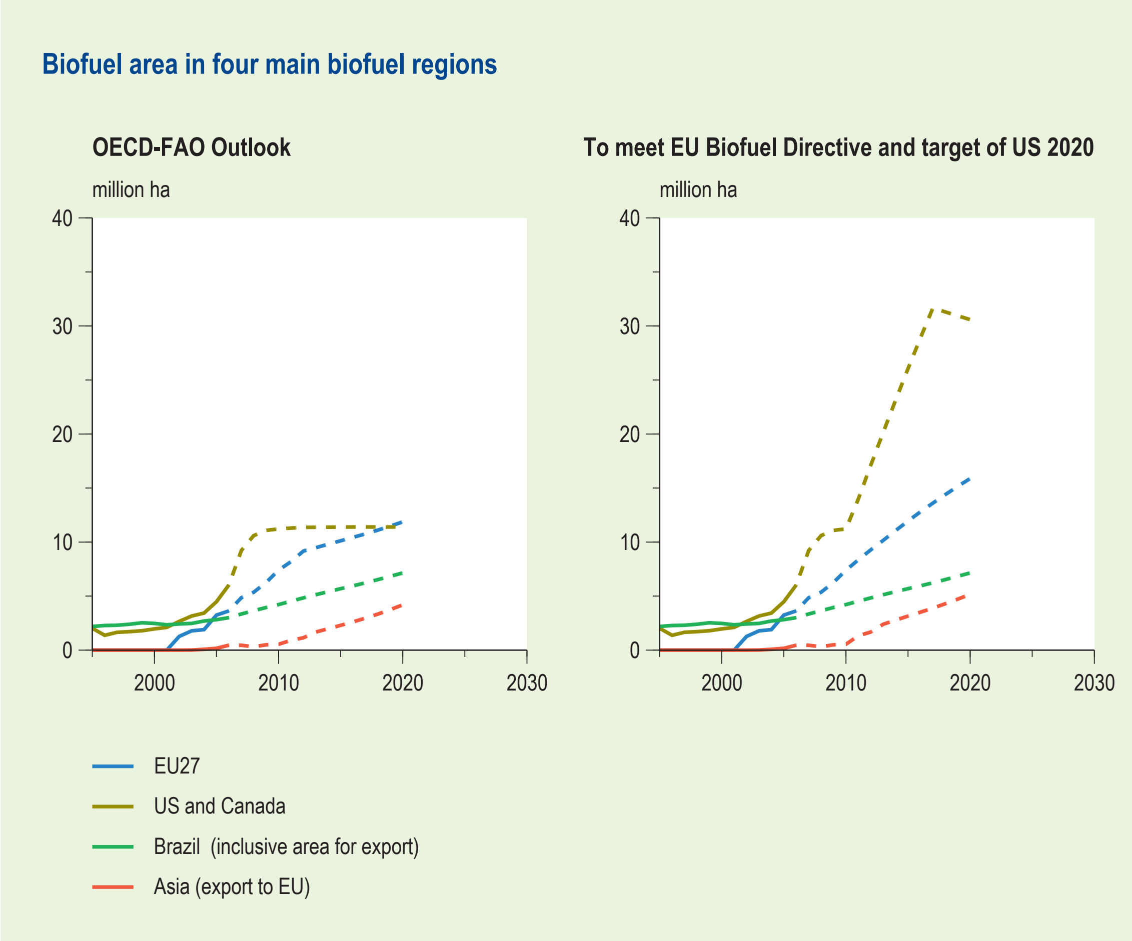

Figure 4.4 Size of biofuel area in EU, US, Canada, Brazil and Asia, according to OECD/FAO (left panel; 2007) and while meeting the United States and EU targets in their own regions (right panel).

2016. For all oil seeds an area increase of around 7% is expected (OECD/FAO, 2007). These area increases include expected yield increases.

To analyse the impact which the growing demand for biofuels has on land use, the five most important food crops -used for production of first generation biofuels- are selected: wheat, corn, oilseeds (e.g. rapeseed, sunflower and soybean), palm oil and sugar cane. The production of these crops utilise about one third of the total in global arable land area and one eighth of the total in globally utilized as agricultural land. In 2000, the total global area that these crops took up was around 500 Mha. According to the OECD-FAO Outlook, this area is expected to reach 555 Mha in 2020. Of this total, the area used for biofuels is expected to increase from 4 Mha in 2000 (less than 1% of the total area of wheat, maize, sugar cane and oilseeds) to 35 Mha in 2020 (more than 6%), assuming default developments (OECD/FAO, 2007). This scenario shows that 60% of the land increase between 2000 and 2020 will be due to the demand for biofuels, and that 40% will be due to the demand for food and feed. The development of biofuel areas is visualised in Figure 4.4 (left panel).

When the United States and EU targets are both considered, the size of the area needed for biofuels increases to around 60 Mha in 2020 (Figure 4.4; right panel). For the EU, it is assumed that about two-thirds of the required feedstocks for the production of biofuels will be produced

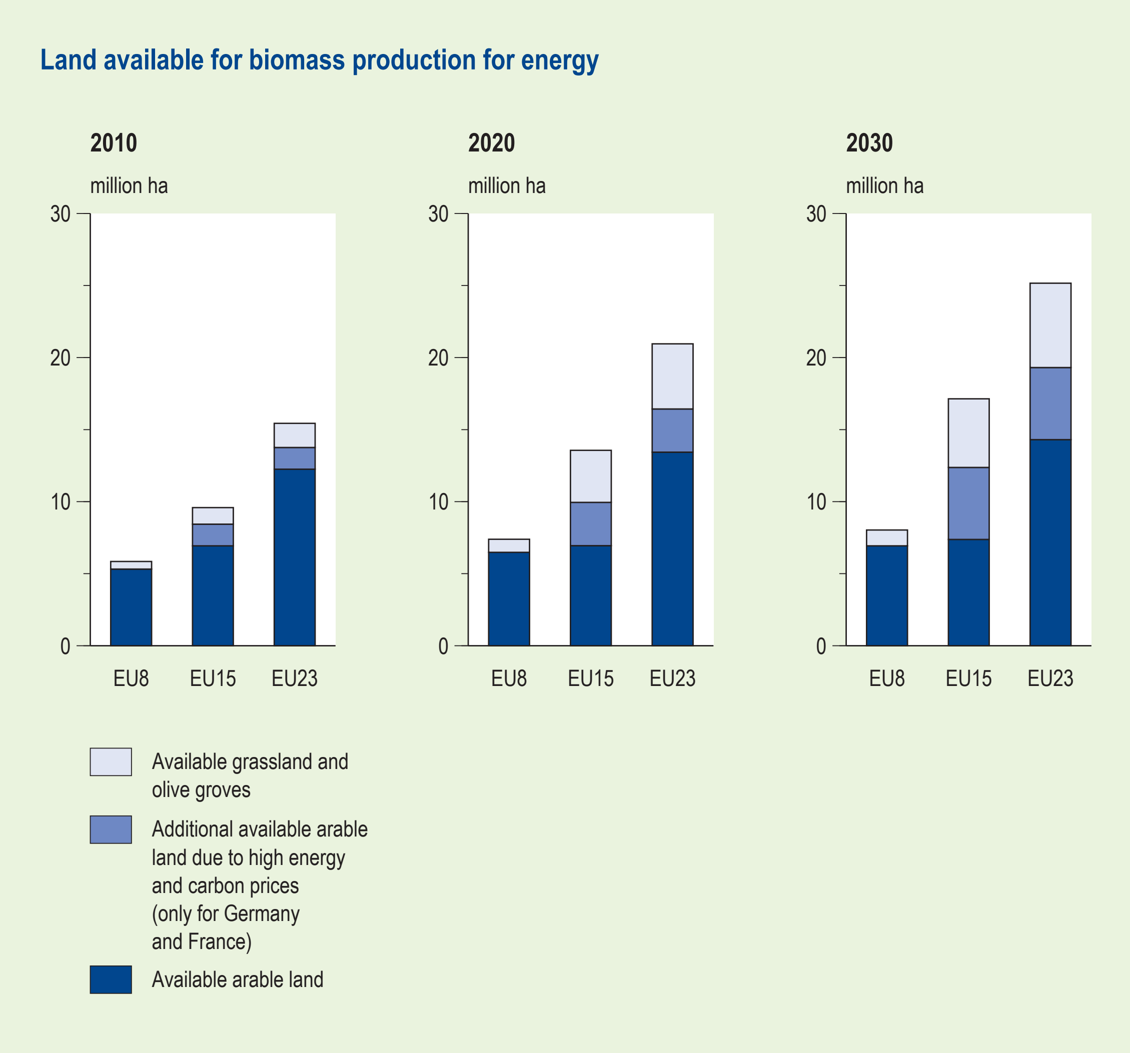

Figure 4.5 Projected land released from agricultural use within Europe that can be used for biomass production (EEA, 2006). EU23 refers to the 25 European Member States in 2004, except Malta and Cyprus. EU8 and EU15 are subtotals, comprising accessed countries from Central Europe in 2004 and the 15 'old' Western European Member States, respectively.

locally, and one-third will be imported from both Brazil (bioethanol) and Asia (palm oil). For the US, it is assumed that 100% of the required feedstocks for the production of bioethanol will be produced locally. It is assumed that the average regional yield will also apply to the additional land that is required worldwide. The additional demand shows that between 2000 and 2020, 70% of the increase in required land is due to the demand for biofuels and 30% is due to the demand for food and feed. The resulting biofuel area constitutes almost 10% of the total area of wheat, maize, sugar cane and oilseeds (581 Mha).

In Europe, an area of around 16 Mha is probably needed for biofuels. This area is needed for the production of about two-thirds of the feedstocks required to meet the biofuel target in the EU. The remaining production will have to be imported. Calculations show that, to meet the biodiesel demand, an additional land area of about 5 Mha (palm oil) is needed, and that meeting the bioethanol demand requires an additional land area of about 1.5 Mha (sugar cane in Brazil). When no biofuels are grown, some of the crop area is still needed to grow animal feed (a by-product of first generation biofuels). Therefore, one can conclude that 14 Mha is solely needed to fulfil the 57% of the EU 10%-target when the entire production is taken in first generation biofuels only. The additional 43% of the target requires about 6.5 Mha outside Europe. These figures are based on the assumption that the average yield of the additionally required land is equal to the average of the whole region. This may lead to some underestimation of total land area, because the additionally required land is likely less suitable. A lower than projected yearly yield increase might cause some additional uncertainty, also. It is concluded that the required land area in total might have a range from 20 up to 25-30 Mha.

Again, introduction of new techniques (second generation biofuels) may lower the demand for land, but it is very unlikely that the total land demand for the Commission's biofuel target will be less than 20 Mha.

4.3 Land availability within Europe

The next question is, whether such an amount (at least 20 Mha, of which 15 Mha in Europe itself) is available. According to a study by the European Environment Agency on European potentials (EEA, 2006), the amount of agricultural land in the EU22 that can be used for bioenergy production amounts up to 16 million hectares by 2020 (Figure 4.5). This land can be found in both Central and West European countries, mainly in Poland, Spain, Italy, the United Kingdom, Lithuania and Hungary. Germany and France are expected to release substantial areas due to the competition effect of bioenergy production versus food/feed production for exports (EEA, 2006). The potential available land is made up of arable land released from food and fodder production, and land that is released through productivity increases. In the EEA study even specific biodiversity criteria are considered (EEA, 2006). This study is the basis of many assumptions that all biofuels can be produced within the EU.

In the EEA study, countries without any available agricultural land are generally those with intensive or very competitive farming systems. High biodiversity grasslands are excluded, as they are valuable for important elements of (agro-)biodiversity (birdlands, species rich swards et cetera). The applied land-use criteria are comparable to those in the Commission's proposal. More land may be available when grasslands and olive groves are taken into account, but these probably do not qualify under the presently proposed criteria (EEA, 2006; Figure 4.5).

