Safeguarding the sustainability of bioenergy in Europe

The implementation and impact of the EC Renewable Energy Directive and Fuel Quality Directive

LEI WAGENINGEN UR

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Marie-Luise Rau
Edward Smeets
Emil Georgiev
Myrna van Leeuwen

LEI report 2012-057
October 2012
Project code 2271000159
LEI Wageningen UR, The Hague

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Safeguarding the sustainability of bioenergy in Europe; The implementation and impact of the EC Renewable Energy Directive and Fuel Quality Directive
Rau, M.-L., E. Smeets, E. Georgiev and M. van Leeuwen
LEI report 2012-057
ISBN/EAN: 978-90-8615-595-8
115 p., fig., tab., app.

This research has been partly financed by the Dutch Ministry of Economic Affairs, Agriculture and Innovation.

Photo cover: Shutterstock

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List of abbreviations

CDM	Clean Development Mechanism
CIFOR	Center for International Forestry Research
DGS	Distillers' grains and solubles
CHP	Combined heat and power
CI	Conservation International
CO_2	Carbon dioxide
DNDC	DeNitrification-DeComposition
dLUC	Direct land use change
EC	European Commission
EIA	US Energy Information Administration
Eurostat	The statistical office of the European Union
EBB	European Biodiesel Board
EU	European Union
EU-27	27 EU member states
FAO	Food and Agricultural Organisation of the United Nations
FIE	Fertiliser induced emissions
FQD	EU Fuel Quality Directive
GATT	General Agreement on Tariffs and Trade
GHG	Greenhouse gas
iLUC	Indirect land use change
IPCC	Intergovernmental Panel on Climate Change
IBAT	Integrated Biodiversity Assessment Tool
ISO	International Standard Organisation
ISCC	International Sustainability and Carbon Certification
IUCN	International Union for Conservation of Nature
JRC	Joint Research Centre of the European Commission
J, kJ, EJ, PJ	Joule, kilo Joule, Exajoule, Petajoule
LCA	Life cycle assessment
LCIA	Life cycle impact assessment
Mtoe	Million tonnes of oil equivalent
MAGNET	Modular Applied GeNeral Equilibrium Tool: Computable equilibrium model based on the GTAP model
MODIS	Moderate Resolution Imaging Spectroradiometer

N_2O	Nitrous oxide
NREAP	National renewable energy action plans of the EU member states
NGO	Non-governmental organisation
NUTS	Nomenclature of Units for Territorial Statistics
OECD	Organisation for Economic Co-operation and Development
RCA	Responsible Cultivation Area
RED	EU Renewable Energy Directive
RTRS	Round Table on Responsible Soy Association
TBTA	Technical Barriers to Trade Agreement
TWh	Terawatt hour
UK	United Kingdom
UN	United Nations
UNECE	United Nations Economic Commission for Europe
US	United States
WCED	The World Conference on Environment and Development
WTO	World Trade Organisation
WWF	World Wildlife Fund

Contents

Preface

The production and use of bioenergy is an important component of the energy policies at the EU level and in many EU member states. Important objectives behind these supporting policies are, among others, to reduce the dependence on imported fossil oil and thus to increase energy security, to generate employment and to increase resilience against fossil oil price fluctuations. Another important objective, especially in Europe, is the reduction of greenhouse gas (GHG) emissions from road transport.

However, concerns have been raised about the effectiveness of biofuel-promoting subsidies with respect to the above-mentioned targets and about potential negative impacts on, among others, food security and biodiversity. The European Commission (EC) has formulated sustainability criteria for bioenergy production and use that are included in EU legislation, namely the Renewable Energy Directive (RED) and the Fuel Quality Directive (FQD).

In this study, the sustainability criteria in the RED-FQD are investigated and reviewed. First, an overview is given of the current and future use of bioenergy, and bioenergy policies in the EU are discussed. Next, it is discussed how the RED-FQD sustainability criteria are operationalised into practically indicators, including a critical evaluation of the scientific robustness, completeness and accuracy of the approaches and indicators used in the RED-FQD. Finally, various options are formulated and a discussion is presented on how the sustainability of biofuels can be investigated using economic models such as the global computable general equilibrium model MAGNET (Modular Applied GeNeral Equilibrium Tool). Such an analysis is needed to ascertain the impact of biofuel policies and will help to provide useful insights and advice for policy-makers.

This project is funded by the Ministry of Economic Affairs, Agriculture and Innovation of the Netherlands.

L.C. van Staalduinen MSc
Managing Director LEI Wageningen UR

Summary

S.1 Key results

The sustainability criteria included in the Renewable Energy Directive (RED) and the Fuel Quality Directive (FQD) of the European Union (EU) most likely have a limited effect on the supply and costs of liquid biofuels for transport. The net cost effects are probably about a few euro cents per litre, assuming large-scale production systems, although the impact might be higher for small-scale producers and if more advanced or stricter criteria are implemented.

The RED and FQD are currently the most important sustainability schemes used in the EU. The European Commission (EC) recently approved seven private certification schemes that firms can use in order to demonstrate compliance with these sustainability requirements. Other systems (e.g. Dutch NTA 8080 and 8081) are currently under review by the EC. Within the EU, it can be expected that voluntary schemes, which are not approved by the EC, will gradually disappear at the level of the individual EU member states.

The RED-FQD include targets for greenhouse gas (GHG) emissions savings and also prohibit the use of areas with high biodiversity value and land with high carbon stock for biofuel production. Important omissions are that the definition of areas with high biodiversity value and high carbon stock does not cover certain types of wooded vegetation and grassland. Also indirect effects on land use, food security and oil consumption are not covered by the sustainability criteria of the RED-FQD.

S.2 Complementary results

The impact of the FQD-RED GHG criteria on the supply of liquid biofuels for transport is most likely negligible, as all biofuel chains meet the GHG saving target if additional measures are implemented. These costs are estimated to be about 61 million euro in 2020 (COWI consortium, 2008; exclusive costs of certification process). This is equivalent to less than 1% of the production costs of liquid biofuels for transport. The impact on costs or potential of biofuels of compliance with the land exclusion criteria is probably negligible at the EU level.

Economic operators have to provide information on the compliance with the criteria as well as apply adequate standards of independent auditing and a mass

balance system to ensure compliance along the supply chain. The costs of these certification processes are difficult to estimate, but they probably increase the costs by about 1%.

However, the impact of the FQD-RED criteria is potentially higher for small-scale producers and if more advanced or stricter criteria are implemented, e.g. related to indirect effects on food security and land use. Another indirect effect that has recently emerged is the rebound effect (Smeets et al., 2012). This is the phenomenon that a biofuel tax credit or biofuel use mandate increases the total consumption of fuel: biofuel use reduces the demand for gasoline and fossil oil demand and as a result the price of gasoline and fossil oil decreases globally, which in turn may lead to an increasing demand and use of these commodities. The rebound effect partially offsets fossil energy use and GHG emission reductions from biofuel use.

S.3. Methodology

The results presented are based on a literature review specifically addressing the following questions:
- What policy measures do governments implement to promote sustainable bioenergy? How do they function?
- What sustainability criteria are applied? How are they measured and what is the impact on supply and costs of bioenergy?
- What information is needed to measure and ultimately incorporate sustainable bioenergy in simulation models?

The report is organised in six chapters: In Chapter 1, we elaborate on the concept of sustainability and its implication for the biobased economy. We start with a data analysis of supply and demand in order to point out main biobased products (bioenergy, biofuels and biomaterials) and main countries producing and demanding them. Chapter 2 provides an overview of the different measures for sustainable biomass (bioenergy, biofuels and biomaterials) across selected EU member states. Here, we look at the EU RED-FQD and how the respective provisions are implemented in practise. In Chapter 3, we look into the measurement of sustainability criteria, and Chapter 4 elaborates on approaches to modelling sustainability criteria in economic models. The report closes with a summary and conclusion in Chapter 5.

Samenvatting

Waarborgen van de duurzaamheid van bio-energie in Europa; De implementatie en impact van de Europese Richtlijn Hernieuwbare Energie en de Richtlijn Brandstofkwaliteit

S.1 Belangrijkste uitkomsten

De duurzaamheidscriteria van de Richtlijn Hernieuwbare Energie (Renewable Energy Directive, RED) en de Richtlijn Brandstofkwaliteit (Fuel Quality Directive, FQD) van de Europese Unie (EU) hebben waarschijnlijk een beperkt effect op de levering en kosten van vloeibare biobrandstoffen voor transport. Het netto-kosteneffect komt waarschijnlijk neer op een paar eurocent per liter, uitgaande van grootschalige productiesystemen, hoewel de impact groter kan zijn voor kleinschalige producenten en als er geavanceerdere of strengere criteria worden geïmplementeerd.

De RED en FQD zijn op dit moment de belangrijkste richtlijnen op het gebied van duurzaamheid in de EU. De Europese Commissie (EC) heeft recentelijk zeven particuliere certificeringsregelingen goedgekeurd die bedrijven kunnen gebruiken om aan te tonen dat ze aan deze duurzaamheidseisen voldoen. Andere systemen (bijv. NTA 8080 en 8081) worden op dit moment beoordeeld door de EC. Naar verwachting zullen vrijwillige regelingen binnen de EU, die niet door de EC zijn goedgekeurd, geleidelijk aan verdwijnen op het niveau van de EU-lidstaten.

De RED en FQD omvatten doelen voor het verminderen van broeikasgasemissies en verbieden bovendien het gebruik van gebieden met een hoge biodiversiteitswaarde en gebieden met een grote koolstofvoorraad voor de productie van biobrandstoffen. Belangrijke wijzigingen zijn dat de definitie van gebieden met een hoge biodiversiteitswaarde en gebieden met een grote koolstofvoorraad niet langer bepaalde soorten bosland en grasland omvat. Ook zijn de indirecte effecten op landgebruik, voedselveiligheid en olieconsumptie niet opgenomen in de duurzaamheidscriteria van de RED en FQD.

S.2 Overige uitkomsten

De impact van de broeikasgascriteria van de FQD en RED op de levering van vloeibare biobrandstoffen voor transport is waarschijnlijk verwaarloosbaar, aangezien alle biobrandstoffenketens aan de doelstelling voor het terugbrengen van de broeikasgasemissies voldoen als er aanvullende maatregelen worden getroffen. Deze kosten worden geschat op ca. 61 miljoen euro in 2020 (COWI consortium, 2008; exclusieve kosten van het certificeringsproces). Dit komt overeen met minder dan 1% van de productiekosten van vloeibare biobrandstoffen voor transport. De impact op de kosten of het potentieel van biobrandstoffen om naleving van de landuitsluitingscriteria mogelijk te maken, is waarschijnlijk zeer gering op EU-niveau.