Here, a crucial consideration will be how current set-aside land will be used for biofuel production. In European impact assessments, it is assumed that around 5 Mha set-aside land may be used for biofuel production (section 4.1; EC, 2007b). After 1993, the EU wanted to limit production of commodity crops like cereals and introduced 'set-aside land'. Under this arrangement, a defined percentage of productive agricultural land was taken out of production and farmers received compensation for this set-aside land. From 2000 onwards, the percentage of obligatory set-aside in the EU15 was set at 10%. In the new Member States farmers are exempted from the obligation of set-aside. Set-aside agricultural land is mainly found in Germany, Spain, France and the United Kingdom. Altogether about 5.6 million hectares in the EU15 was registered as set-aside in 2005, which is some 4.3% of the utilised agricultural area. The set-aside regulation allowed industrial production of crops for non-food or feed purposes, mainly biofuels. In 2005, about 1 million hectares of set-aside was used for this purpose, more than half of it located in Germany. In 2007 the obligatory set-aside percentage was set at 0% because of the increasingly tight situation on the cereals market. The Commission expects that, due to this proposal, 1.6

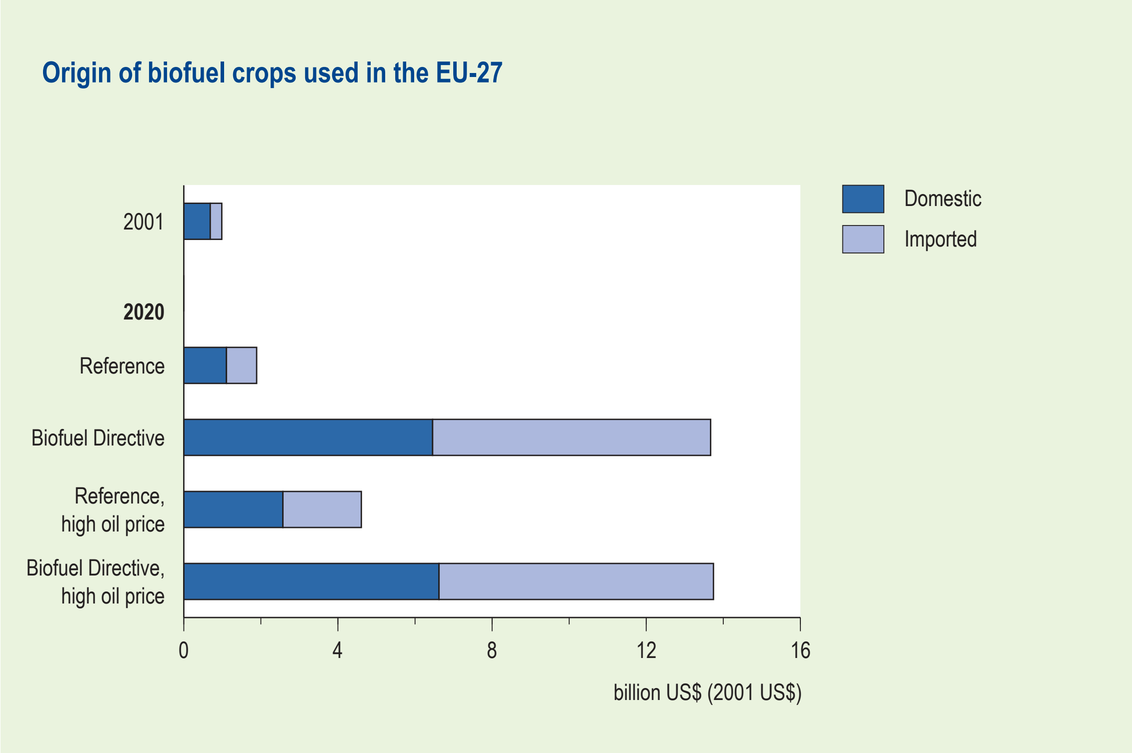

Figure 4.6 Origin of biofuel crops used in the EU27 (in billion US$, 2001; Banse et al., 2008).

to 2.9 million hectares are returned into agricultural food production. Although not originally meant as environmental measure, the set-aside arrangement contributed positively to support biodiversity in farmland areas. This was particularly studied in Britain and several field studies showed that several farmland birds, in particular, benefitted from set-aside (DEFRA, 2007). Therefore, the use of set-aside land for biofuel production will encounter a discussion whether this land can be used without affecting biodiversity concerns (chapter 6).

Nevertheless, the theoretical available amount of land, as estimated by the EEA (Figure 4.5; 2006), seems sufficient for the European ambition in 2020, which requires about 15 million hectares of productive land within the EU (Figure 4.4; right panel). Of course, the answer to whether this can be really achieved depends on the condition under which land will become available. In the EEA scenario study, abandonment takes place under the assumption of a further reform of the CAP (Common Agricultural Policy), with total liberalisation of the animal product markets. In other studies where other choices in CAP reform are simulated, other results for land availability are given. For example, the Eururalis-2 scenario study includes a scenario that accentuates regional market development instead of a global economy, and projects only 3.5 million hectares of abandoned agricultural land (Rienks, 2008). Therefore, the availability of land within Europe, in combination with biodiversity concerns as laid out in the proposal for a Directive, is very much dependent on future changes in CAP. It seems that one of the more important conditions for land availability within Europe is liberalisation of CAP. The location of abandoned land within the EU is also uncertain. EEA (2006) indicates high potentials in Central Europe, whereas Eururalis-2 returns more abandoned land in the EU15 countries (Rienks, 2008; Eickhout and Prins, 2008).

4.4 Imports of biofuels

When European agricultural policies are liberalised completely (to get enough land available in the EU), it will be very difficult to maintain production of biofuels within the EU, given high competitiveness of biofuel production in other regions (for example sugar cane production in Brazil). When full liberalisation of the agricultural market is simulated in a macro-economic general equilibrium economic model (LEITAP; Van Meijl et al., 2006; Eickhout et al., 2007), in combination with meeting the European biofuel target (Banse et al., 2008), more than 50% of the required biofuels will be imported from other regions. Even simulations with high oil prices are not affecting these results drastically (Figure 4.6). When scenarios are considered where no CAP reform is assumed, around 30% of the biofuels are still expected to be imported (Eickhout and Prins, 2008). These results are based on analyses with first generation biofuels (Banse et al., 2008).

Therefore, it will be very unlikely that all required biofuels will be grown in Europe. More importantly, the Commission's proposal can be seen as an incentive to produce biofuels outside Europe, which is difficult to manage. Moreover, alternatives for bioethanol and biodiesel can be produced more efficiently in other regions. For example, when 50% of the required bioethanol is produced in Brazil with sugar cane, the area needed is 'only' 2 million ha. This shows that for reasons of productivity, production outside Europe is recommendable. This trade-off of productivity and location of production is not addressed in the current proposal.

4.5 Conclusion

Even without an additional demand for biofuels, scenarios show a need for extra agricultural land on a global scale, because of population and welfare growth. Biofuels are an additional land demanding source and will lead to additional pressure on land. Even when productivity increases twice as fast as expected, additional land will be needed for growing crops for biofuels. To increase land abandonment within the European Union, further liberalisation of European agriculture is often considered. However, the same process of liberalisation will also lead to more imports of biofuels or biomass for biofuels. The implication is an extra conversion of land outside of Europe. It is assumed the cultivation of wood and woody materials can be done on land which is not suitable for food and feed production. However, the extra impetus in the Commission's proposal to use these types of biomass is too weak to guarantee that this will occur in practice. Land conversion has two important ecological aspects: soil emissions of CO_2 and loss of natural area and biodiversity. They are discussed in the following chapters.

5 Greenhouse gas reductions

One of the most important advantages that biofuels have over fossil fuels, is their assumed lower greenhouse gas (GHG) emissions in the production chain. In their proposal, the European Commission states that the greenhouse gas reduction due to the use of biofuels, needs to be at least 35%. To calculate this greenhouse gas reduction, several aspects of the production process need to be considered. The following elements might have a significant impact on the results:

- The assumed or actual crop yield.
- Carbon emissions because of land use changes (if relevant).
- N_2O emissions which can be attributed to the production of the biomass crop.
- Emission due to processes in the production chain, especially CO_2 and N_2O emissions in the chemical industry of fertiliser production.
- The use of biomass for process energy in the production chain.
- The allocation method.

In this chapter the proposal by the European Commission is compared to these aspects, using data by Hamelinck and Hoogwijk(2007).

5.1 Methodology in the Commission's proposal

Article 17 in the Commission's proposal (EC, 2008a) encompasses the methodology, that the European Commission is proposing, to calculate the GHG reduction by using biofuel compared to fossil fuel. In the proposal, different options are possible: either default values as given by the Commission will be taken or a detailed calculation methodology is followed. Clearly, many Member States will prefer to use default values, in order to minimise the work load. Therefore, the Commission has used conservative levels of greenhouse gas reductions. In its Annex to the Impact Assessment, the Commission states that 'it is recommended to calculate default values on the assumption that emissions from processing are 40% higher in the default case than in the typical case'(EC, 2008c). This clearly shows that the Commission does not want to set the default greenhouse gas reductions at a high level.

The default greenhouse gas reduction values are only allowed to be used when the raw materials are cultivated outside the Community, or in those regions within the Community which are assigned beforehand by the Member States (this needs to be done before 31 March 2010). These areas within the Community need to have equal or lower emissions for cultivation than assigned by the Commission in Appendix VII-D (Article 17(2)). Biofuels which are produced in other areas than those assigned by the Member States, need to be accounted for with actual values for cultivation (Article 17(3)). These conditions can be seen as specific disincentives for using raw material from EU land that is liable to high N_2O emissions from cultivation.

In Appendix VII-C, the Commission is proposing a fairly detailed methodology, in which most of the aspects of a well-to-wheel analysis are considered (EC, 2008a). The following emissions need to be included in the calculations: emissions from the extraction or cultivation of raw materials, annualised emissions from carbon stock changes caused by land use change, emissions from processing, emissions from transport and distribution and emissions from the fuel in use. In the case of by-products from first generation biofuels, the accounting will have to be done on the basis of the energy content. This allocation method of by-products is transparent and relatively simple to calculate. The method is independent of market developments, which would not be the case if the accounting would have been based on economic value of by-products.

In summary, the proposed methodology by the European Commission is very extensive and, theoretically, accounts for most of the steps that need to be considered in a well-to-wheel analysis. An important aspect of the proposed methodology is the consideration of soil emissions due to land use change. The Commission proposes high default values. For example, if permanent grass (not highly biodiverse, since this category is excluded in Article 15(3) (see chapter 2) is converted to arable land for biofuels, the emissions become 18 tonnes CO_2-equivalent/ha per year. This value is difficult to overcome by the advantages of biofuels. Therefore, the methodology is a clear incentive to use existing arable land and not permanent grassland or lightly forested areas. However, it is questionable if a uniform application of these defaults within EU will lead to sufficient discrimination, since the average carbon content of the soils under arable land and grassland differ by agro-ecological zones.

The only disadvantage of the proposed methodology is that displacement of food and feed crops is not considered. However, this issue is difficult to address for individual consignments (see chapters 6 and 7). This omission in the criteria implies that the soil emissions, which are mentioned above, could be the result of land conversion, indirectly forced by the increasing demand for biomass for biofuels. This issue is addressed in section 5.4.

5.2 GHG reductions per production chain

The default values, as chosen in the proposal, are documented in Annex 7 of the Commission staff working document, which is an annex to the Impact Assessment of the European Commission (EC, 2008c). In this Annex 7, the reasoning for the methodology is given and the choice of default values is explained. This explanation shows that the typical values in Appendix VII-A and B are based on energy allocation of by-products (as proposed in the methodology). To build in a safety valve, most of the default values are set to lower GHG reductions than the calculated value, including accounting of by-products by energy allocation. This also shows the European Commission's cautiousness with respect to the use of biofuels.

Here, several production chains are considered and compared with default values from the European Commission (see Annex A). For 2020, emissions are calculated, including an increase in agricultural productivity and process efficiency. The differences between the default and typical values in the Commission's proposal illustrate that the assumptions made could be important. Note that for wood based biofuels it is assumed that processing emissions are zero, since only biomass is used. It should be realised that, in practice, there will be a wide range of situations with different emissions. Therefore, the differences do not imply the values are incorrect or not suitable. It shows that different assumptions are important for the calculation results. However, there is no reason to expect higher emissions than the default values, if good agricultural management and good industrial process management are guaranteed.