Economische actoren moeten informatie verstrekken over de naleving van de criteria en zijn verplicht adequate standaarden van onafhankelijke auditing en een massabalanssysteem toe te passen om naleving in de gehele productieketen te garanderen. De kosten van deze certificeringsprocessen zijn lastig te schatten, maar zullen de totale kosten waarschijnlijk ongeveer 1% doen stijgen.

De impact van de criteria van de FQD en RED is echter potentieel groter voor kleinschalige producten en als er geavanceerdere of strengere criteria worden geïmplementeerd, bijv. met betrekking tot indirecte effecten op voedselveiligheid en landgebruik. Een ander indirect effect dat recent is ontdekt is het 'rebound-effect' (Smeets et al., 2012). Dit is het fenomeen dat een heffingskorting op biobrandstoffen of het verplicht stellen van het gebruik van biobrandstoffen leidt tot een toename van de totale brandstofconsumptie: het gebruik van biobrandstoffen verlaagt de vraag naar benzine en fossiele olie en daardoor neemt de prijs van benzine en fossiele olie wereldwijd toe, wat weer kan leiden tot een stijgende vraag naar en toenemend gebruik van deze grondstoffen. Dit rebound-effect zorgt voor een vermindering van fossiele brandstoffen en broeikasgasemissies ten opzichte van fossiele brandstoffen.

S.3 Methode

De gepresenteerde resultaten zijn gebaseerd op een literatuuronderzoek dat specifiek gericht is op de volgende kwesties:

- Welke beleidsmaatregelen implementeren overheden om het gebruik van duurzame bio-energie te stimuleren? Hoe werken deze maatregelen?
- Welke duurzaamheidscriteria worden toegepast? Hoe worden deze gemeten en wat is de impact op de levering en kosten van bio-energie?

- Welke informatie is nodig om duurzame bio-energie te meten en deze energie op te nemen in simulatiemodellen?

Het rapport is onderverdeeld in zes hoofdstukken: In Hoofdstuk 1 behandelen we het concept duurzaamheid en de implicaties hiervan voor de biobased economy. We beginnen met een data-analyse van vraag en aanbod om vast te stellen wat de belangrijkste biobased producten zijn (bio-energie, biobrandstoffen en biomaterialen) en welke landen deze producten het meest produceren en vragen. Hoofdstuk 2 biedt een overzicht van de verschillende maatregelen voor duurzame biomassa (bio-energie, biobrandstoffen en biomaterialen) in bepaalde EU-lidstaten. Hierbij gaan we dieper in op de RED en FQD van de EU en de manier waarop de respectieve bepalingen in de praktijk worden geïmplementeerd. In Hoofdstuk 3 bespreken we hoe duurzaamheidscriteria worden gemeten en in Hoofdstuk 4 worden benaderingen voor het integreren van duurzaamheidscriteria in economische modellen verder uitgewerkt. Het rapport wordt afgesloten met een samenvatting en conclusie in Hoofdstuk 5.

1 Framework: definition and scope

This chapter provides the framework for presenting measures for promoting the sustainability of bioenergy; for a definition see Appendix 1. Section 1.1 starts with an overview that indicates the importance of the biomass market in the EU and the world. Then, the definition of sustainability and its principles and criteria are described in Section 1.2, whereas Section 1.3 addresses measures to promote sustainable bioenergy.

We focus on governmental measures and the definition of sustainably endorsed by governments or international organisations. The focus is on public measures rather than private sector initiatives. Where possible, private sector initiatives will be mentioned, but they will not be compared or specifically analysed. The policy measures that we look at are trade-related. That is, the measures are relevant for the trade of bioenergy, biofuels, and biomaterials in terms of their possible impact today and in the future. Due to their potential trade impact, domestic measures such as subsidies for biofuel production for example are also included to a certain degree. The importance of bioenergy, biofuels, and biomaterials is highlighted by providing some background information about production and consumption as well as trade patterns.

1.1 Importance of bioenergy, biofuels and biomaterials: supply and demand

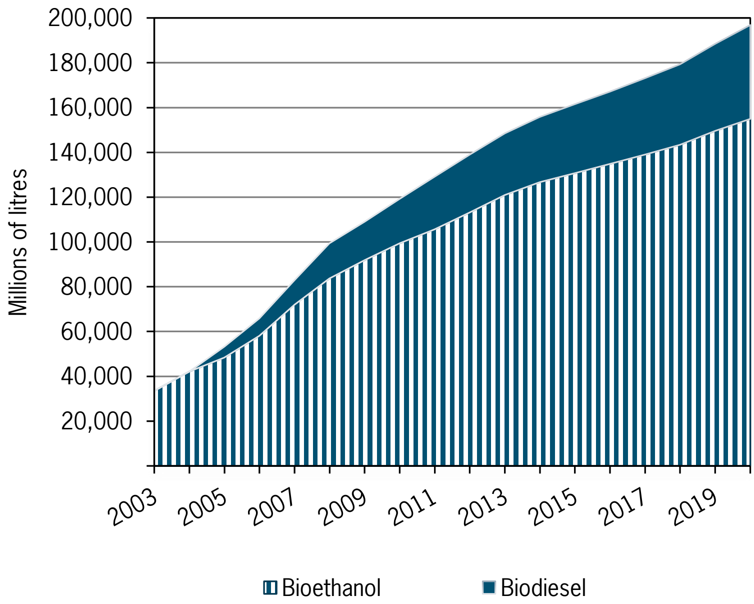
This section provides an overview of the supply and demand of biobased products in order to point out the importance of the respective products. Note that we could not obtain information about whether the products classify as sustainable or not. Information about sustainable biobased products is not readily available for a comparative analysis across products and countries.

Supply of bioenergy, biofuels and biomaterials

Overall, the two most important liquid biofuels are bioethanol (ethanol produced from biomass and/or biodegradable fraction of waste) and biodiesel (a diesel quality liquid fuel produced from vegetable or animal oil) (Eurostat, 2009). In the year 2010, nearly 120 billion litres of biofuel were produced globally (see Figure 1.1). Using OECD-FAO data, the global production of bioethanol and biodiesel will reach 155 million and 42 million litres, respectively, in 2020. Their summed production will increase by about 65% (197 billion litres) from 2010 to 2020.

In 2010, the EU, the US and Brazil accounted for about 80% of the global biofuel production. As shown in Figure 1.2, the global biofuel production is dominated by these countries, more specifically the US (35%), Brazil (27%) and the EU (17%). According to the OECD-FAO projections, the US is the main producer of bioethanol (41%) in 2020, followed by Brazil (33%) and the EU (11%). On the other hand, the EU (42%) is the main producer of biodiesel in 2020, followed by the US (10%) and Brazil (7.5%). Three other countries also play an important role in the production of biodiesel world-wide: India (7.8%), Argentina (7.7%) and Malaysia (3.2%).

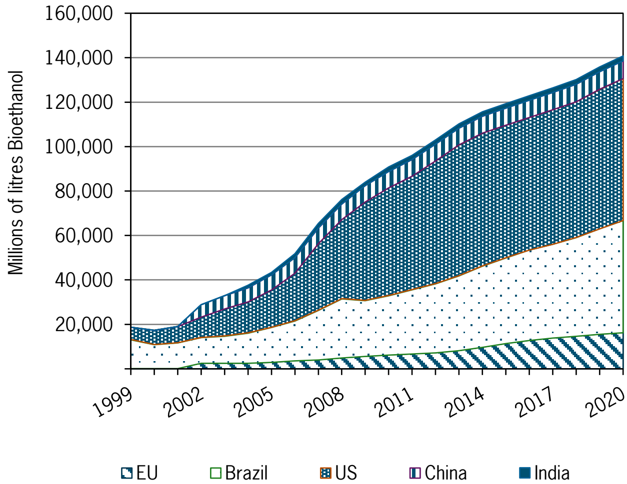
Figure 1.1 **World biofuel production - projections up to 2020 (million litres)**



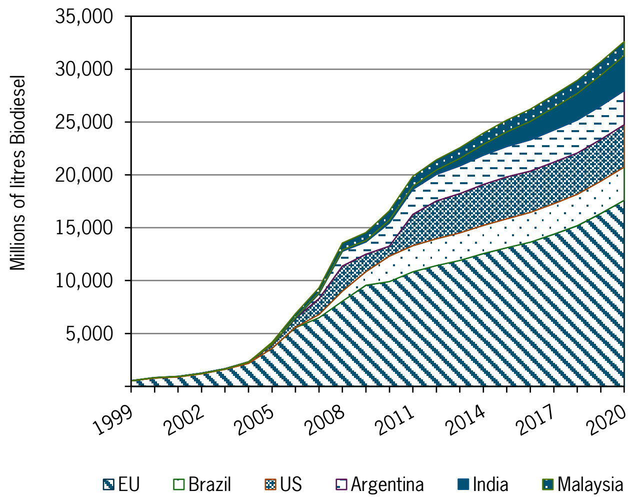
Source: OECD-FAO Agricultural Outlook (2011-2020).

Figure 1.2	Bioethanol and biodiesel production in selected countries - projections up to 2020 (million litres)

A) Bioethanol



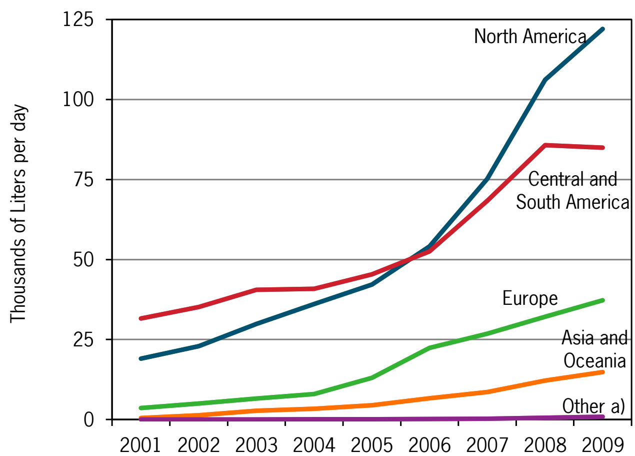
B) Biodiesel



Source: OECD-FAO Agricultural Outlook (2011-2020).

Figure 1.3 provides some production figures for biofuels by region and selected countries in the period 2001-2009; for more details see tables A.1 and A.2 in the Appendix. Between 2001 and 2009, the world bioethanol production increased by about 311%. In the same period, world biodiesel production increased about 14 times. The strongest growth of bioethanol was realised in Europe and Asia and Oceania while Brazil, Central and South America and Africa, Eurasia and the Middle East showed the largest increase for biodiesel. The US has overtaken Brazil as a major producer of bioethanol, while Europe has remained the main source of biodiesel.

Figure 1.3 **World biofuel production by region, 2001-2009 (1,000 litres per day)**

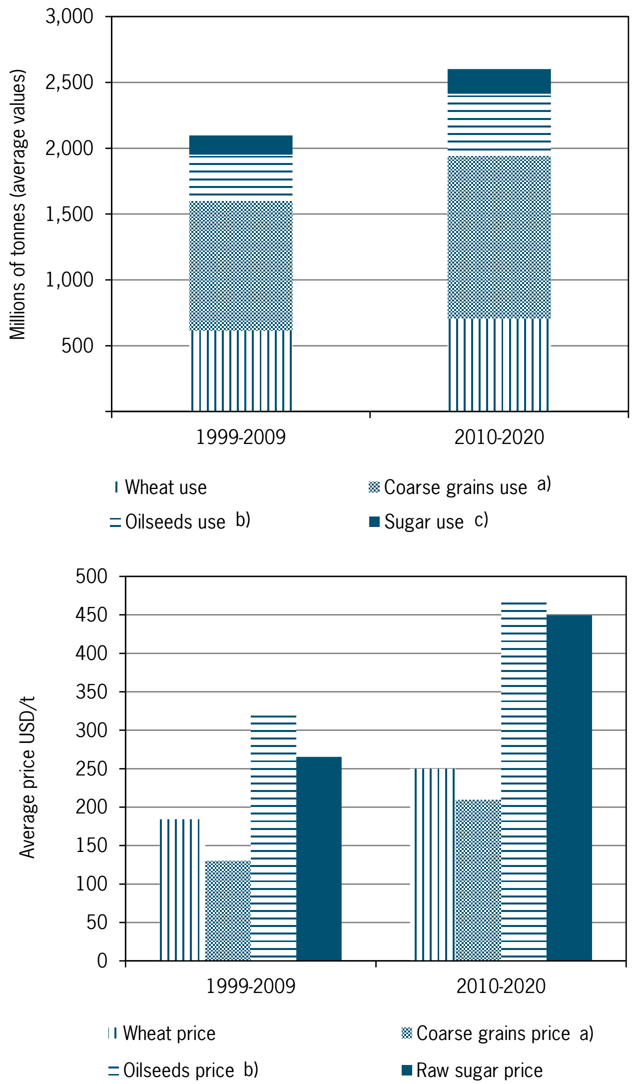


a) Africa, Eurasia and the Middle East.
Source: US Energy Information Administration (EIA).

Biofuels can be produced from many feedstock commodities, including sugar cane, sugar beets, wheat, coarse grains and various oilseeds. Figure 1.4 presents the four most important crops used for the production of biofuels as well as the average global prices of these crops between 1999 and 2020. Table A3.1 in the Appendix presents more detailed information on various biomass sources used for energy purposes.[1]

[1] Society and all economic activities require energy. There is the differentiation between consumption usages, with the main purposes being defined as energy, heating & cooling, transportation.

Figure 1.4	World biofuel production: crop use and prices - average 1999-2009 and 2010-2020



a) Coarse grains include maize, barley, oats, sorghum and other coarse grains; b) Oilseeds include rape-seed/canola, soybean and sunflower seed; c) Sugar includes raw sugar and refined (white) sugar which are measured in raw sugar equivalents.
Source: OECD-FAO Agricultural Outlook 2011-2020.

Demand of bioenergy, biofuels and biomaterials

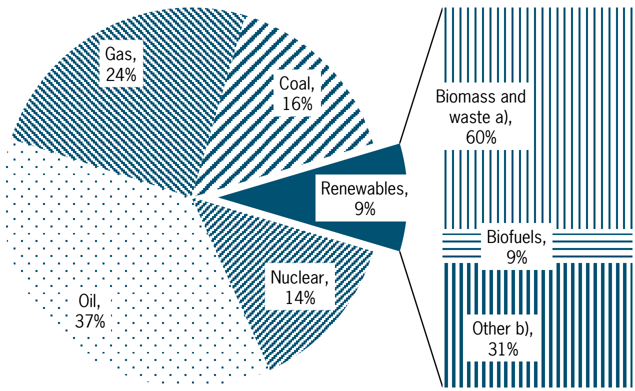
Figure 1.5 shows a breakdown of the EU-27 and the US energy consumption. In 2009, about 6.4 exajoules (EJ)[1] (9%) of the primary energy consumption in the EU-27 were met by energy from renewables, of which biomass accounted for about 70%.[2] In the same year, the US consumption of renewable energy was about 8.2 EJ (8%), whereby 50% came from biomass. As a result, the energy consumption of biomass in the EU and the US amounted to 4.4 EJ and 4.1 EJ, respectively, representing 5.4% (EU) and 4% (US) of the total energy consumption in 2009. Note that gross energy consumption is defined as the sum of: (1) final energy consumption, i.e. energy delivered to industry for manufacturing processes, to the transport sector, including international aviation, and to other sectors (households, services, agriculture, et cetera); (2) consumption of electricity and heat by the energy branch for electricity and heat generation (own use by plant) and (3) losses of electricity and heat in transmission and distribution (Eurostat, 2010).

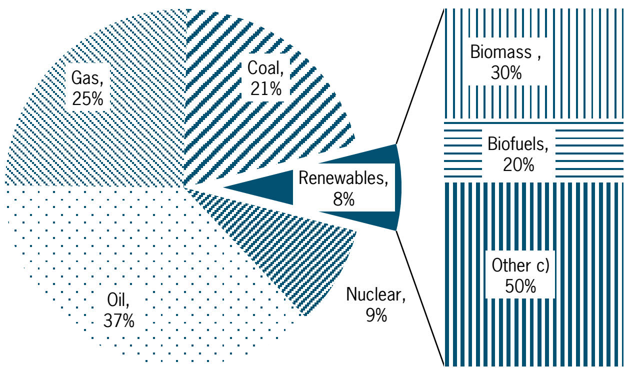
Figure 1.6 presents the share of renewables in gross inland energy consumption in the EU-27. The analysis distinguishes three sources of renewable energy: 1) hydro, geothermal, wind and solar energy, 2) energy from biomass and waste and 3) energy from liquid biofuels. As shown, the share of renewables in total energy consumption stays well below the production targets that were set for 2008 and 2012 (compare Section 3.2). In 2009, renewable energy made up about 9% of total energy consumption in EU-27, which is three per cent points (or three quarters) less than the target of 12% of renewables aimed for by 2012. However, the share of renewables has significantly increased between 2005 and 2009, showing a clear upward trend.

[1] 21 EJ = 10^18 Joules (J) = 10^15 kilojoules (kJ) = 24 million tonnes of oil equivalent (Mtoe).

[2] Appendix 2 elaborates on whether the EU will meet the consumption in the light of the targets set. The figure presented in Appendix 2 shows that the EU Member States mainly import bioethanol from Brazil.

Figure 1.5 Breakdown of EU-27 and US energy consumption in 2009

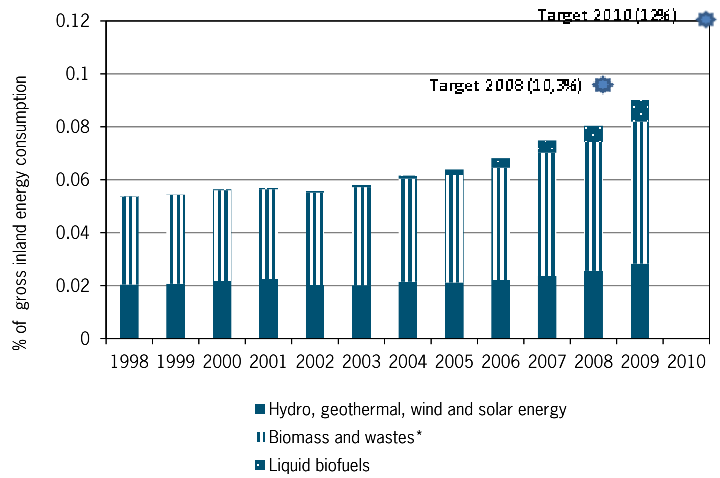




a) Biomass (heat content of the consumed biofuels or biogas; heat consumed after combustion during incineration of renewable wastes); b) Hydropower, geothermal energy, wind and solar energy; Liquid fuels used in in electricity, heating and cooling; c) Hydropower, geothermal energy, wind and solar energy; d) Gross inland energy consumption contains the energy consumed by households, industry and services, including the losses in the transmission and distribution.

Source: Own calculations based on Eurostat and US Energy Information Administration (EIA).

Figure 1.6 **Share of renewables in EU-27 gross inland energy consumption (%)**

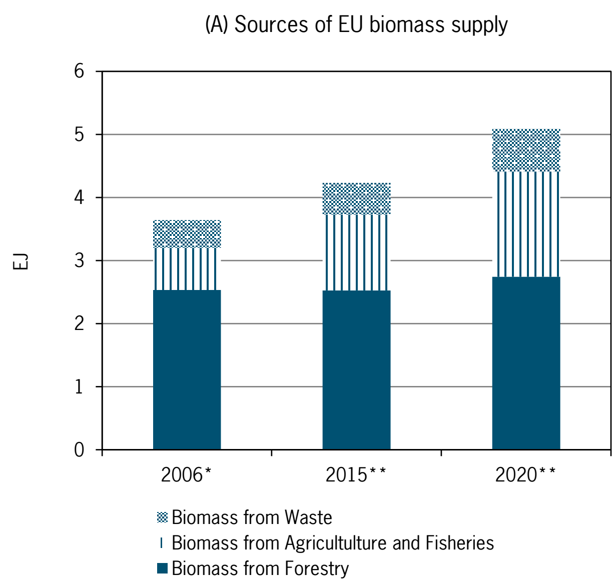


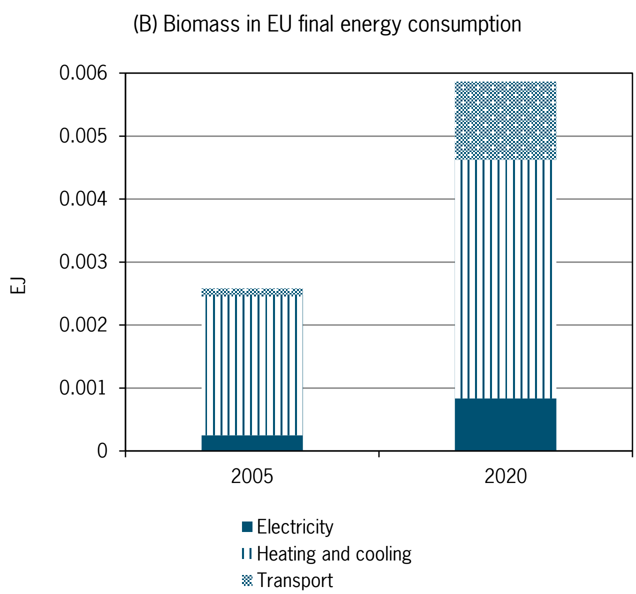
* Biomass (heat content of the consumed biofuels or biogas; heat consumed after combustion during incineration of renewable wastes).
Source: Eurostat.