Figure 5.1 shows the results for the overall reductions. The impact of some of the different assumptions, as mentioned above, is given explicitly per production chain. The first set of assumptions is about the use of bioenergy in the production chain and the best available technology in fertiliser production. In the production chain, energy is needed for transport and processing. In most cases, the input is fossil energy, but also biomass can be used as a resource. For

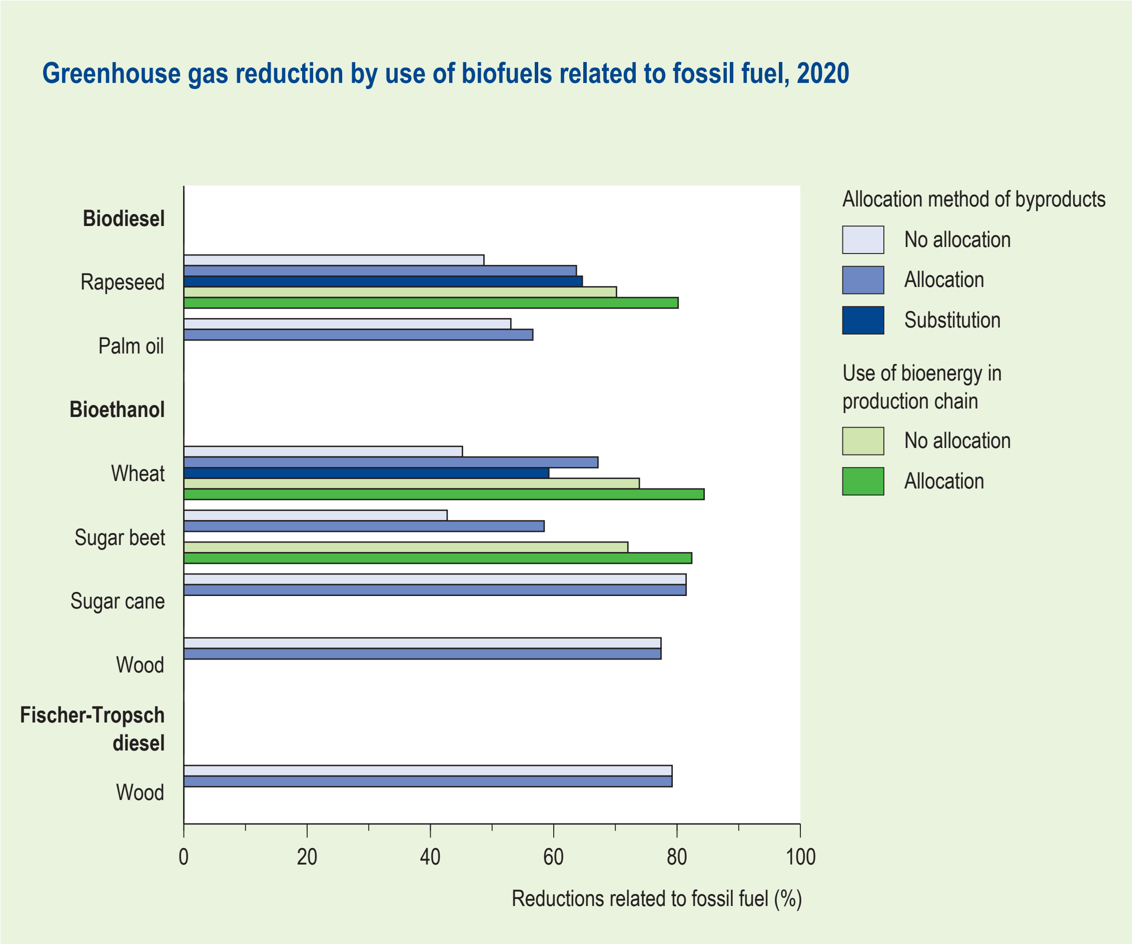

Figure 5.1 GHG savings according to MNP calculations for different aspects (on the basis of Hamelinck and Hoogwijk, 2007 and Ros and Montfoort, 2006). Use of bioenergy in production chain also refers to best available technology for fertiliser use. Allocation method is energy based as in the Commission's proposal. Substitution refers to substitution of soy meal as animal feed and fossil glycerine.

products like sugar cane and wood ethanol or wood based Fischer-Tropsch diesel, bioenergy is already assumed to be normal practice. For others it is not, but it might be a way to increase the greenhouse gas reduction rate. It should be realised that, in these cases, land use will increase.

Another crucial uncertainty is how allocation of by-products is considered. Here, three different steps are considered. Firstly, no allocation of by-products is applied, leading to the lowest greenhouse gas reductions for traditional biofuels. Secondly, allocation of by-products based on the energy value of these products, like glycerine or animal feed, is assumed. This approach is the proposed methodology in Appendix VII-C of the proposal of the European Commission. Thirdly, substitution of fossil products or animal feed with by-products of biofuels is assumed. For example fossil glycerine is substituted by bioglycerine, and animal feed can be a substitute for soy meal, with corrections for the soy oil. The greenhouse gas reduction rate increases when more by-products can be used.

Figure 5.1 shows that the methodology of handling by-products is a crucial step for achieving greenhouse gas reductions. The difference between the energy based allocation method and the substitution method, seems quite acceptable. More calculations with different management practices (fertiliser use) show these differences to be in the order of -15 to 15%. The impact on land use (and biodiversity) is not accurately calculated by the energy based allocation method. This will be further discussed in the next section.

In some cases, actual information on only one part of the process chain might be sufficient to comply with the criterion, even though the total emission reduction would not. This could happen when default values are prohibitive and only one part of the process chain is causing the default low greenhouse gas reduction, as in the case of palm oil. Biofuels, which do not comply with the criterion of 35%, can be mixed with others. The default values can probably be applied to calculate a weighed average emission reduction for the mixture, although Article 16(1) seems to prohibit such an accounting. The Commission's proposal is not clear about this.

In Europe, most of the bioethanol produced for transport ends up as ethyl tertiary-butyl ether (ETBE) in petrol, which is easier to handle. The emissions of additives like ETBE are not equal to the emissions of the ethanol pathways used, because of the extra synthesis step to produce ETBE. They are higher and, therefore, the greenhouse gas reduction is lower. However, ETBE replaces fossil methyl tertiary-butyl ether (MTBE; 1-5% in gasoline), to some extend. MTBEs reference value is higher than the emission of petrol, and the reduction is a bit higher, too, because of this replacement by ETBE. For reasons of simplicity, an 'average' value has been chosen in the proposal of the Commission, but in actual practice, blendings will realise up to 10% lower emission reductions. The way the proposed method allocates emissions to by-products -like straw and excess electricity- is positive, because it prevents the inclusion of emission reductions which are not strictly related to the biofuels.

5.3 The impact of fertiliser use

So far, it can be concluded that the Commission's proposes a detailed methodology, but that most of the Member States will work with the default values, since these values are easy to use and have been chosen with care.

However, the issue of fertiliser use has hardly been mentioned. In the proposed methodology (Appendix VII-C), fertiliser use should be considered. However, it hardly addresses the issue that fuel production per hectare and farmers income will increase with higher doses of fertiliser. Therefore, a target for biofuels will automatically introduce an incentive for increased use of fertiliser. Moreover, land use concerns are another incentive to minimise the area that is used for biofuels. Clearly, intensification through fertiliser use will be one of the impacts of the Commission's proposal.

Fertiliser use will lead to additional N_2O emissions, decreasing the GHG reductions. Figure 5.2 shows this trade-off for rapeseed biodiesel: the GHG reductions are declining when high N application rates are applied. When only default values from the proposal are used (36% reduction for rapeseed biodiesel) and farmers use a lot of fertiliser to optimise their income, the 'actual' GHG reductions become very uncertain. For other production chains the results will be different (Smeets et al., 2008) and probably for each production chain an optimal N application rate can be distinguished. This aspect is not considered sufficiently in the current proposal and shows the complexity of the problem that is introduced by the target of 10%.

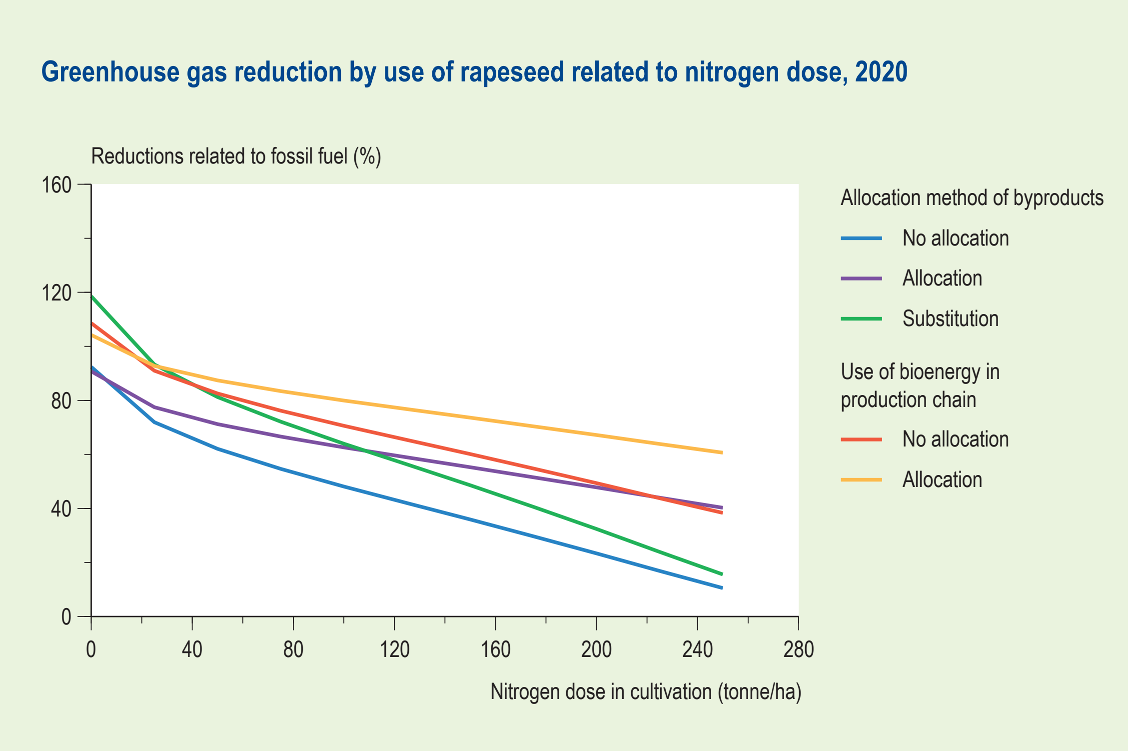

Figure 5.2 GHG savings for different N application rates, for different allocation rules of byproducts.

5.4 Soil emissions

The proposed calculation method for greenhouse gas emissions includes direct soil emissions (Appendix VII-C of the proposal). If, on a specific site, land is converted to produce biomass for biofuels, the future carbon content (in equilibrium) might be different from the present carbon content. This difference implies a CO_2 emission (but in some cases it could be an uptake). The Commission's proposal includes values for carbon contents for different land characteristics and assumes that the new equilibrium will be reached in 20 years.

Based on these values, soil emissions of 18 tonnes/ha per year are calculated for the conversion of permanent grassland or lightly forested area into arable land (see section 5.1). Although in actual practice, there will be a large range of values, these soil emissions are very relevant. Therefore, it is important to optimise the emission reduction per hectare of cultivated land. When the results from Figure 5.1 are translated into avoided greenhouse gas emissions per hectare (Figure 5.3), it becomes clear that these avoided emissions are very dependent on the allocation method that is used in the calculation methodology.

Figure 5.3 shows the emission reduction per hectare for the different biofuels, without soil emissions. Not only the GHG emissions are allocated, but land use is also included. These allocations are not the same, because land use is only related to the cultivation and GHG emissions are released in all steps of the process in the production chain. The allocation of excess electricity is included. It is also shown, that the use of bioenergy in the processes has no positive effect on this indicator, and for sugar beet it is even negative compared to sugar cane produced without sugar cane. The substitution method leads to some exceptional results. Especially the substitution of soy meal -as animal feed- by by-products of rapeseed or wheat, implies also the substi-

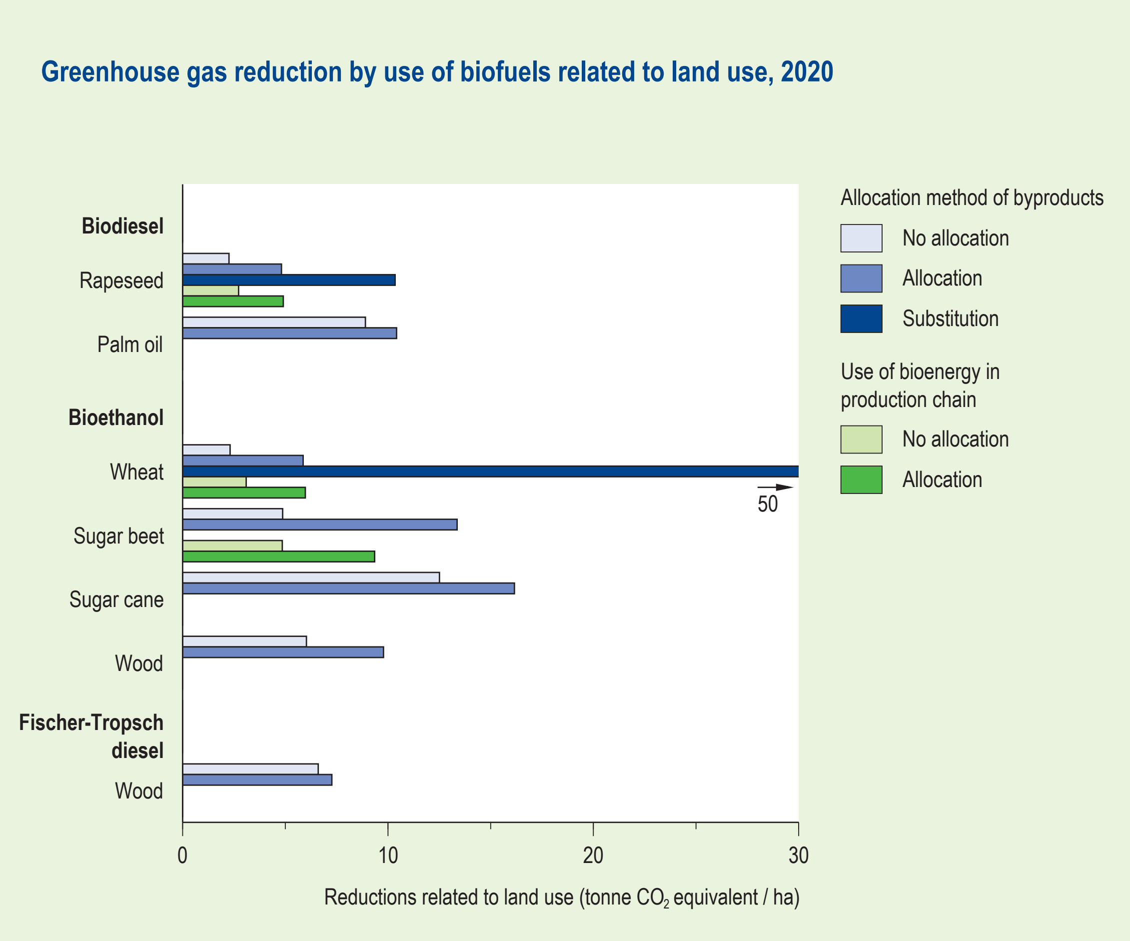

Figure 5.3 Avoided emissions per hectare for the same production chains and sensitivity settings as in Figure 5.1.

tution of land for soy. Because of relatively low soy productivity, compared to rapeseed and wheat, the net land use is quite small. In some situations a gain of land can be calculated, but increasing productivities for soy could change this picture strongly. This result places a question mark over wood based biofuels, used as direct input in the transport sector, and whether they return much better benefits than presently used biofuels.