Combination of projections about supply and demand

In Figure 1.7, panel (A) shows the supply and consumption of biomass in the EU-27 projected up to the year 2020. The total supply of biomass is estimated to increase from 3.6 EJ in 2006 to about 5 EJ in 2020. We distinguish between three sources of biomass: biomass from waste, biomass from agriculture and fisheries, and biomass from forestry. As shown, the increase of the total supply of biomass can be largely explained by increasing biomass production from agriculture and fisheries. The latter is estimated to reach 1.7 EJ in 2020, which is about 33% of the total production of biomass. The production of biomass from waste and from forestry is estimated to increase by 75% and 8%, respectively, from 2006.

Figure 1.7	EU-27 biomass supply and consumption - projection (EJ)





* 2006: domestic biomass + imported biomass - Exported biomass; ** 2015 and 2020: domestic biomass.
Source: National Renewable Energy Action Plans of the EU Member States.

Panel (B) of Figure 1.7 shows that the total EU-27 consumption of energy produced from biomass is estimated to more than double between 2005 and 2020. The consumption of electricity produced from biomass will increase from 0.00025 EJ in 2005 to 0.00083 EJ in 2020. According to the estimation, the consumption of renewable energy for heating and cooling and transport will also rise between 2005 and 2020. The consumption of energy for heating and cooling will increase from 0.0022 EJ in 2005 to 0.0038 EJ in 2020. For transport these numbers are 0.00012 EJ and 0.0012 EJ in 2005 and 2020, respectively.

1.2 Sustainability criteria

This section sets the definition of sustainability and presents the principles and criteria for sustainable biomass. Our focus is on biomass for biofuels as well as biomass for other end-uses, such as bioenergy and biomaterials. We start with a definition of sustainability and proceed to the three principles mainly accepted in the modern sustainability concept. Finally, we will define sustainability criteria for biomass that are currently universally addressed.

How is sustainability defined?

Although the concept of sustainability is not new, there is still no universally agreed definition of sustainability. On the contrary, one can find in the literature a variety of definitions, meanings and interpretations. Some scientists have even counted up to 300 different definitions (Dobson, 2000). The most well-known definition of sustainability is the one introduced in the Brundtland report 'Our Common Future', written in the framework of the World Conference on Environment and Development (WCED) in 1987.

> 'Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.' (WCED, 1987: p. 43)

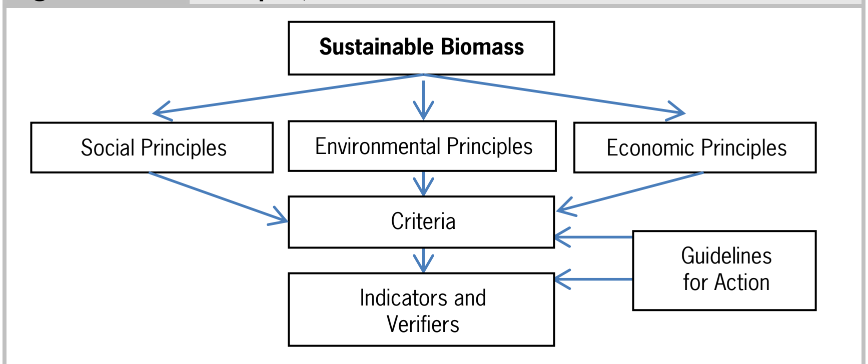
The weakness of this definition is, however, that the 'needs' of future generations are vague and might cover a wider variety of aspects from food to cell phones (Langeveld et al., 2010). The definition only sets an ideal premise and does not clearly specify particular principles for measuring and modelling sustainability. A further development of the sustainability definition resulted in a widely accepted, multiple approach considered in terms of the following three areas where sustainability matters: society, environment and economy. This is known as the Triple Bottom Line approach, which dates back to the late 1990s (Elkington, 1998). Figure A4.1 in the Appendix illustrates this definition.

The Triple Bottom Line approach steps away from the traditional model of purely financially judging the 'needs' of the future by introducing additional judgment principles that take into account the environmental and social needs of the future when making decisions today. However, there has been some criticism on the model due to the lack of accurate measuring tools to calculate not just quantitatively but also qualitatively the social and environmental principles (Norman and MacDonald, 2004). Section 3.1 deals with the measurement of sustainability criteria in detail.

Sustainability criteria for biomass

According to the definition of sustainability there is a need for specific criteria and indicators for exemplification of each of the three principles. We present here a hierarchical framework for sustainable biomass for energy and other end-uses, which relies on existing sustainability schemes. Figure 1.8 presents a generic structure of principles, criteria and indicators for sustainable biomass.

Figure 1.2 **Principles, criteria and indicators for sustainable biomass**



Source: Based on Bueren and Blom (1996); Mendoza and Prahbu (2000); UN (2008); Vis et al. (2008).

We consider the sustainability principles as the starting point for describing the objective of sustainable biomass. The principles are usually broadly (often non-quantifiable) formulated and open-ended, related to social, environmental and economic issues. In order to translate these sustainability objectives into practical observable requirements, sustainability criteria for biomass are developed. A criterion is much more specific than a principle. Indicators are quantitative or qualitative minimum parameters which are used to measure whether the criteria for sustainable biomass are met. Verifiers are used to test the indicators. Guidelines are being developed by governments (and also by non-governmental organisations, NGOs) to indicate how one should comply with the criteria and indicators.

Table 1.1 provides an overview of possible general principles and criteria with relevance for sustainable biomass. For this purpose, we screened some public and private sector initiatives for sustainability criteria. The sustainability criteria are grouped with regard to the three principles of sustainability, described above. Not all criteria can be shown due to the fact that this would result in a very long list. We focus on those principles and criteria that are addressed by the concept of sustainability according to the guidelines of the United Nations (WCED, 1987) and the EU's sustainable development strategy (EC, 2001) (see Table A.4 in the Appendix). Looking at the EU sustainability strategy relevant for bioenergy, we give examples of criteria, indicators, verifiers as well as guidelines in Table A.5 in the Appendix.

Table 1.1 Overview of general sustainability criteria with respect to biomass

Sustainability principles	**Environmental sustainability**	**Economic sustainability**	**Social sustainability**
Sustainability criteria for biomass	- Biodiversity - Ecosystems - Natural resources - Atmosphere and greenhouse gas emissions - Water and soil - Deforestation - Waste - Landscape - Traceability	- Businesses perspective - Competitiveness - Economic growth - Employment - Resources - Yields - Technology - NGOs	- Equity - Participation - Demography - Poverty - Land ownership - Labour - Health - Food - Energy - Human rights - Law - Trade - Acceptance

Source: Lyytimäki et al. (2011); Van Dam (2010); EC (2009a); EC (2009b); Cramer et al. (2007); Lewandowski and Faaij (2004).

Biomass is virtually any organic material which originates mainly from agricultural crops and residues, forestry, wood processing industries and waste. Many feedstock commodities have increasingly been used for various energy purposes, such as transport biofuels, electricity, heating and cooling. One main driving force behind the promotion of biomass is the potential environmental benefits of saving greenhouse gas (GHG) emission, which can be achieved by replacing the conventional, carbon-intensive, non-renewable sources with biomass sources. The ever growing production and use of biomass gives rise to international trade, which probably will highly expand in the future. Increased trade and demand for biomass can lead to environmental degradation, which in turn may lead to various economic and social problems, such as food availability and access to food, and deterioration of labour conditions. According to the United Nations Economic Commission for Europe around 24% of woody biomass for energy comes from direct removals from forest and agricultural in Europe (UNECE/FAO, 2009). For instance, this can lead to deforestation, forest degradation, distortion of soil carbon stocks as well as productivity losses and losses of highly bio-diverse ecosystems. The issue of the indirect land change impacts, known as ILUC, has been widely discussed on the national and international floor.

In the remainder of this section, we summarise the relevant issues that sustainability criteria for bioenergy, biofuels and biomaterials aim to address, thereby further describing the criteria listed in Table 1.1.

Environmental sustainability criteria

1. Conservation, management or restoration of biodiversity
2. Preservation of existing ecosystems
3. Conservation and efficient use of natural resources
4. Protection of the atmosphere, reduction of greenhouse gas emissions
5. Water availability, conservation and pollution avoidance of water and avoidance of soil erosion
6. Combating of desertification and drought
7. Minimisation of wastes and improving waste management
8. Conservation of typical landscape elements and improvement of landscape variation
9. Biomass has to be traceable in the chain

Economic sustainability criteria

1. Integration of environmental concerns in business decision-making and managements plans, long-term commitments
2. Ensuring competitiveness and the ability to adapt to market conditions
3. Strengthening and diversifying the economy
4. Improving employment, wages and enhancing professional and dedicated human resources
5. Reliability of resources, sustainable trade and minimisation of supply disruptions and over-dependencies on a limited set of suppliers of biomass
6. Sustainable rate of harvesting
7. Comprehensive development and research programme for new technologies and production processes
8. Strengthening the role of non-governmental organisations

Social sustainability criteria

1. Equal opportunities and access to resources ensuring adequate quality of life
2. Capacity building and development of human capital and skills
3. Democratic participation and involvement in decisions
4. The activity should not contribute to poverty
5. Avoidance of land tenure conflicts, providing equitable land ownership
6. Improving employment, wages and labour conditions
7. Protection of human safety and health
8. Enough food of sufficient quality, so biomass production does not lead to severe competition with food production
9. Energy supply safety
10. Rights of children, women, indigenous people and no discrimination
11. Compliance with laws and international agreements
12. Fair trade conditions, so biomass from non-certified resources does not enter the trade chain
13. Acceptance of the production methods by producer and consumer

During the past few years, numerous initiatives have been undertaken by the EU, the individual EU member states as well as some other countries. The initiatives include the development of particular guidelines for sustainable biomass to the full implementation of sustainability criteria. Table 1.2 presents a number of regulatory initiatives already in place in the EU, Germany, the Netherlands, the UK, and Switzerland as well as in the US and Brazil. Note that the overall emphasis in this report is on EU initiatives.