Most of the GHG emission reductions are between 5 and 15 tonnes of CO_2-equivalent per hectare per year. Sugar cane and sugar beet are doing relatively well. However, all of these values are lower than the potential soil emission of 18 tonnes/ha per year. With this kind of land conversion, the biofuels could not comply with the criterion of 35% reduction. Therefore, although the European Commission's proposal is considering the issue of land displacement well enough in the proposed methodology (in Appendix VII-C of the proposal), it is *not* doing so – as explicitly stated – in the default values given in Appendix VII-A/B. Although it is stated, that these values are valid if produced with no net carbon emissions from land use change. It is unclear how this will be checked.

These rules are probably sufficient to prevent soil carbon emissions from the production of biofuels. The results in chapter 4 show that a 10% target for biofuels will contribute to global land conversion, although because of the criteria not directly for biofuels for Europe. If it indirectly drives towards the conversion of land and only about half of this land would be permanent grassland or lightly forested area, then the positive effect of the biofuels on GHG emissions would already have been undone.

5.5 Conclusions

In the proposal of the European Commission, default values are introduced that all Member States can use, as long as biofuels are grown outside the European Community or in assigned NUTS2 areas. Consequently, most producers in Member States will use the default values. These default values are set in a way, that the criterion of 35% does not stop most of the biofuels to enter the market. For palm oil, there seem to be restrictions. The default value for the emission of palm oil diesel has been set relatively high, unless processing of palm oil does not cause additional methane emissions.

The energy based allocation method results in different reductions than the substitution method. The last is more representative of practical situations. However, it is understandable that the energy based method has been selected, because of its relative simplicity. Some calculations show differences of -15 to 15% in emission reductions. Differences in land use are more relevant in most cases.

The analysis in chapter 4 shows there is a need for extra land to produce biofuels globally. To comply with European criteria, the newly converted land outside the EU is not likely to be used for biofuels for Europe, but for exports to other nations, domestic use or for the cultivation of feed and food. Indirectly, the resulting soil emissions can be related to biofuel production for Europe, making the overall impact of biofuels on greenhouse gas emissions likely to be negative (section 5.4). Therefore, the total emission reduction from using biofuels will not likely be 35% because of the 10% blending. In combination with an increase in transport emissions, the impact of biofuels on the European GHG balance will be marginally. This conclusion will be even stronger when higher fertiliser application rates are considered - a logical consequence of the push for more biofuels (section 5.3).

The expected results of biofuels are very dependent on the use of by-products. Especially animal feed is potentially an important co-product of biofuels, provided they are not based on the cultivation of wood or woody materials only. Therefore, the end use of co-products needs to be assessed as well, before the final call on the 'sustainability' of biofuels can be given. The global production of animal feed is crucial in this respect. Substitution calculations have some very positive results, but the growing demand for feed is a sustainability problem in itself. Therefore, impact assessments of biofuels using the substitution method without considering the global impact of feed production, might be too positive.

6 Biodiversity and change in land use

Besides objectives for greenhouse gas reductions, the European Commission has also formulated sustainability criteria to prevent loss of valuable biodiversity and undesired land use changes (Article 15(3) and 15(4); see chapter 2). In promoting the use of biofuels, two contrasting issues are playing a role in relation to biodiversity. On the one hand, biodiversity is positively affected by climate change mitigation (IPCC, 2007), but on the other hand, it is often negatively impacted by changes in land use (CBD/MNP, 2007). This is of interest for policy formulation because the EU has agreed on climate stabilisation at a level of 2ºC, but has also agreed upon a halt of biodiversity loss by 2010. These two targets ask for a careful consideration of the consequences of setting sustainability criteria for biodiversity and land use impacts. The climate change versus land use change aspect is addressed in section 6.2 and the global biodiversity concerns are addressed in section 6.3.

6.1 Criteria in the Commission's proposal

In order to prevent valuable land for biodiversity from being used for biofuel production, the Commission's proposal excludes several categories of land (chapter 2). In Article 17(3) specific land types are excluded from any change in land use, since they are considered to have a high biodiversity value. These specific land types are protected areas, pristine and restored forests and highly biodiverse grasslands. Article 17(4) prevents specific land use changes that would lead to high carbon losses. Wetlands and forested lands with specific definitions are not fully excluded from use, but their status may not be changed (chapter 2).

The abovementioned criteria lead to the following types of land, which may be available for biofuel crop production:

- Abandoned agricultural areas, i.e. areas which have been taken out of production. These can be either crop production areas or pastures.
- Natural grasslands with a low biodiversity value, although this value is difficult to determine (see below).
- Moderately degraded soils, which can still be used for crop production.

One of the key uncertainties is the definition of highly biodiverse grasslands. The Commission states that '*criteria and geographic ranges to determine which grasslands shall be covered by the proposal*' will be established after approval of the proposal. With the term 'highly biodiverse grassland' the Commission introduces in EC legislation a new land category. The Commission defines it as grassland that is species-rich, not fertilised and not degraded. This definition will certainly give room for interpretation and debate. In the context of the rural development policy, the Commission introduced the term 'high nature value areas' which closely relates to 'highly biodiverse grassland'.

It is advisable to relate these different terms to one another. An important component of highly biodiverse grasslands is undoubtedly the semi-natural grasslands. These are grassland ecosystems which are extensively managed by farmers (mowing and/or grazing), thus preventing natural succession to forest. For the EU Member States in central and eastern Europe, estimates show that about 12% of the total agricultural area consists of these semi-natural grasslands (about 7 million ha). These semi-natural grasslands make up around 45% of the total area of permanent grasslands in these States (Veen et al., 2001). Both the semi-natural grasslands, which have been subject to relatively low nutrient application, and those left unfertilised, support a high biodiversity. Many sensitive plant, bird and butterfly species are connected with these types of biotopes. Therefore, the definition of highly biodiverse grasslands in Europe is probably best linked to the discussion on high nature value areas, to prevent new definition discussions on European types of land use.

6.2 Climate versus land-use change

The criteria in the proposed Directive on excluded lands, are meant to limit undesirable trade-offs causing further habitat loss, connected to the presented biofuel ambition. This is essential, as, historically, the conversion of natural habitats to human dominated land use has been identified as the largest pressure on global biodiversity, so far (Sala et al., 2000). However, for future biodiversity decline it is projected that climate change will become more and more important (MA, 2005; CBD/MNP, 2007). Therefore, a balance has to be drawn between biodiversity loss through further land use conversion and avoided biodiversity loss through climate change mitigation. With this balance, it is possible to indicate how efficient biofuel crops are in delivering a positive contribution to a synergy for biodiversity between the EU climate and biodiversity targets.

The aggregated biodiversity indicator 'Mean-Species-Abundance of original species' (MSA) is applied in finding such a balance. MSA integrates the effects of different pressures (Alkemade et al., 2006). Integration is performed by expressing biodiversity and pressures into area equivalents. The indicator is often used in global scenario studies (UNEP, 2007; OECD, 2008). Therefore, this indicator is suitable for analysing the balance between the immediate effects of land use change and expected biodiversity gains due to potential avoided climate change. Integration and aggregation is possible by expressing all pressures in an affected area with a complete original biodiversity (unit km^2 MSA).

The (mostly) negative effect of human land use on 'original biodiversity' has been extensively studied by reviewing literature on land use changes and associated changes in species abundance (Alkemade et al., 2006). Here, the effect of land use is determined by the difference in biodiversity values of previous land use in a reference scenario, and the biodiversity value of biofuel crops, either grown intensively (current arable crops; section 3.1) or more extensively (upcoming biofuel types like perennial grasses, short-rotation wood). The positive effect of reduced CO_2 emissions is derived from modelling exercises on future greenhouse gas effects (Bakkenes et al., 2006). Several uncertainties play a role in this calculation, but the main element are the climate sensitivity to the atmospheric system (T-response to elevated CO_2) and the biodiversity response to increased temperatures. The effect of avoided CO_2 emissions was calculated using a comparison between a baseline scenario and a mitigation scenario (i.e. a scenario that is aimed at reaching a 450-ppm CO_2-equivalent concentration; Van Vuuren et al., 2007). From this scenario comparison, the resulting avoided temperature change, and the avoided biodiversity response were taken for the year 2100.

Clearly, the intensive production of biofuels is directly impacting biodiversity in a negative way, unless already intensively managed arable land is used. The positive impact of biofuel production through avoided climate impacts, is affecting biodiversity only after many crop rotations. First calculations indicate that the emission reduction of around 6,000 (± 3,5000) tonnes of

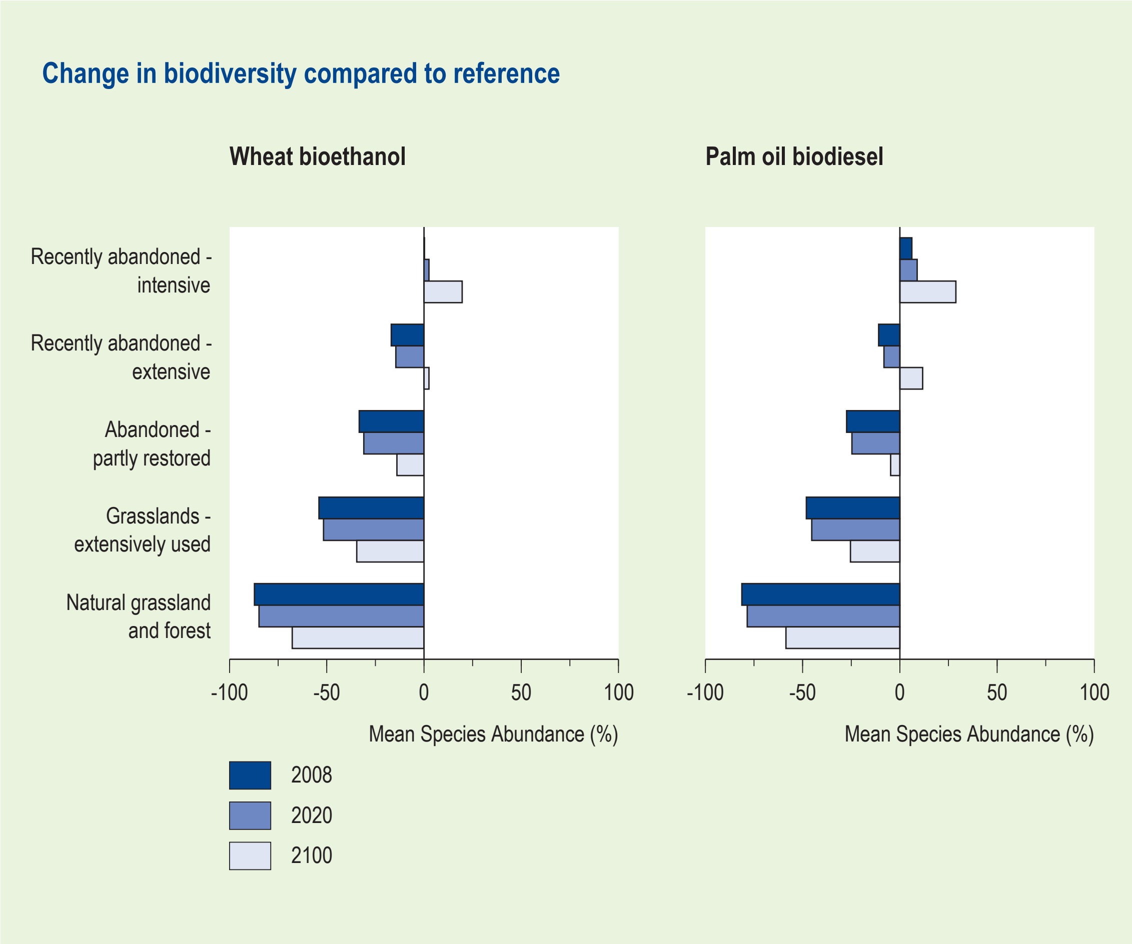

Figure 6.1 Biodiversity balance of land-use change and avoided climate change for wheat production (left panel) and palm oil production (right panel).

CO_2-equivalents, prevents the loss of one hectare of biodiversity through climate change (in MSA terms). Since emission reductions by biofuels are in the range of 5 to 15 tonnes CO_2-equivalent per hectare (assuming no significant loss of soil carbon; section 5.4), a yearly loss of biodiversity of around 10 to 35 m² of MSA can be compensated by one hectare of biofuels. Clearly, only a longer term use of biofuels will lead to positive outcomes for biodiversity, although this term will be around 100 years.

So far, general calculations have been presented. The biodiversity balance mostly depends on the actual land that is converted into biofuels and on the number of years that a particular biofuel crop is grown. In Figure 6.1 the results are shown for wheat and palm oil.

The first year of production (2008) is dominated by the negative effect of land use. This creates a situation that may be called a 'biodiversity debt' (cf. carbon debt in Fargione et al., 2008). In the following years, the positive effect of avoided climate change gets more important with each harvest cycle, as it has a cumulative effect. When natural habitats (whether grasslands or forests) are used for biofuel production, the negative effect of land use change continues to dominate the positive climate change effect, even up to 2100. At the extreme opposite side, biofuel production on recently abandoned lands that were under intensive agricultural management, will immediately result in positive effects, as the former land use does not present valuable biodiversity.

The category of extensively used grasslands is especially vulnerable, as these lands may present high values in (agro-)biodiversity. In Europe, such high nature value areas (section 6.1) are already under pressure of conversion and intensification. The period up to 2100 is not enough to compensate the biodiversity loss due to land use change. The use of moderately degraded lands will also result in immediate biodiversity wins, due to the improved land use. But there are not enough production data available, yet, to assess the development over time. Moreover, for degraded lands, only a limited amount of production data is available, for instance for Jatropha.

The differences between wheat and palm oil are not very striking (Figure 6.1). This is due to the fact that both crops have a large impact on land use change, while the positive effect of their CO_2 performances will always take a considerable amount of time. Part of the current preference for new generation crops is that they can be produced on land unsuitable for food production, but these will also show a lower than optimal productivity. However, different crop productivity on different types of land (with different fertility) has not been taken into account in the present analysis.

Applying the biodiversity balance for different crops on different land types shows that greenhouse gas reductions from biofuel production are often not enough to compensate for the biodiversity losses from increased land use conversion, not even within a time frame of several decades. Beneficial effects for biodiversity are only noted, when abandoned intensively used agricultural lands or (moderately) degraded lands are used. On these lands, biofuel production can even lead to gains in biodiversity (Figure 6.1). More information on the possibilities and production potential in degraded lands is necessary to estimate their real contribution. Under the proposed criteria, natural and extensively used grasslands remain under further threat. Because the exact meaning of the criterion 'high diverse grasslands' is not made clear, this type of land is potentially available for biofuel production, which may put additional pressure on this type of ecosystem.

6.3 Global biodiversity impacts

As mentioned in section 6.1, one of the important uncertainties with respect to biodiversity is the introduced category of highly biodiverse grasslands. This unclear definition is even more important outside the EU, as a large share of the European target for biofuels will be supplied by imports (section 4.4).

As shown in section 4.2, the future of global availability of land can be assessed in a scenario analysis. Here, such a scenario exercise is repeated with focus on biodiversity impacts and to evaluate whether the EU ambition can be achieved with strict limitations on land use as possibly proposed in the Commission's proposal. The introduced category of highly biodiverse grasslands applies to both natural and extensively used semi-natural grasslands. An identification of valuable grasslands within the EU will be made, following the approval of the Directive (section 6.1). An inventory of hotspot areas in high nature value areas, currently prepared for the Rural Development Programme (DG-AGRI) Pillar-II, will be a good candidate for this grassland criterion. However, for areas outside the EU huge uncertainty will remain about which grasslands may be used for biofuels and which may not. Therefore, a range of scenario outcomes is presented, in which grassland exclusion is varied.

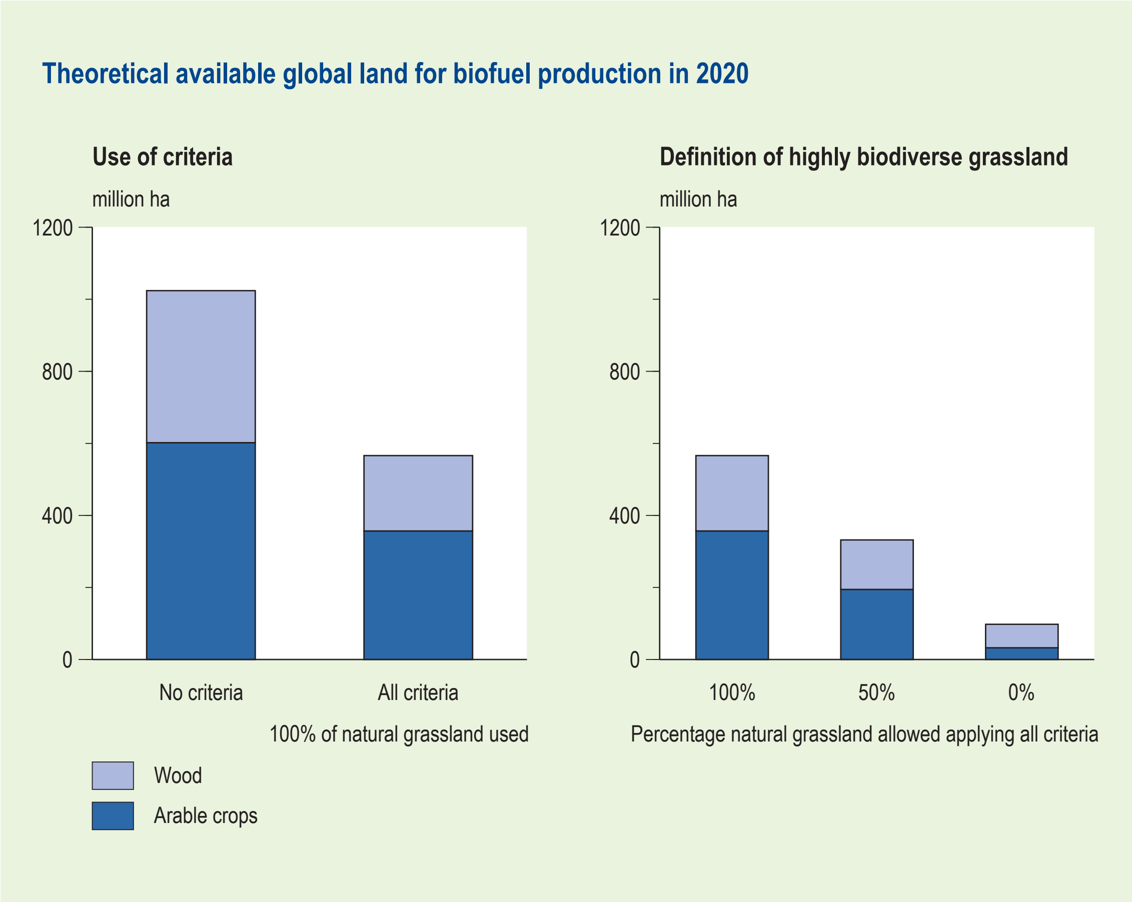

Figure 6.2 World potential for biofuel energy by 2020, applying different sets of land maps with sustainability criteria. The percentages refer to the use of natural grasslands (0% = no natural grasslands allowed, 50% = using only half; 100% = use of all natural grasslands allowed).

For the global analysis, the scenario of MNP's Sustainability Outlook was used (MNP, 2007), which gives projections of future land use as modelled with the IMAGE model framework (MNP, 2006). This baseline scenario was combined with the excluded lands, as proposed in the Directive (chapter 2 and section 6.1). Furthermore, areas for food production (arable lands plus pastures) are assumed unused, to avoid competition for food (Hoogwijk et al., 2005).

When all natural grasslands are allowed for use and no criteria are applied, there is about 600 Mha of land available, which is suitable for the production of current arable crops. Another 400 Mha is available when lands suitable for woody biomass are also taken into account (Figure 6.2; left column in left panel). This potential is mostly located in Brazil and West Africa. Applying all criteria as proposed by the Commission, but still allowing all grasslands to be used, reduces this potential by about 50% (Figure 6.2; right column in left panel).

When the definition of biodiverse grasslands is interpreted in a strict way, all theoretical potential grassland will be excluded (Figure 6.2; right column in right panel). This leaves about 100 Mha total available land with about 35 Mha of land suitable for arable crops. This area mostly consists of abandoned agricultural lands.

The ambition for Europe alone, requires an estimated area of 20 to 30 Mha for first generation crops (section 4.2). The combined targets of the US and the EU, require a productive area of 60 Mha. This implies that on a global scale, the abandoned lands can not supply sufficient biomass for the transport sector, either. As the biofuel demand can not be met by woody biomass, yet, natural grasslands will probably become under pressure to meet the biofuel demand. This conclusion may become even stronger when more land is needed to fulfil the entire ambition of renewables in all sectors (EC, 2008a).

These figures show that globally, the potential in abandoned agricultural lands can not supply sufficient biofuels for the European and US ambitions for transport. The future availability of abandoned lands is also a very uncertain factor, which depends on agricultural developments. Therefore, a push to use natural and extensively used grasslands, is most probable, in order to reach the proposed targets. Without a clear definition for biodiverse grasslands, it is difficult to predict to which extent the use of natural and extensively used grasslands will coincide with biodiversity concerns. But even without such a definition, protection of natural grasslands is advisable as these systems can contain considerable stocks of soil carbon.

6.4 Conclusions for biodiversity

The land exclusion criteria in the proposed Directive are effectively targeted at several valuable types of land cover, that either contain high soil carbon stocks or high biodiversity values. Categories of lands that are still allowed to be used are abandoned agricultural lands (from crop growth), natural grasslands with low biodiversity values and moderately degraded lands. Using abandoned intensively used agricultural lands and (moderately) degraded lands may be beneficial, as biofuel crop production can help to restore the biodiversity in these ecosystems. More information on the possibilities and production potential of degraded lands is necessary, to estimate their real contribution.

However, natural grasslands remain under threat with the proposed land use criteria. This is especially important as natural grasslands are currently underrepresented in the Global Protected Areas Network (Chape et al., 2003). Reducing greenhouse gas emissions is important to avoid future changes in biodiversity (through climate change). However, stimulating biofuel production does not contribute to this positive biodiversity effect, at least not within a time frame of several decades. An analysis with a 'biodiversity balance' indicator shows that the greenhouse gas reductions from biofuel production are insufficient to compensate for biodiversity losses from land use change, in most cases. This result will be even worse when soil carbon emissions from land use change are taken into account.

Despite the strict biodiversity criteria in the proposal, the push for biofuels will most probably lead to additional land-use changes and further loss of natural areas, mainly grasslands. The global availability of abandoned land for biofuels is very small, and therefore, it will be hard to meet all global biofuel and biomass targets without further use of grasslands. The use of pristine and restored forests and highly diverse grasslands are excluded from use, but these systems may still be under pressure from biofuel production through displacement of food production areas. Whether this can be seen as loss of biodiversity, can only be answered when an appropriate indicator for grasslands can be determined, which can be applied worldwide.

Generally speaking, the European criteria will probably be effective in preventing biodiversity loss within the European Union, as soon as a clear definition of highly biodiverse grasslands is given. However, outside the European Union biodiversity loss will probably not be prevented, especially not in grassland areas. In fact, through the displacement effect of current agricultural practices, biodiversity loss may even be aggravated due to the push for biofuels. To address biodiversity concerns, a new biodiversity indicator needs to be developed, which addresses both land use and climate change. This report gives a first conceptualisation of such an indicator, but further elaboration is needed.

7 Food security

At present, the world counts over 850 million people who can be classified as being hungry or undernourished (FAO, 2004). Their condition is caused by poverty and lack of access to food resources, not by an insufficient global food production. High food prices will generally worsen their situation, although this creates chances for smallholder farmers, as well. The impact of higher global food prices, due to the increased demand of feedstock for biofuels, on food security, is difficult to determine, since it is hard to quantify the consumer and producer responses to changing prices and other incentives.

Higher prices will lead to a (slightly) lower consumption of food and meat (and hence feed) and to a higher global production of these commodities, which consequently creates a new equilibrium at a higher price. A higher price is necessary to stimulate farmers to produce more, partly by raising yields per ha and partly by planting more hectares of the most wanted commodities. The larger the shock within the food system - caused by a steep increase in the demand of biofuels - the higher the food prices (temporarily) will be.