Table 1.2	Examples of governmental sustainability initiatives for biomass
Country	**Regulatory initiatives by governments**
EU	EU Renewable Energy Directive and Fuel Quality Directive
California (US)	Low Carbon Fuel Standard (LCFS)
US	Renewable Fuel Standard (RFS2)
Germany	Biomass Sustainability Order (BioNachV)
The Netherlands	The Cramer Criteria
Brazil	Social Fuel Seal
Switzerland	Biofuels Life Cycle Assessment Ordinance (BLCAO)

Source: FAO Bioenergy and Food Security Criteria Indicators (BEFSCI) project, available at: http://www.fao.org/bioenergy/foodsecurity/befsci/62379/en/

1.3 Measures to promote sustainable bioenergy

This section gives a brief overview of policy measures to ensure sustainable biomass production. There is a host of different measures, and they are mainly found in combination to promote biomass production in general. Measures to promote biomass production have frequently been implemented in various policy areas, such as climate change policy, environmental policy, agricultural and rural policies or energy policy. Note that the measures are public policy measures and thus formulated by some kind of legal documentation.

OECD (2008) describes common policy measures to promote biomass production as the kind of toolbox of possible options for policy-makers to choose from. The main categories of different types of measures are supply, demand and supporting R&D initiatives for bioenergy production. Using the categorisation by De Jager et al. (2011), we differentiate between the following concrete support measures:

- Feed-in tariffs;
- Premium paid to suppliers;
- Quotas for minimum shares or blending requirements (targets);
- Tax exemption;
- Investment grants and other financial incentives (often for R&D).

In the EU, these support measures are linked to sustainable bioenergy as they are only valid for suitable bioenergy. Only those suppliers or operators in the EU that produce sustainable bioenergy according to the EU sustainability criteria qualify for receiving support. The support measures are not directly applicable to bioenergy production outside the EU, but if inputs into bioenergy production are concerned there will be implications since EU suppliers and operators will demand inputs that meet the sustainable criteria in order to ensure support.

In bioenergy trade or trade of inputs to generate bioenergy products, there is no differentiation between sustainable and other bioenergy and neither do tariffs differ according to sustainability. The sustainability of bioenergy cannot be enforced by trade policy measures. Note that sustainability standards and certification may be used as import requirements in the future. Such measures are non-tariff measures, for which the World Trade Organisation (WTO) established general principles and rules in order to minimise trade-distorting effects. If sustainability certification for bioenergy is applied on foreign products and becomes mandatory in the trade of the relevant energy products or inputs, it can be expected that there will be discussions and possible disputes at the WTO level due to lack of agreement about sustainability criteria, issues and measurement issues (compare Chapter 3).

In the remainder of this section, the aforementioned measures will be briefly introduced. The measures applied in the EU Member States will be elaborated on in Chapter 3. More specifically, we will provide an overview of measures and their scope per type of renewable energy and Member State (for example see Section 2.5).

Feed-in tariffs

Feed-in tariff systems ensure a certain price during a limited period of time. The level of support is thus fixed, thereby reducing investment and market risks for suppliers and operators. With a feed-in tariff, suppliers and operators do not face price signals and are not subject to resulting market changes. Hence suppliers and operators do not adjust their production accordingly. There is the general possibility of windfall profits that operators could earn if the feed-in tariffs are generous and more than compensate for the actual costs of providing proof about the sustainability of the respective renewable bioenergy.

Premium systems

They are overall similar to feed-in-tariff systems, expect for that suppliers are exposed to price changes and associated risks. The premium paid to suppliers can be linked to price developments; for example there may be minimum prices and price caps, which respectively determine the premium to be paid. Usually, the premium is determined so that the additional costs of supplying renewable and possibly sustainable bioenergy are covered. Consumers pay for the premium, and the premium system thus crucially depends on the consumers' willingness-to-pay for renewable energy, which differs from country to country. The consumers' willingness-to-pay is influenced through the consumers' awareness and specific market conditions, for example 'green marketing', education and knowledge. As noted by Van der Linden et al. (2005), 'green marketing' has not yet generally produced a large and sustained demand for renewable energy, as desired by investors and suppliers, unless demand is heavily subsidised. It may be due to scepticism of consumers that the premium is not effectively used to promote renewables.

Quota systems (targets)

Quotas prescribe the minimum share of renewable energy for suppliers (blending target), with the shares usually increasing over time. Suppliers are obliged to meet the minimum shares, otherwise they may face some sort of penalty. In other words, the quota represents demand, and with increasing shares, the aim of quota systems is to increase demand for renewable energy. In some cases, quota obligations are combined with tradable certificates, which reflect the value of the renewable energy given current technology. With technological progress, diffusion and learning, the price of a tradable certificate can change such that a cost efficient outcome for suppliers and consumers can always be achieved.

National targets of mandatory blending requirements function like a quota, whereby the quota prescribes that a certain percentage should be or rather has to be sustainably produced bioenergy. Such targets significantly support the respective industry and lead to price competition between providers, which in turn results in cost-efficient solutions (under market structures of perfect competition).

Tax exemption

There are many types of different tax incentives, including the tax exemption of renewable energy from energy taxes, tax refunds, lower rates of value-added tax and for investors exemptions from income or corporate taxes. They all increase the competitiveness of renewable energy sources, and may be based on investment or on production. Such tax incentives are widespread, probably because they are usually easy to implement and implementation costs are routinely covered by government budgets.

Investment grants and other financial incentives

Investment grants comprise grants to cover investments in renewable energy as well as to provide fiscal incentives, for example reduced interest rates. In addition, there are various programmes to foster research and development activities in the field of renewable energy in general and in particular in the field of sustainability. In recent years, the focus of such activities has been on projects concerning second-generation biofuels that, in contrast to first-generation biofuels, are made from non-edible feedstock such as wood and straw.

2 Sustainable bioenergy according to the EU Renewable Energy Directive (RED) and the Fuel Quality Directive (FQD)

The EU brought forward the RED-FQD in order to realise its energy strategy.[1] The two directives lay down a common framework for the promotion of renewable energy and the quality of petrol and diesel fuels in the EU, also relating to administrative procedures, information and training; see EC (2009a) and EC (2009b), respectively. In both directives, biofuels and biomass play a significant role. The directives RED-FQD only apply to biofuels for transport and bioliquids used for other purposes (electricity, heating and cooling), both imported or produced in the EU, and do not cover the use of solid biomass in energy applications.

The RED-FQD are binding in so far as the EU member states have to account for the respective provisions in their national legislation. Each member state has freedom about how and with which measures to achieve the provisions and goals set in the directives, translating them into their national legislation. The EU Member States ratified the two directives by the end of the year 2010. For the implementation, the EC is more specific than usually in the case of directives and requires that the EU Member States submit individual National Renewable Energy Action Plans (NREAP), which the European Commission (EC) will approve and use for monitoring purposes. In addition to setting national targets, the plans should also describe measures that the respective Member State will take to achieve the national targets, including the sustainability criteria and goals.

This chapter addresses the first research question of this report: What policy measures do governments implement to promote sustainable bioenergy and how do they function? More specifically, we elaborate on existing EU measures

[1] Table A.7 in the Appendix gives a one-to-one comparison of the provisions in the RED and FQD. The consolidated legal documents of the directives are as follows: Renewable Energy Directive (RED): Directive 2009/28/EC on the promotion of the use of energy from renewable sources, OJ L 140/16, 5.6.2009 (accessed January 2012: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009: 140:0016: 0062:EN :PDF) and Fuel Quality Directive (FQD): Directive 98/70/EC relating to the quality of petrol and diesel fuels, OJ L 350, 28.12.1998 (accessed January 2012: http://eur-lex europa.eu/LexUriServ/LexUriServ.do?uri= CONSLEG:1998L0070:2011 0622: EN:PDF).

to promote sustainable bioenergy by also considering their implementation, which is crucial to achieve the sustainability goals. We first introduce the sustainability criteria and their practical implementation, as described in the EU Renewable Energy Directive (RED) and the Fuel Quality Directive (FQD) (Section 3.1), and then look at the different measures: targets, tax exemption and subsidies as well as certification schemes for sustainability (Sections 3.2 to 3.4). To conclude the chapter, we give a summary overview of the support measures and their scope in the individual EU Member State (Section 3.5).

2.1 EU sustainability criteria in the RED and FQD

The RED-FQD is claimed to contain 'the most comprehensive and advanced sustainability scheme of its kind anywhere in the world' (EC, 2010c: p. 7). In 2010, the EC presented the results of the very first attempt to develop sustainability criteria for biomass other than biofuels and bioliquids (EC, 2010d). These criteria were used in almost all respects in the RED and FQD and have thus become the EU sustainability criteria for bioenergy, biofuels and biomaterials. The sustainability criteria for biofuels (FQD), biofuels and bioliquids (RED) are binding, while the sustainability criteria for solid and gaseous biomass (RED, Article 17) are not binding. Overall, the EC encouraged the EU Member States to develop their own national sustainability schemes, including criteria and indicators. Thus, there are national sustainability schemes for bioenergy; for instance, the Cramer criteria developed on behalf of the Dutch government are an example of a national initiative for sustainability criteria.

In order for biofuels and bioliquids to be counted towards the national renewable energy targets, and to be eligible for government support (tax reduction or subsidies), economic operators must meet the sustainability criteria. Given this conditionality, the national sustainably schemes of the Member States generally include the EU sustainability criteria. Some schemes go beyond the EU criteria, covering other additional aspects and indicators (compare Table 2.4).

Table 2.1 presents the respective criteria by separately looking at environmental and socio-economic principles of sustainability. For the detailed indicators see Appendix 9.

Table 2.1	EU sustainability criteria for biofuels, bioliquids, solid, gaseous biomass	
	Criteria for biofuels a) (FQD), biofuels and bioliquids b) (RED)	**Criteria for solid c) and gaseous d) biomass (RED Article 17(9))**
Environmental principles	Criteria e): A minimum GHG saving (Articles 17(1) , 17(2) and 22(1))	The same conditions as those in first column Exceptions: - GHG criterion not applied to waste and residues - applies only to larger installations >1 MW
	Criteria: Protection of high biodiversity (Articles 17(3), 17(7) and 22(1))	The same conditions as those in first column Exceptions: - applies only to larger installations >1 MW
	Criteria: Avoid use and loss of high carbon-stock land (Articles 17(4) and 17(5))	The same conditions as those in first column Exceptions: - applies only to larger installations >1 MW
	Criteria: 'Cross compliance' with environmental requirements under the Common Agricultural Policy (Article 17(6)) *Applicable only within the EU*	The same conditions as those in first column Exceptions: - applies only to larger installations >1 MW
	Criteria f): Waste management (Articles 17(1) and 22(1))	The same conditions as those in first column Exceptions: - no GHG criterion for waste and residues - applies only to larger installations >1 MW
	Criteria: Soil, water and air protection (Articles 17(7) and 22(1)) *Not required by the EU, but there is a requirement of reporting on these issues*	The same conditions as those in first column Exceptions: - applies only to larger installations >1 MW

a) Liquid and gaseous fuels used in transport; b) Liquid fuels used in in electricity, heating and cooling; c) Solid fuels used in electricity, heating and cooling; d) Gaseous fuels used in electricity, heating and cooling; e) This criterion covers direct land change only; f) This criterion only needs to fulfil the GHG criterion; g) Under the FQD (Article 7a (1)a) there is a requirement on Member States to report information on the country of origin of all road transport fuels (fossil and renewable) and where they are purchased. Under the RED there is no requirement to make information public.
Source: EC (2010d); EC (2009a); EC (2009b).