It should be stressed that almost all (global and local) markets are influenced by global commodity prices, although some delay might occur in more remote areas. In principle, this is beneficial, since as a result price signals can be transferred to as many farmers as possible, so they all can respond by increasing their production and thus lowering the prices again, in the long run. Farmers and land owners may benefit from these higher prices.

The fact that an individual consignment of biofuels is produced in a rich, food abundant region, does not mean that there is no impact on food security for people in other regions. Europe is now a food exporting region. This is because diverting exported products to an internal use, in the form of biofuels, leads to higher global prices. The central question is how to monitor the effects of the proposed Directive (EC, 2008a), in order to determine (in time) its impacts on food security.

7.1 What is food security?

There are four dimensions to food security: availability, access, stability and utilisation. The FAO defines food security as a condition which exists *'when all people, at all times have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life'* (FAO, 2002).

Further development of bioenergy sectors might affect food security in numerous ways. The effects of bioenergy on food security will be context-specific, depending on the particular technology and characteristics of the country involved. For instance, liquid biofuels derived from food crops will have different food security implications than modern bioenergy systems based on lingo-cellulosic or waste materials. FAO has initiated working groups for assessing the food security implications of bioenergy. The questions that need to be addressed by those working groups are:

1. What are the expected impacts on food prices at all levels on food insecure households?

Table 7.1 Summary of price effects of stimulation of biofuels in different studies.

Study	Quantity of biofuels taken into account	Aspects per topic to be considered
OECD, 2006	US: 7.5 billion gallons EU: 5.75% Canada: 500 million litres	Vegetable oil :+ 20% Sugar: + 60% Wheat : + 4%
EC, 2007b	Implementation of EU-directive (10%)	Cereals: + 3-5% Rapeseed: + 8-10% Sunseed: + 15%
Schmidhuber, 2006	Additional 10 million tonnes	Sugar: + 2-11% Maize: + 2-4% Wheat: + 1-2%
Msangi et al., 2007	Lower figures for 2nd generation ; higher figures 1st generation only	Maize : + 26-41% Oilseeds : + 45-76% Sugar cane: + 49-66% Wheat : + 21-30%
Elobeid and Hart, 2007	US: 22 billion gallons	Maize: + 20% Oilseeds : + 9% Wheat : + 9%
Banse et al., 2008	Implementation of EU-directive (10%)	Cereals: + 6% Oilseeds: + 8% Sugar: + 3%

2. What are the implications for food availability in terms of competition for natural resources such as land or water, or human resources such as labour? What about inputs in agriculture, particularly for households dependent on their own food production?
3. What are the implications on incomes, employment and land rents given current inequities in access to productive resources? Is there anything different about bioenergy that could mitigate or overcome factors of exclusion that contribute in part to food insecurity and rural poverty?
4. What are the implications of bioenergy on environmental sustainability and climate change, as they affect food security?
5. Who (public sector, private sector, civil society) is best placed to monitor and address possible conflicts arising from the competition between biomass uses for food, feed or fuel?
6. How can low-income food deficit countries ensure that food security concerns are addressed, given the possibility of unintended consequences due to rapid development of bioenergy and the complex linkages between agriculture, energy, environment and trade?

As long as these studies are ongoing, very accurate answers on the impact of biofuels on food security cannot be given. Since, new policies are put in place, a first indication is given here.

7.2 Impact of biofuels on food prices

All reviewed literature agrees that the implementation of biofuel policy will lead to increased commodity prices (Table 7.1), although the various authors give different effects, partly due to differences in calculated situations.

Banse et al. (2008) implemented the EU Biofuel Directives (5.75% in 2010 and 10% in 2020; EC, 2003 and EC, 2008a respectively) and compared the cost effects with a baseline development, in which European agricultural policies are liberalised completely. This will lead to an increase in import of biofuels (see section 4.4) and a considerable impact on global food prices (Figure 7.1).

Figure 7.1 Percent changes in real world prices, 2020 relative to 2001 (Banse et al., 2008).

7.3 Impact of biofuel production on food security

The crucial question is to what extent these higher prices will lead to a decreased food security. There is only limited literature available to answer this question.

Schmidhuber (2006) distinguishes in his analysis four types of poor countries, depending on whether they are net importers or exporters of oil and of agricultural products. Countries that export both oil and agricultural products gain from higher oil prices, like Malaysia and Ecuador. Food importing countries suffer from higher food prices, up to US$ 500 per capita. In low income, food deficit regions higher world market prices lead to a significant impact on purchasing power. Elobeid and Hart (2007) demonstrate that the impact of the US policy on biofuels lead to cost increases for food baskets of up to 15% in certain Sub-Saharan African countries. This is also demonstrated in Figure 7.2a and 7.2b. From the African countries, Egypt, Cape Verde, Morocco, Mauritania, Swaziland and Lesotho all import more than 100 kg of cereals per ha. Assuming a price increase in cereals of 0.20 US$ per kg (and no compensation in the form of extra food assistance or increased domestic production), the impact on the GDP is 2-10% for the various countries (Figure 7.2b). People in developed countries are also affected by higher prices for cooking oil and other commodities.

The effect of increased food prices may vary enormously, not only between countries but also within countries. People living in urban areas, in effect most landless people, will suffer from higher food prices. Farmers, land owners and farm employees may benefit from higher food prices. In order to allow farmers in poorer countries to benefit from higher commodity prices, a number of conditions have to be met; access to information and markets and the availability of

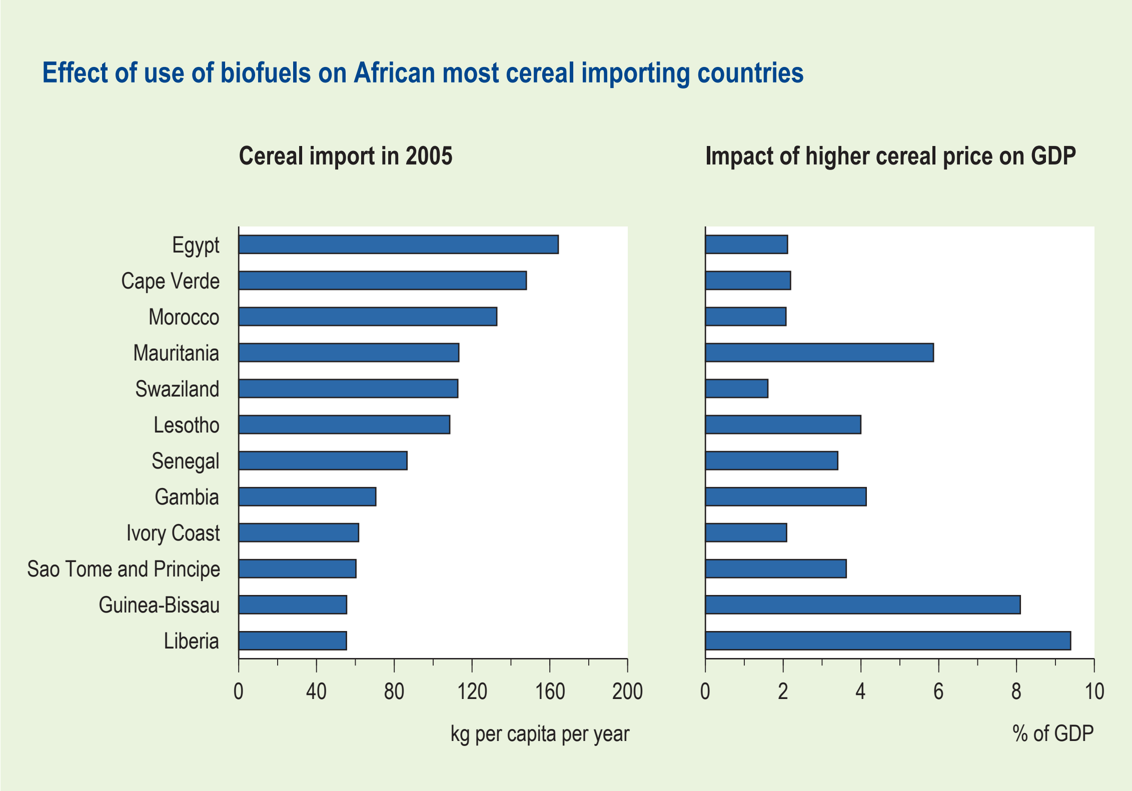

Figure 7.2 Cereal import (kg per capita per year) of top ten African cereal importing countries (Figure 7.2a; left panel) and effect on GDP (%) of increase of cereal prices by 0.20 US $ per kg (Figure 7.2b; right panel). Based on data from FAO (2007).

water and other inputs (Von Braun, 2007). Special and targeted policies need to be in place for the world's absolute poor and hungry, in order to prevent a deterioration of their position.

7.4 Conclusions on food security

The central question is, whether a criterion to prevent deterioration of food security can be implemented on microscale (individual consignments), or whether this problem can only be addressed at the regional, national or global level. As is shown before, it is not possible to implement a criterion on food security on the level of individual consignments. Even if biofuels are being produced in richer countries, the production will undoubtedly have an effect on global commodity prices. This effect will be larger if countries (or industries) have to comply with producing a certain quantity of biofuels, irrespective of the price of the feedstocks.

If the criterion on food security is to be implemented on a macro-level, several questions arise:
1. How can the criterion actually be implemented?
2. Who is responsible for monitoring?
3. How is the feedback on the results of the indicator organised?
4. Should the criterion be used ex-ante or ex-post?

In order to prevent serious effects of biofuels, policies on food security of the world's poor, as well as effective monitoring and response systems need to be in place. Another option might be to include a safety valve into the system, such as limiting the obligation in the event of high commodity prices and the careful monitoring of global stocks. In that sense, the former Biofuel Directive (EC, 2003) was more flexible, asking for national indicative targets with a reference value (of 5.75% in 2010), from which Member States could differentiate under certain conditions. Such an approach is especially relevant, since the demand for food and feed is particularly inelastic and, when combined with another inelastic demand (because of a fixed and mandatory quantity of biofuels), this may lead to large price fluctuations.

8 Synthesis

Chapter 1 of this report raised three main research questions. An overview of the sustainability aspects of biofuels is given in this report, by assessing global consequences of the 10%-target (chapter 4) and checking the sustainability criteria as proposed by the European Commission (chapters 5, 6 and 7). The summarising 'answers' on the three research questions are given in this chapter.

8.1 Are the Commission's criteria sufficient?

Chapters 5 and 6 show that the criteria, as such, are targeted well enough to prevent major biodiversity losses and greenhouse gas emissions at a consignment level within the European Union. For biodiversity, the most crucial issue is the lack of a clear definition of 'high biodiverse grasslands'. Section 6.3 shows that the current and unclear definition of grasslands covers the global theoretically potential land for biofuel production, to a large extent. Therefore, the Commission's proposal is not clear enough to prevent further loss of biodiversity with respect of these grasslands. To prevent a separate discussion on grassland definitions, the discussion could best be geared towards the existing work on defining 'high nature value areas'. Globally, the lack of a clear protection plan for important grasslands is also a major uncertainty. Therefore, additional protection of valuable ecosystems should also be considered when the use of biofuels is stimulated.

With respect to greenhouse gas reductions, the list of default data in Annex VII of the proposal shows that none of the biofuels, which are on the market today or are expected to be in the future, will have problems with the criterion mentioned. The most critical situations for fuel producers or suppliers can be solved by either presenting more data on the actual situation or using more bioenergy in the process chain. Moreover, producers will only provide extra data, if they are better than the default value of one of the three distinguished parts of the process chain. So, even if the actual overall values would not be above 35%, a specific biofuel would comply.

In many process chains, the extra use of biomass for process energy might improve the results. Examples are biodiesel for tractors and transport and production of heat and electricity by burning biomass. A potential reduction increase of about 20% for crops like rapeseed and wheat is assessed, based on exploring calculations (section 5.2). It should be realised, that the high reductions for biofuels based on wood or for sugar cane ethanol, can also be explained by the use of biomass to process energy. Taking into account that crops like wheat or rapeseed deliver byproducts like animal feed, then biofuels based on wood or woody biomass are not necessarily performing much better. This is discussed further in section 8.2.

The results also depend on the allocation method. The Commission's proposal prescribes the energy based allocation method, for good reasons. The substitution method is more likely to simulate practice, but will be quite complicated. For rapeseed and wheat, the difference between energy based allocation and the substitution method (with animal feed substituting soymeal) is about 0-15%.

It can be concluded, that almost no biofuel is prevented from entering the market by the criterion of 35%. Even a higher reduction criterion (up to 60%) would probably have a small impact on the crops used for biofuels, but would lead to 'smart' solutions in practice. Because most default values comply with the 35% criterion, it saves a lot of the administrative burden.

In general, the Commission's criteria are well thought-out, regarding biofuels at a consignment level. However, a crucial question remains to what extent the additional demand for biofuels would lead to additional land use change. Section 4.2 shows that additional land use change can be expected. And sections 4.3 and 4.4 show that a considerable amount of biofuel is likely to be imported. This global land conversion, partly driven by the demand for biofuels, is not covered by the criteria. To analyse the potential impact, a more relevant indicator is the GHG emission reduction per hectare (as proposed in section 5.4). In this way, an assessment can be made of the compensation for indirect soil emissions. Using the values presented in the Commission's proposal for the conversion of lightly forested area or permanent grasslands into arable land, greenhouse gas emissions would be almost 18 tonnes CO_2-equivalent per hectare, per year. Clearly, these emissions are preventing biofuels from being grown in those areas and, therefore, the Commission's proposal can be seen as an incentive to grow crops on idle lands and current arable land. However, the displacement effect of current arable land for growing food and feed is not addressed in the proposal. This leaves the question of whether the use of biofuels will improve the total greenhouse gas budget. Therefore, one of the targets of the Commission, greenhouse gas reduction, is hardly met by stimulating current biofuels.

From a biodiversity perspective, section 6.2 shows that biodiversity is not benefiting from biofuels in the short term. Only when intensively used arable land is converted to biofuels, the impact on biodiversity may be positive. In other instances, the impact on biodiversity would only be positive after a very long period (up to 100 years). When the total reduction of greenhouse gas emissions becomes uncertain, the impact on biodiversity is most likely to be negative, for all cases. With respect to food security, higher food prices are very likely because of the push for biofuels (chapter 7). Compensating mechanisms for food importing countries should also be in place when biofuels are stimulated as done in the proposed Directive.

8.2 Which biomass production chain would meet the proposed criteria more easily?

The characteristics of the different biomass production chains are mainly determined by the cultivation and the conversion of the biomass into liquid biofuels. On some points, the proposal provides further impetus to the use of wastes, residues, non-food cellulosic material and ligno-cellulosic material. The most favourable current situation would be the optimal use of the energy in wastes and residues which, in themselves, have no useful applications. The cultivation of woody biomass for liquid biofuels is discussed here, and compared with the other biofuels.

Crops providing vegetable oils, sugars or starch, are the main resources for the biofuels presently on the market. They are produced in Europe (mainly rapeseed, sunflower, wheat and sugar beet), in Latin America (mainly sugar cane) or in Asia (mainly palm oil), and are also food crops. The production is blamed for a negative impact on food security and increasing food prices. For the conversion, well-known and rather simple processes are used, although for the processing of vegetable oils a new option is hydrogenation, leading to a better quality of biodiesel. In many cases, different byproducts such as animal feed are produced. Biomass, such as woody materials or 'poisonous' oils like Jatropha oil, are regarded as better options, because they are not suitable for the food market, they can be cultivated on non-arable land, their produc-

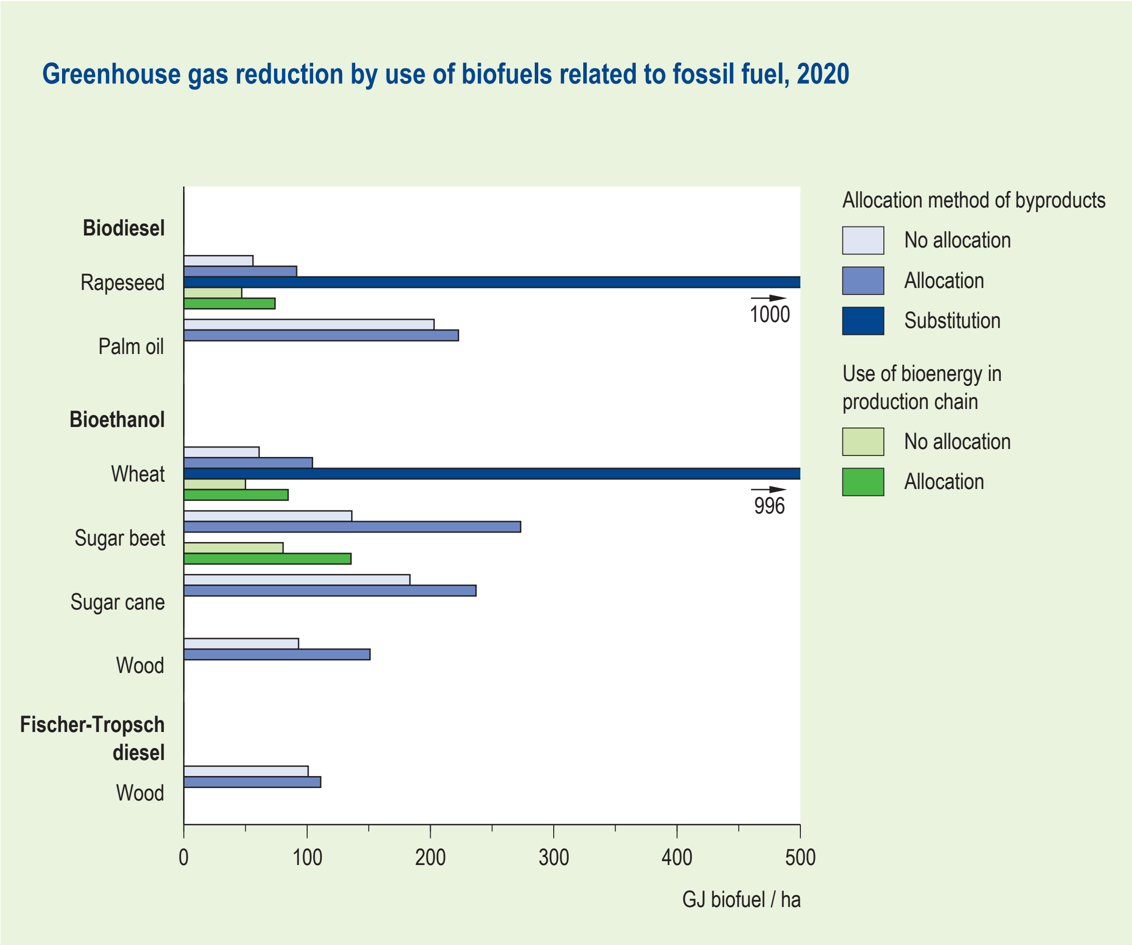

Figure 8.1 Productivity of biofuels (in terms of energy) on land (including land for bio-energy in the production chain and corrected for substituted land)

tivity (in GJ/ha) is assumed to be better and the reduction of greenhouse gas emissions is higher. With respect to non-arable land, the crucial uncertainty is the extent to which low-productive lands can be used for the production of biomass. The successful cultivation of considerable amounts of biomass requires, at the very least, reasonable conditions and/or substantial inputs to realise economically interesting productivities. Problems of availability of water can not be neglected in this respect. Furthermore, the conclusion that these non-arable lands are of low biodiversity value, can be questioned as well. Therefore, it is still uncertain if these lands will be available for the production of biomass that can be used for transport.

With respect to productivity, the production of biofuels is measured best in amounts of energy per hectare of land. Figure 8.1 shows the production of bioenergy as end product per hectare. Sugar cane, sugar beet and palm oil have high productivities. Wood only outperforms wheat and rapeseed. For sugar cane and wood should be noted that the use of biomass for process energy is already included (being or expected to become normal practice). This explains the high emission reduction percentages for these biofuels (chapter 5). These high greenhouse gas reductions are mainly based on cleaner heat and electricity through bioenergy. However, especially the conversion of wood into ethanol or Fischer Tropsch biodiesel is very energy-intensive and, therefore, it 'loses' when amounts of energy per hectare are regarded. Figure 8.1 also shows high productivities when the substitution method is applied to the byproducts of wheat and rapeseed, mainly because the substitution of soymeal as animal feed (with corrections for soy oil), which reduces the amount of land needed.

In agricultural practice, in many cases, it is no question of food or feed or energy. Several products or byproducts can leave the production chain with different purposes. The use of all products will be optimised with the biorefinery concept, where all parts of and valuable substances in the crops are used. The application of agricultural byproducts (or residues as they are called mostly) and other waste streams for biofuel production might be a good thing, although in many cases these byproducts or wastes are already used for other applications. Another important characteristic of most of the production chains, of the present biofuels, is that they provide animal feed, as well. Cultivation of woody biomass does not.

Based on these results, there is no clear answer to the question if biofuels based on cultivated woody (lignocellulosic) materials are really more efficient than those based on the crops that are presently used. In that respect, it can not univocally be said which production chain performs better. The conclusions are probably easier to draw, when waste and residuals are used for biofuel production, but these biofuels are not expected to enter the transport market in large amounts, before 2020. The additional incentive in the Commission's proposal to allow all 'second generation' biofuels to be double counted (chapter 2) is probably not specific enough.

8.3 Can the outcome of using renewables in the transport sector be improved?

The proposal of the Commission includes a 10% target for renewable energy in transport to, also, stimulate more sustainable developments in related sectors. The Explanatory Memorandum, as well as the proposed Directive, are all about biofuels. This raises the question whether the proposal supports other renewable options and whether biofuels are the best option for transport and the best way to apply the biomass. The discussion on the latter is determined by two facts:

1. Global availability of biomass is limited. There are lots of competing applications. Therefore, optimal use of the biomass is an important issue. It also implies that the long term potential of biofuels for transport might be restricted, at least on a global scale.
2. The greenhouse gas emission reduction of biomass is higher when using it for the generation of electricity, than using the same amount for the production of liquid biofuels. Because of this point, the Commission's proposal deserves support in the way the excess electricity is allocated: no credits go to the biofuels for that part. The advantage of electricity generation is especially true for woody materials and this might change the view on -the generally believed to be more promising- new biofuels. For example, a tonne of wood reduces about 500 kg CO_2 when it is transferred to Fischer-Tropsch biodiesel, but it reduces 1000-1200 kg of CO_2 when it is applied directly in the electricity sector (EC, 2005).

The advantage of biofuels is that they can easily be introduced in the present transport system, by just blending a certain percentage of them with fossil fuels. It seems, that energy security is the most valid argument for applying biofuels in the transport sector. The costs of producing first generation biofuels are not real a high barrier, especially in light of the present high oil price. However, the potential of reducing greenhouse gas emissions in 2020, is quite low. A reduction of 3-5% per kilometre (<10% biofuels and <50% average emission reduction per MJ, excluding soil emissions) can be expected, which is far less than the increase in transport kilometres.

Without the certainty of much more available biomass after 2020, and with the risk of biodiversity loss, biofuels are not an unquestionable sustainable option.

Still, there is also a need for sustainable alternatives for transport, both from an environmental and an energy security perspective. These alternatives exist. The most important new driving technologies for vehicles are: fuel cell cars on hydrogen, hybrids, plug-in hybrids and complete electric cars. Their costs are still relatively high, because they are in the development phase. There are lots of uncertainties about their role in future. However, in a long-term transition process towards a new transport system their potential seems high, even though their impact depends on the sustainability of the hydrogen production and the generation of electricity.

Are hydrogen and electricity really promising alternatives? This question can be related to the question of an optimal use of biomass by comparing four pathways, all starting with same amount of wood as the source of energy, and ending with kilometres driven by an average car. Four pathways and fuels can be distinguished. Table 8.1 gives the most important assumptions.

Table 8.1 Assumptions for four pathways of wood to kilometres driven by an average car

	Product per tonne of wood Fuel (MJ)	Product per tonne of wood Elektricity (MJ)	Fuel efficiency MJ/km
Bioethanol blending	5.4	2.1 (excess)	2.08
Fisher-Tropsch diesel	5.3	0.5 (excess)	2.4
Hydrogen in fuel cell cars	5.0	2.9 (excess)	1.03
Electric cars		6.4 (η = 0.35)	0.54

Figure 8.2 shows the results of the calculations. Fuel efficiency is highest in the electricity pathway, hydrogen follows and Fischer-Tropsch diesel and bioethanol stay behind. The excess electricity produced as a byproduct of second generation biofuel production, could be as valuable for transport as the biofuels themselves. Again it must be emphasised that the technology to bring these concepts into practice need improvement in the price/performance ratio.

For an efficient use of the available biomass and for supporting potentially attractive options from a long-term perspective, it would be recommendable to allow all pathways to contribute to the proposed 10% renewable energy goal for transport. However, what can be expected, in actual practice, for the electricity and hydrogen pathways as a direct result of the Commission's proposal?

Electricity

- Electricity is no renewable resource in itself. In 2020, it can be expected to be generated from renewable resources for 20-30%. So it will be accounted for, for this percentage (a stronger impetus would be provided if the extra amount of renewable electricity as part of the extra electricity produced, compared to a reference year, could be used).
- Wood used for the generation of electricity entering the grid can be assigned to transport for a negligible part only.
- Because the goal for renewable energy is expressed in terms of fuel energy for transport (and not in kilometres), the high efficiency of electric cars and thus their low energy use puts renewable energy at a disadvantage to the use of biofuels.