Table 2.2 (continued)	**EU sustainability criteria for biofuels, bioliquids, solid, gaseous biomass**	
	Criteria for biofuels a) (FQD), biofuels and bioliquids b) (RED)	**Criteria for solid c) and gaseous d) biomass (RED Article 17(9))**
Socio-economic principles	Criteria: Food availability and access (Articles 17(7) and 22(1)) *Not required by the EU, but there is a requirement of reporting on these issues.*	The same conditions as those in first column Exceptions: - additional monitoring of the origin of biomass g) - applies only to larger installations >1 MW
	Criteria: Employment, wages and labour conditions (Article 17(7)) *Not required by the EU, but there is a requirement of reporting on these issues.*	The same conditions as those in first column Exceptions: - applies only to larger installations >1 MW
	Criteria: Land tenure/access and displacement (Article 17(7)) *Not required by the EU, but there is a requirement of reporting on these issues.*	The same conditions as those in first column Exceptions: - applies only to larger installations >1 MW

a) Liquid and gaseous fuels used in transport; b) Liquid fuels used in in electricity, heating and cooling; c) Solid fuels used in electricity, heating and cooling; d) Gaseous fuels used in electricity, heating and cooling; e) This criterion covers direct land change only; f) This criterion only needs to fulfil the GHG criterion; g) Under the FQD (Article 7a (1)a) there is a requirement on Member States to report information on the country of origin of all road transport fuels (fossil and renewable) and where they are purchased. Under the RED there is no requirement to make information public.
Source: EC (2010d); EC (2009a); EC (2009b).

The EU sustainability criteria can be summarised as follows:

- Directive 2009/28/EC, Article 17 (2): Sustainable biofuels/bioliquids have to emit at least 35% less greenhouse gases than fossil fuels. In 2017 these savings have to be at least 50%. Biofuels produced from new installations have to save at least 60% after 2018.
- Directive 2009/28/EC, Article 17 (3), (4) and (5): Sustainable biofuels and bioliquids cannot be produced from raw materials obtained from land with high biodiversity value (land that from January 2008 onwards was (a) primary forest, (b) a natural protected area and (c) highly biodiverse grassland and (d) peat lands) and with high carbon stock (land that from January 2008 was wetland, forest land with trees higher than 5 meters and a canopy cover of more than 30% and/or forested with a canopy cover of 10-30%, unless it

can be proven that GHG emission reduction targets can still be achieved following conversion).

- Directive 2009/28/EC, Article 17 (6): Sustainable biofuels/bioliquids have to be made of raw materials generated in compliance with minimum requirements of good agro-environmental practices as specified in Regulations (EC) No 73/2009. This is within the EU and thus affects EU farmers generating raw material for bioenergy production.

The EU sustainability criteria cover some aspects, but other aspects, namely those relating to the socio-economic principles of sustainability, are not covered. While referring to the principles set in the conventions of the International Labour Organisation (ILO), concrete indicators for socio-economic criteria are not defined and do not need to be applied according to the current EU legislation. Note that socio-economic principles are mentioned in relation to reporting about the socio-economic impact. More specifically, the RED requires that Member States officially report on the socio-economic impact of the sustainability of bioenergy (every 2 year). Looking at the EU level, German and Schoneveld (2011), for example, provide an impact assessment on social sustainability of the current situation of EU bioenergy based on the private schemes accredited by the EC.

The EU sustainability criteria are defined for biofuels and biomass but do not entirely apply to waste and residues, which are also used to generate renewable energy. According to Directive 2009/28/EC, Article 17 (1), the GHG saving criterion only applies to waste and residues of products other than agriculture, aquaculture, fisheries and forestry. Furthermore, sustainability criteria are not prescribed for solid and gaseous biomass used in electricity, heating and cooling.

Conformity assessment and verification

Verification of compliance with the sustainability criteria is essential and lies within the responsibility of the Member States. In the Member States, economic operators have to prove that they fulfil the sustainability criteria as required, and the EU legislation sets general rules for doing so. More specifically, Article 18 of the RED deals with the verification of compliance with the sustainability criteria for biofuels and bioliquids; Article 7c of the FQD also deals with the verification of compliance.

For conformity assessment and verification, the Member States require the following from economic operators:

- Information on the compliance with the criteria required (Article 18(3) RED, and Article 7c(3) FQD);
- Use of a mass balance system to ensure compliance along the supply chain (Article 18(1) RED) (chain of custody);
- Application of an adequate standard of independent auditing (Article 18(3) RED).

In order to ensure the integrity of the sustainability schemes along the supply chain and efficiency, while limiting the administrative burden for businesses, the EC has chosen for a mass balance system. The mass balance system makes the connection between information or claims of sustainability concerning raw or intermediate products and claims concerning final products, without imposing product segregation and integrity preservation. That means that mixing consignments of raw material or biofuel with differing sustainability characteristics, i.e. products complying and non-complying with sustainability criteria, is allowed as long as the volume in a physical container keeps the same sustainability characteristics throughout the supply chain from primary producers to consumption. The European Biodiesel Board (EBB) points towards some practical aspects of the mass balance system, in particular with regard to the blending necessary to achieve technical (as opposed to sustainability) characteristics that businesses have to apply for biofuels for example (EBB, 2009).

Overall, the verification of compliance should take place as follows (EC, 2010c):

- *National schemes of the EU Member States*
  Producers provide the relevant national authority with data about their compliance with the respective national sustainability schemes.
- *Private schemes*
  Producers use one of the voluntary private schemes that the EC has accredited in order to verify compliance with the sustainability criteria. As elaborated in Section 3.4, the EC has approved seven private schemes for sustainable biofuels so far; other voluntary schemes are expected to be approved in the future.
- *Bilateral or multilateral agreements*
  Producers supply sustainable bioenergy products in accordance with the terms of the bilateral or multilateral agreements that contain provisions about sustainability between the EU and third countries.

Note that the latter mainly seems to refer to trade agreements between the EU, the individual Member States and trade partner countries and thus targets imported renewable energy or products used for generating renewable energy in the EU. Except for co-operation on labour standards, sustainability aspects have generally not been part of trade agreements, whether multinational or bilateral trade agreements. With the aim of mitigating greenhouse gas emission, the International Centre for Trade and Sustainable Development (ICTSD) advocates a framework for an international sustainable energy trade agreement (SETA) that could be negotiated in the WTO context or may become a plurilateral agreement outside of the WTO context. For further information see ICTSD (2011). Such an agreement would bring together countries interested in addressing long-term climate change and would also help to achieve long-term sustainability of bioenergy, while maintaining open markets for trade. Concerning EU trade agreements, there seems to be scope to include sustainability aspects in the new generation of EU deep and comprehensive free trade agreements (DCFTAs) with trade partner countries.

Reporting

The RED emphasises the importance of reporting in order to monitor the EU bioenergy goals across Member States. First of all, Member States have to submit National Renewable Energy Action Plans (NREAP), as already mentioned, and deliver progress reports every two years (Directive 2009/28/EC, Article 22). In these plans, each Member State has to provide details of the following:

- How to meet the respective legally binding 2020 targets for the share of renewable energy (i.e. wind-, solar-, hydro- and biomass)?
- Projections about the share of renewables in gross final energy consumption,[1] whereby information has to be separately reported for electricity, heating and cooling and transport in the period 2010-2020.
- What are the sectoral targets and the technology mix to be used?
- Which measures and reforms will be undertaken to overcome the barriers to developing renewable energy by 2020?
- Timeline and roadmap to follow.

[1] Gross energy consumption is defined as the sum of: (1) final energy consumption, i.e. energy delivered to industry for manufacturing processes, to the transport sector, including international aviation, and to other sectors (households, services, agriculture, et cetera); (2) consumption of electricity and heat by the energy branch for electricity and heat generation (own use by plant); and (iii) losses of electricity and heat in transmission and distribution (Eurostat, 2010).

In order to draft the NREAPs, a template set of tables was published by the EC (EC, 2009d). So far, all 27 Member States have submitted NREAPs to the Energy Research Centre of the Netherlands, which was contracted to create an external database and quantitative report of all NREAPs received (ECN, 2011). There is no direct information about the share of bioenergy meeting the EU sustainability criteria. As only sustainable bioenergy contributes to targets and qualifies for any kind of support, this information could give clues about the supply and demand of sustainable bioenergy in the individual EU Member States.

As mentioned, the reports by the Member States have to include information about social sustainability, but social sustainability is not part of the EU sustainability criteria. Overall, the reporting mechanism is expected to create incentives for operators to apply socio-economic sustainability criteria and will encourage (private sector) initiatives to capture socio-economic aspects as well as other sustainability aspects to which operators will be certified.

The EU Member States report to the EC and the EC will report further to the European Parliament and the Council on the impact on social sustainability in the EU and third countries. The information covered is about the demand for biofuel, the availability of foodstuffs and prices, in particular for people living in developing countries, and wider development issues. Reports shall also address land use rights as well as labour rights (EC 2009: p. 38). The reports will be prepared by the Member States, with operators providing the respective info as necessary. Note that the reporting obligation can be omitted if the bioenergy products are certified by voluntary schemes or are produced in countries that have concluded an international agreement recognised by the EC (bilateral or multilateral agreements) (compare the section about verification and conformity assessment). These exemptions aim to reduce the administrative burden of the data collection and reporting.

Enforcement

As mentioned, the sustainability criteria are not mandatory such that producers and suppliers can comply with the sustainability criteria on a voluntary basis. Sustainable renewable energy will thus be offered next to other energy, leading to market segmentation. The enforcement takes place via the condition that only sustainable bioenergy will be accepted for achieving national targets and receiving governmental support.

2.2 Targets (consumption, production and emission reduction)

In the EU's energy strategy, a 20% cut in GHG emissions, a 20% increase in energy efficiency and a 20% increase in the use of renewable energy have to be reached by 2020 (EC, 2011a). In addition, the strategy also indicates that 10% of the EU transport energy has to come from renewable sources[1], no matter whether this is renewable energy from wind, solar, or hydropower or from first and second generation biofuels. Note that biomass is by far the most important source for renewable energy in the EU, delivering almost 70% of the total renewable energy in 2007 and having the fastest growing share (compare Section 1.1). Only sustainable bioenergy production counts towards the national targets of the renewable energy use.

In the EU's final gross energy consumption, the consumption share of renewable energy should be 20%. This is an ambitious goal, given that the overall 2020 potential for renewable energy in the EU (excluding imports) makes up for a share of 28.5%, compared to the current gross final consumption (De Jager et al., 2011).[2] The 20% target does not have to be reached by all EU Member States. Depending on current shares and other indicators such as GDP, the individual targets for each Member State were set as national targets. The targets apply to locally produced and imported biomass alike. As such, the incentives for providing sustainable biomass on the one hand are given to EU producers of bioenergy, but on the other hand demand is also fostered by encouraging buyers that have to contribute to achieving the targets.

Table 2.2 lists the national targets for 2020 and also gives the overall GHG emission reduction targets. In the RED, these targets have neither been defined with respect to the type of renewables nor specified according to the use of biomass other than biofuels for transport. However, the RED defines specific GHG emission reduction criteria for sustainable biofuel, using petrol as the benchmark for comparison. The targets for the consumption shares in the RED for example refer to renewable energy in total (thereby including wind, solar and hydropower) and not specifically to biomass. Focusing on biomass, the last two columns of Table 2.2 present the consumption shares of biomass and projections for 2020, which indicates the importance of biomass.

[1] The EU transport sector produces more than 20% of the GHG emissions in the EU (EC, 2010b).
[2] De Jager et al. (2011) estimate the EU production potentials for different types of renewable energy (i.e. electricity, heat and cooling, transport), given costs and technology. Imports are not accounted for in their estimation.

Table 2.2	**Targets for the consumption of renewables and GHG emission reduction by 2020**						
Renewable energy as a share of gross final energy consumption according to RED*						**Biomass share of gross final renewable energy consumption a) *****	
Country	**Consumption share in 2005 (%)**	**2020 targets (%)**	**2020 GHG non-ETS targets b) ****	**2020 GHG ETS targets c) ******	**2020 GHG emission cap d) **** (%)**	**Consumption share in 2005 (%)**	**Projection of share in 2020 (%)**
Austria	23.2	34	-16	-21%	-18%	49.1	50.0
Belgium	2.2	13	-15	-21%	-18%	90.0	70.2
Bulgaria	9.4	16	+20	-21%	-4%	75.7	81.1
Cyprus	2.9	13	-5	-21%	-13%	8.8	30.6
Czech Republic	6.1	13	+9	-21%	-8%	81.8	84.8
Denmark	17	30	-20	-21%	-20%	75.0	74.4
Estonia	18	25	+11	-21%	-9%	98.7	84.0
Finland	28.5	38	-16	-21%	-18%	83.6	77.4
France	10.3	23	-14	-21%	-16%	62.4	59.8
Germany	5.8	18	-14	-21%	-17%	68.6	54.1
Greece	6.9	18	-4	-21%	-13%	63.7	44.9
Hungary	4.3	13	+10	-21%	-1%	(in 2010) 87.6	72.2
Ireland	3.1	16	-20	-21%	-20%	52.1	46.4
Italy	5.2	17	-13	-21%	-16%	32.2	43.4
Latvia	32.6	40	+17	-21%	7%	81.4	82.1
Lithuania	15	23	+15	-21%	4%	94.6	87.8
Luxembourg	0.9	11	-20	-21%	-20%	59.9	67.7
Malta	0	10	+5	-21%	-10%	(in 2010) 21.9	24.3

a) In the sectors: electricity, heating and cooling and transport; b) GHG emission targets by 2020 relative to 2005 for non-ETS (Emission Trading System) emissions (agriculture, transport, residential, some industry). c) GHG emission targets by 2020 relative to 2005 for ETS emissions (energy and heavy industry); d) Together the ETS and non-ETS form the EU emissions cap. Since a single, EU-wide cap under the EU ETS will be introduced from 2013, an effort sharing arrangement between Member States has been determined solely for the reduction in emissions from sectors not covered by the EU ETS.
Source: * EC (2009a); ** EEA (2011); *** ECN (2011); **** Greens/EFA (2008).

Table 2.2 (continued)	Targets for the consumption of renewables and GHG emission reduction by 2020						
Renewable energy as a share of gross final energy consumption according to RED*						**Biomass share of gross final renewable energy consumption a) *****	
Country	**Consumption share in 2005 (%)**	**2020 targets (%)**	**2020 GHG non-ETS targets b) ****	**2020 GHG ETS targets c) ******	**2020 GHG emission cap d) **** (%)**	**Consumption share in 2005 (%)**	**Projection of share in 2020 (%)**
Netherlands	2.4	14	-16	-21%	-18%	80.7	51.5
Poland	7.2	15	+14	-21%	-4%	(in 2010) 91.9	77.1
Portugal	20.5	31	+1	-21%	-9%	69.3	51.2
Romania	17.8	24	+19	-21%	1%	(electricity) 0.1	(electricity) 3.4
Slovak Republic	6.7	14	+13	-21%	-6%	46.8	65.4
Slovenia	16	25	+4	-21%	-7%	54.8	57.7
Spain	8.7	20	-10	-21%	-15%	46.9	42.2
Sweden	39.8	49	-17	-21%	-18%	57.7	59.7
UK	1.3	15	-16	-21%	-18%	69.2	50.6
EU27	13.2	20	-10	-21%	-14%	59.0	55.5

a) In the sectors: electricity, heating and cooling and transport; b) GHG emission targets by 2020 relative to 2005 for non-ETS (Emission Trading System) emissions (agriculture, transport, residential, some industry). c) GHG emission targets by 2020 relative to 2005 for ETS emissions (energy and heavy industry); d) Together the ETS and non-ETS form the EU emissions cap. Since a single, EU-wide cap under the EU ETS will be introduced from 2013, an effort sharing arrangement between Member States has been determined solely for the reduction in emissions from sectors not covered by the EU ETS.
Source: * EC (2009a); ** EEA (2011); *** ECN (2011); **** Greens/EFA (2008).

2.3 Tax exemption and subsidies

In order to receive tax exemption, subsides or other financial support, the bioenergy must be sustainable according to the EU criteria. The Member States have their own tax reduction rates and programmes to financially support bioenergy production in their country. For all 27 EU Member States, De Jager et al. (2011) provide details. More specifically, information about investment grants and other financial incentives is listed for electricity from biomass, biogas and biowaste. Tax exemption and investment subsides are described for heat from biomass plants. Overall, tax exemption and reductions are by far most common for biofuels, accounting for the largest share of all biofuel support measures (Jung et al., 2010).

2.4 Certification - EU accreditation of private sustainability schemes

The EC has established a procedure to assess whether a voluntary scheme fulfils the sustainability requirements and has recently recognised seven voluntary certification schemes. Table 2.3 presents a brief overview of these seven voluntary schemes, and Table 2.4 gives an overview of the sustainability criteria applied. Note that some schemes such as the Better Sugar Cane Initiative (Bonsucro), Greenergy, the Roundtable on Sustainable Biofuels (RSB) and the Round Table on Responsible Soy (RTRS) existed prior to the RED and prior to the EU initiative to approve private certification schemes for sustainable bioenergy.

The seven sustainability schemes directly apply in all EU Member States, although some of the schemes target the production of bioenergy crops in third countries, for example Brazil. The schemes cover different types of certification schemes ranging from company and sector initiatives to multi-stakeholder initiatives, which in particular include the involvement of stakeholders (including NGOs) in the standard-setting. The different types of schemes are presented in the last column of Table 2.3.

The sustainability schemes themselves are run as private companies (or organisations) and not by the EC. The EC only assesses the initiatives that have been submitted for recognition for quality of their respective control system and reliability. The schemes have to ensure that: (1) all companies in the supply chain are audited before making any claims about sustainability under the scheme; (2) a follow-up audit of the companies in the supply chain takes place at least once a year; (3) the auditors are competent and independent (e.g. via

ISO certificates or membership at the International Accreditation Forum) and (4) the administrative system is protected against fraud (EC, 2011c).

When the EC deems the rules of the schemes to adequately cover the EU sustainability requirements, the scheme is recognised in an official EC decision, published in the EU Official Journal. After twenty days, the EU Member States must accept the products under the respective scheme as sustainable. The recognition of the schemes by the EC (and by the EU Member States) is valid for five years. Any extension requires a new submission and a new decision. Note that the EC can also withdraw its decision if it becomes clear that the scheme does not fulfil the rules.

Table 2.3	Brief overview of the private schemes for sustainable bioenergy accredited by the EU		
Name	**Product (and country) coverage**	**Type of scheme**	**Number of firms certified***
ISCC (International Sustainability and Carbon Certification)	More than 450 companies in about 25 countries Worldwide. ISCC comprises sustainable biomass, biofuels and bioliquids at the different stages of the supply chain.	Voluntary certification system led by consultancy company Meo Carbon Solutions and supported by the German government.	851 certificates, more than 1000 registrations (as of 13 January 2012)
Bonsucro EU (Better sugar Cane Initiative)	All geographic locations. Covers production from sugarcane based biofuels at the different stages of the supply chain.	A global multi-stakeholder, non-profit initiative dedicated to reducing the environmental and social impacts of sugarcane production.	12 mills, 2 supply chain companies (as of 6-1-2012)
RTRS EU RED (Round Table on Responsible Soy EU RED)	Covers soy-based feedstocks cultivated outside the European Union. Comprises stakeholders from throughout the soy value chain.	A global platform, multi-stakeholder scheme (roundtable initiative)	Ten certified producers and 4 certified chains of custody companies (as of 3 January 2012)
RSB EU RED (Roundtable on Sustainable Biofuels EU RED)	Covers all feedstock and geographic locations. Comprises all stakeholders, including farmers, biofuel producers, transportation, environmental and social NGOs, research institutes, governments and investors.	RSB is located at the Ecole Polytechnique Fédérale de Lausanne and is led by a multi-stakeholder steering board. (Roundtable initiative), multi-stakeholder scheme (roundtable initiative)	Four participating operators have successfully undergone a due diligence process, first RSB Certificate issued in February 2012

Source: Reports for the assessment for voluntary schemes to meet the EC sustainability criteria, available at the webpage of Director-General of the Energy: http://ec.europa.eu/energy/renewables/ biofuels/sustainability_schemes_en.htm (accessed March 2012) and NL Agency and NL Energy and Climate Change (2012).