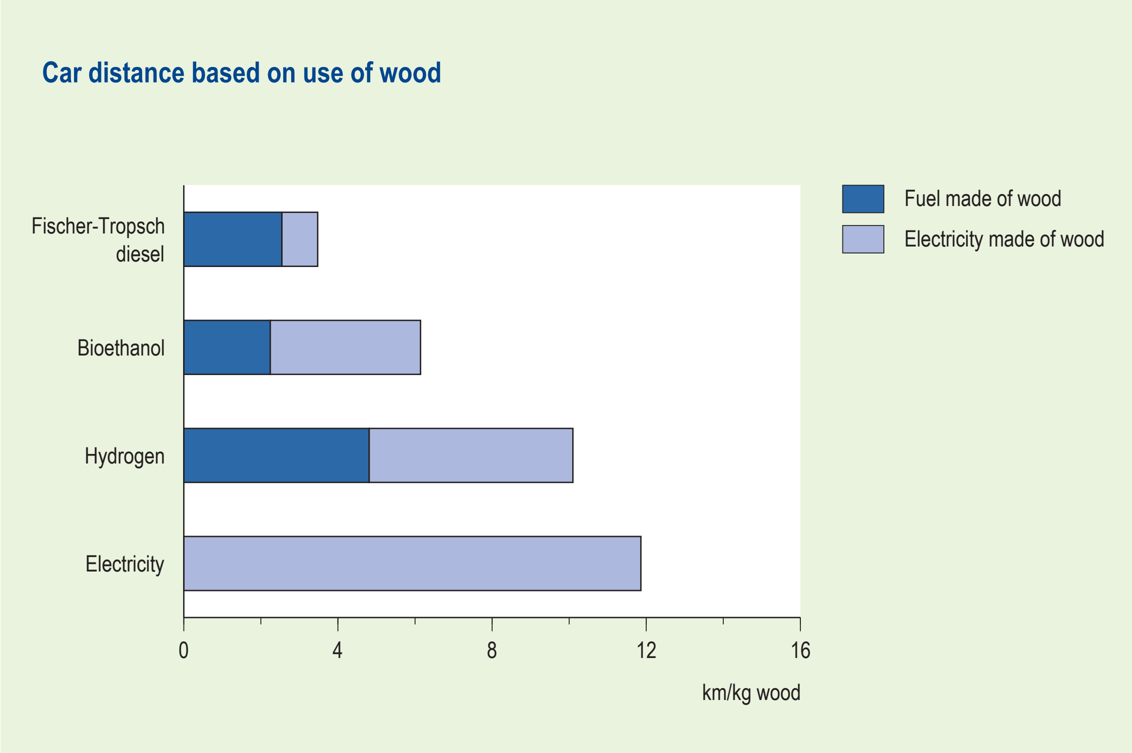

Figure 8.2 The efficiency of using wood for transport in four different pathways (De Visser et al., 2006; WBC, 2004).

- The first step towards electric vehicles is hybrid cars. Because they are still running on fossil fuels (although more efficient) this development is not rewarded by the proposal of the Commission.

Hydrogen

- Hydrogen is no renewable resource in itself, but it can be produced from renewable resources dedicated to transport.
- Realising a new system of fuel-cell cars on hydrogen is quite complex, because it needs a new production system, a new distribution system, as well as new cars. This will take several steps. All three are necessary, for hydrogen to contribute to the Commission's proposal, which is only likely for niche markets in 2020, with the exception of specific cars with traditional engines that are able to use hydrogen.

Obviously, these alternatives will play a negligible role in reaching the target of 10% renewable energy for transport in 2020. Other related policy proposals, such as the Fuel Quality Directive and standards for CO_2 emissions, might have a relevant impact, but they are not analysed in this context. In California an interesting alternative policy option has been chosen in 2007, the Low Carbon Fuel Standard (see text box).

Text box

California issued a new guideline in 2007, the 'Low Carbon Fuel Standard' – LCFS) prescribing a 10% reduction of the 'carbon intensity' (on a well-to-wheel base) of transport fuels in 2020.

The LCFS will use market-based mechanisms that allow providers to choose how they reduce emissions while responding to consumer demand. For example, providers may purchase and blend more low carbon ethanol into gasoline products, purchase credits from electric utilities supplying low carbon electrons to electric passenger vehicles, diversify into low carbon hydrogen as a product and more, including new strategies yet to be developed.

UC Berkeley analysed the technological pathways to realise the goal (Farell et al., 2007). The main conclusion is: 'On the basis of a study of a wide range of vehicle fuel options, we find a 10 percent reduction in the carbon intensity of transportation fuels by 2020 to be an ambitious but attainable target. With some vehicle and fuel combinations, a reduction of 15 percent may be possible. All of the major low carbon fuel options to reduce GHG emissions from the transportation sector (e.g., biofuel production and electric vehicles) have technical and economic uncertainties that need further research and evaluation. However, there is a wide variety of options, of which many show great potential to lower the global warming impact of transportation fuels. Many research and development efforts are already underway to bring these advanced technologies to market'.

Table 8.2 (next page) summarises the issues that need to be considered when the four renewable routes of transport are assessed. Although hydrogen and electricity are promising fuels for transport, further improvement of the performance of fuel cells, batteries and cost reductions are necessary to make them into realistic alternatives. There is no certainty that all issues in Table 8.2 can be improved in time or at all. However, from the summary in Table 8.2 it also becomes clear that none of the four routes is without problems. Therefore, at this moment, it is best to support all options in the transport sector. The present Commission's proposal does not.

Given all these considerations, the current obligatory target for transport, stimulating only the two biofuel routes in transport, should be reconsidered. Whether the total renewable target in all sectors can be achieved without a mandatory target in the transport sector, should be part of further research. Obviously, biomass can still be used in other sectors, such as heating and cooling, electricity and bio-based products, although sustainability criteria have not been applied in these sectors, yet. For the transport sector, the impact on greenhouse gas reduction and energy security of other Directives, such as the Fuel Quality Directive and the CO_2 standards, should be investigated before other mandatory targets are implemented, as currently proposed by the European Commission in the Renewable Directive.

Table 8.2 Overview of the characteristics of the distinguished technical pathways.

	Bioethanol blending	Fisher-Tropsch diesel	Hydrogen in fuel cell cars	Electric cars
Reduction of GHG emissions (excluding soil emissions)	10-50% (European) 70-90% (imports)	75-90%	80-90% (based on biomass)	90-95% (based on biomass)
Other environmental issues	Small impacts (positive and negative) on local air quality; negative impact on biodiversity	Small impacts (positive and negative) on local air quality; negative impact on biodiversity not unthinkable	Important positive impact on local air quality and noise, possible negative effects of H2 production	Important positive impact on local air quality and noise; possible negative effects of the generation of electricity
Potential in the long term	Limited, because of the restricted availability of land and competition with food; it is very doubtful whether their contribution can be much more than 10%;	Limited, because of the restricted availability of land and competition with other applications (paper industry, electricity generation)	Limitless, because of technical reasons or restricted resources (sun, wind, biomass et cetera)	Limited, because of the characteristics of batteries to cars, suitable for small distances (plug-in hybrids can partly drive on electricity)
Technical development	Well-known processes; biodiesel quality is improved by hydrogenation	In the phase of demonstration plants; for bioethanol production a combination with traditional production on one site, is more likely	Only some vehicles for testing and demonstration; a hydrogen distribution infrastructure or decentralised hydrogen production, is needed	Hybrid cars are on the road, plug-in hybrids for testing and demonstration, electric vehicles available for niche markets
Costs	Depending on the price of biomass and the origin (European biofuels relatively high); byproduct of animal feed	High investments, especially for Fischer-Tropsch diesel; production costs are high, still	Costs are very high, because of several steps in the production chain, especially hydrogen production and fuel cell production	Costs are relatively high - because of high the costs of batteries - but are depending on the radius of action and extra costs for two driving systems in hybrids
Energy security	Short-term availability, but on a small scale and restricted to blends for most of the present biofuels; competition with food security	Restricted relevance in the short-term; biomass availability in Europe limited; Fischer-Tropsch diesel can be used in present diesel cars without blending	Only relevant in the long-term, but because of a variety of resources suitable for hydrogen production with a high potential for much better energy security	Restricted relevance in the short-term, strongly related to the security of electricity supply, which will be based on several resources (including local); batteries might be an electricity source in case of emergences

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Annex A: Production chains considered in the study

In this analysis, the calculations for global and regional impacts are based on a selection of production chains. The chains considered are summed in Table A.1.
In Figure A.1, the results of the calculations of the greenhouse gas emissions for the different biofuels are compared with the values (default and typical) in the Commission's proposal (EC, 2008a). For the calculations agricultural productivity data for the year 2020 have been used.

Tabel A.1 Production chains considered in this report

Used type of biomass	Produced biofuel type
Rapeseed	Biodiesel, hydro-treated vegetable oil
Palm oil	Biodiesel
Wheat	Bioethanol
Sugar beet	Bioethanol
Sugarcane	Bioethanol
Wood	Fischer-Tropsch diesel
Wood	Bioethanol

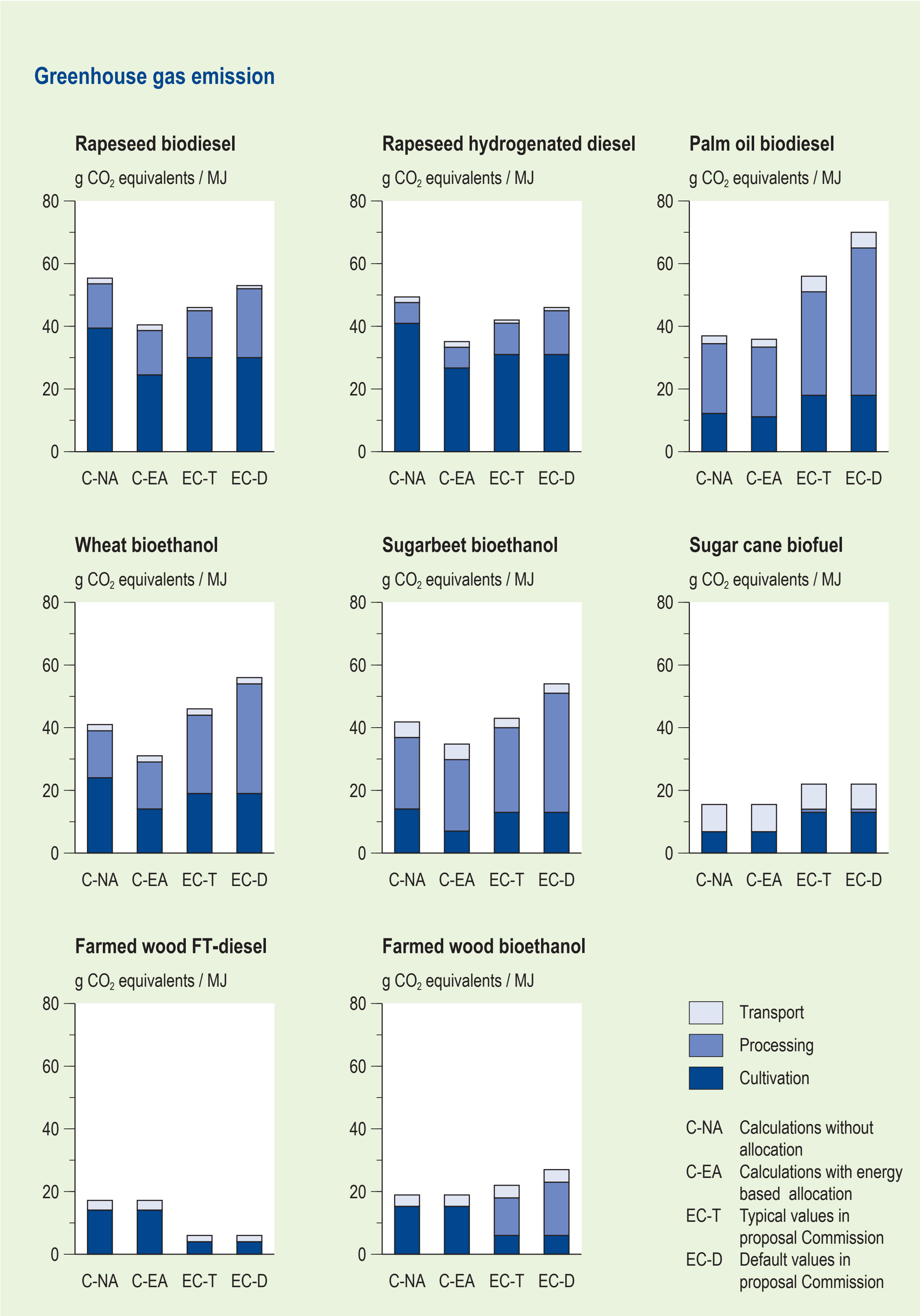

Figure A.1 Greenhouse gas emissions of different biofuel types in three distinguished processing steps by MNP calculations (on the basis of Hamelinck and Hoogwijk, 2007 and Ros and Montfoort, 2006), compared with typical and default values in the Commission's proposal (EC, 2008a).