Table 2.3 (continued)	Brief overview of the private schemes for sustainable bioenergy accredited by the EU		
Name	**Product (and country) coverage**	**Type of scheme**	**Number of firms certified***
2BSvs (Biomass Biofuels voluntary scheme)	Covers all feedstocks and geographic locations. Comprises he whole supply chain, from the biomass producer to the final biofuels distributors under custom duty	Developed by a consortium composed of key players in the French biofuels industry and Bureau Veritas, industry scheme	401 (as of 25 January 2012): 323 first gathering point + storage, 20 first gathering point + storage + trader, 23 traders, 35 transformers
RBSA (Abengoa RED Bioenergy Sustainability Assurance)	Covers all feedstock and geographic locations. Two options: (1) from agricultural production till biofuel conversion; and (2) from agricultural production till final economic operator	RBSA is developed by Abengoa Bioenergia, Spain-based largest biofuel producer in the EU (400 million gallons production capacity), and a large one in the US (370 million gallons), and Brazil (62 million gallons), firm scheme to be used in own production	Certification of own plants, in 2012: 14 plants producing bioethanol and other byproducts derived from the process, and one biodiesel production plant, in Europe (Spain and France, and the Netherlands), North America (the USA) and South America (Brazil)
Greenergy (Brazilian Bioethanol verification programme)	Covers sugarcane feedstock only for the production of bioethanol in Brazil. Greenergy does not permit the use of actual values in the calculation of supply chain GHG emissions	Greenergy is a producer and supplier of petroleum and biofuels for UK transport fuels. UK Government approved carbon and sustainability reporting scheme, firm scheme	Certification of sustainable sourcing, in 2012: 91% of the mills in Brazil (sugarcane) complied with the Greenergy Gold Standard. No information about number of mills available in the Greenergy annual report

Source: Reports for the assessment for voluntary schemes to meet the EC sustainability criteria, available at the webpage of Director-General of the Energy: http://ec.europa.eu/energy/renewables/ biofuels/sustainability_schemes_en.htm (accessed March 2012) and NL Agency and NL Energy and Climate Change (2012).

Table 2.4	Sustainability criteria of private scheme		
Name	**Criteria applied according to RED Articles**	**Criteria beyond RED sustainability criteria**	**Chain of custody / traceability requirement**
ISCC (International Sustainability and Carbon Certification)	17(2): Greenhouse gas emissions savings; 17(3): Conservation of biodiversity; 17(4): Conservation of carbon stocks; 17(5): Conservation of peatlands;	Best agri-environmental practise, Soil, water and air quality, waste Local prosperity, rural/social development Land rights, human and labour rights Local food security	Identity preservation, Segregation Mass balance
Bonsucro EU (Better sugar Cane Initiative)	17(2): Greenhouse gas emissions savings; 17(3): currently not approved; 17(4): Conservation of carbon stocks; 17(5): Conservation of peatlands	Best agri-environmental practise, Soil, water and air quality, waste Land rights, human and labour rights	Mass balance
RTRS EU RED (Round Table on Responsible Soy EU RED)	17(2): Greenhouse gas emissions savings; 17(3): Conservation of biodiversity; 17(4): Conservation of carbon stocks; 17(5): Conservation of peatlands;	Best agri-environmental practise, Soil, water quality, waste Local prosperity, rural/social development Land rights, human and labour rights	Segregation Mass balance Book & claim (via certificates)
RSB EU RED (Roundtable on Sustainable Biofuels EU RED)	17(2): Greenhouse gas emissions savings; 17(3): Conservation of biodiversity; 17(4): Conservation of carbon stocks; 17(5): Conservation of peatlands;	Best agri-environmental practise, Soil, water and air quality, waste Local prosperity, rural/social development Land rights, human and labour rights Local food security	Identity preservation, Segregation Mass balance Book & claim (via certificates)

Source: Reports for the assessment for voluntary schemes to meet the EC sustainability criteria, available at the webpage of Director-General of the Energy: http://ec.europa.eu/energy/renewables/ biofuels/sustainability_schemes_en.htm (accessed March 2012) and NL Agency and NL Energy and Climate Change (2012).

Table 2.4 (continued)	Sustainability criteria of private scheme		
Name	**Criteria applied according to RED Articles**	**Criteria beyond RED sustainability criteria**	**Chain of custody / traceability requirement**
2BSvs (Biomass Biofuels voluntary scheme)	17(2): Greenhouse gas emissions savings; 17(3): currently not approved; 17(4): Conservation of carbon stocks; 17(5): Conservation of peatlands;	Best agri-environmental practise (only recommended), Soil, water and air quality (only recommended)	Mass balance
RBSA (Abengoa RED Bioenergy Sustainability Assurance)	17(2): Greenhouse gas emissions savings; 17(3): Conservation of biodiversity; 17(4): Conservation of carbon stocks; 17(5): Conservation of peatlands;	Corporate social responsibility including local prosperity, rural/social development Land rights, human and labour rights	Mass balance Book & claim via certificates to the mills
Greenergy (Brazilian Bioethanol verification programme)	17(2): Greenhouse gas emissions savings; 17(3): currently not approved; 17(4): Conservation of carbon stocks; 17(5): Conservation of peatlands ;	Soil, water and air quality, waste Local prosperity, rural/social development Land rights, human and labour rights	Mass balance Book & claim via certificates to the mills (Sugarcane industry in Brazil owns, mills, plantation and transport, infrastructure)

Source: Reports for the assessment for voluntary schemes to meet the EC sustainability criteria, available at the webpage of Director-General of the Energy: http://ec.europa.eu/energy/renewables/biofuels/sustainability_schemes_en.htm (accessed March 2012) and NL Agency and NL Energy and Climate Change (2012).

While varying across schemes, the standards of some schemes have been beyond the EU sustainability criteria. In some cases, schemes were however adjusted to meet the sustainability criteria as required by the EC. In the case of the Greenergy scheme for example, the EU sustainability criteria meant that the social sustainability standards were softened for EU compliance. Other schemes, such as the Biomass Biofuels voluntary scheme (2BSvs) and the Abengoa RED Bioenergy Sustainability Assurance (RBSA) entirely lack any social sustainability standards (German and Schoneveld, 2011). Table 2.4 presents the sustainability criteria and their implementation along the supply chain (chain of custody).

All certification schemes, which the EC have so far approved, foresee independent auditors to conduct controls and inspections (third party certification), as required by the RED-FQD. Companies producing or importing bioenergy must demonstrate (via the audits) that the production process is sustainable in terms of the EU sustainability criteria. Auditors usually check documents but also conduct inspections on the spot, covering farmers and mills as well as traders. In the case of bioenergy products from Brazil for example, the Brazilian farms are checked to ascertain if the land where the feedstock for the ethanol has been produced was indeed already farm land before and not tropical forest (EC, 2011); compare the chain of custody information presented in Table 2.4.

Firms and producers that want to be certified as providing sustainable bioenergy products pay a fee to the scheme, either in the form of a membership fee or a fee depending on the quantity. The fees crucially depend on the certification schemes that tend to calculate the fees according to the business size, for example turn-over or production capacity. The certification costs are usually in addition to auditing costs. The study commissioned by NL Agency and NL Energy and Climate Change gives examples of certification costs. For example, the most expensive certification fee is reported to amount to about 15,000 euro per year (large production capacity certified by Bonsucro), while certification of medium-size businesses typically falls between 2,000 and 3,000 euro per year (NL Agency and NL Energy and Climate Change, 2012: p. 44).

2.5 General overview of support measures and their scope

The report by De Jager et al. (2011) gives an overall overview of current support measures and expenditures per type of renewable energy for each EU Member State. Table 2.5 presents which support measures the different Member States use. The letters E, H and T denote the type of renewable energy, i.e. electricity, heat (and cooling) and transport, respectively. In summary, electricity by renewable energy sources is mainly supported by feed-in tariffs. Investment grants are most important support measures for heat and cooling, and tax exemption is most important for transport.

As presented by De Jager et al. (2011), the EU27 net expenditure on support measures for renewable energy amounted to about 35 million euro in 2009. Germany took the lead, spending almost 11 billion euro, followed by Italy (5 billion euro) and Spain (5 billion euro). France (3 billion euro), Sweden (2 billion euro) and the UK (2 billion euro) follow in the distance. These are absolute values. For a comparison across countries, De Jager et al. (2011) provide the level of support in relation to the gross final energy demand (euro/MWh used). In such a cross-country comparison, the support is highest in Sweden (given its relatively small population) (about 6 euro per MWh), followed by Germany and Spain (both about 4 euro per MWh) as well as Austria, Italy, Lithuania and Portugal (about 3 euro per MWh).

Furthermore De Jager et al. (2011) calculated the support expenditures of different types of renewable energy. We do not present them here as their calculations are based on many assumptions about averages and technologies applied. The EU Member States seem to have to substantially increase the financing of renewables in order to implement their respective NREAPs. According to EC (2011b), annual capital investment needs to double in order to reach the necessary 70 billion euro by 2020, and the investment should mainly come from the private sector.

Table 2.5	Overview of support measures for electricity (E), heat and cooling (H) and transport (T) according to EU Member State				
EU Member States	**Feed-in-tariffs**	**Premiums**	**Quota**	**Tax exemption**	**Investment grants**
Austria	E		T	T	H
Belgium	E		E	E, T	E, H
Bulgaria	E		T	H	E, H
Cyprus	E		T	T	E, H
Czech Republic	E	E	T	T	E, H
Denmark	E		T	H, T	E, H
Estonia		E	T	T	
Finland	E	E		T	E, H
France	E	E	T	E, T	
Germany			T	E	E, H
Greece	E		T	H, T	H
Hungary	E			E, T	E, H
Ireland	E			T	H
Italy	E		T	T	H
Latvia	E			T	
Lithuania	E		T	T	E, H
Luxembourg	E		T	T	E, H
Malta	E		T	E, T	E, H
Netherlands	E			T	E, H
Poland			T	E	E, H
Portugal			T	E, T	E, H
Romania	E		T	H, T	H
Slovak Republic			T	E, T	
Slovenia			T	E, T	H
Spain	E	E	E, T	T	E, H
Sweden	E		T	E, T	H
UK	E		T	T	E, H

Source: De Jager et al. (2011).

3 Operationalisation and implementation of the EU Renewable Energy Directive (RED) and the Fuel Quality Directive (FQD) sustainability criteria

This chapter addresses how sustainability criteria are practically applied under the RED-FQD and how they are measured and what the reliability and uncertainties are. The goal is to discuss the way the RED-FQD sustainability criteria, which are described in Section 2.1, are operationalised into practically applicable and verifiable thresholds and indicators in order to show compliance with these criteria. Special attention is paid to the advantages and disadvantages of the approaches and methodologies that are to be used under the RED-FQD.[1]

3.1 Greenhouse gas saving

The RED-FQD require that the greenhouse gas (GHG) saving of bioenergy systems is determined either using the 'default values' or using 'actual values' by calculating or using a combination of both.[2] At this moment only biofuels for transport and biogas are covered, but Article 17(9) of the RED provides that the Commission should report on requirements for a sustainability scheme for other bioenergy uses (i.e. solid and gaseous fuels in electricity, heating and cooling). In February 2010 the EC adopted a report on sustainability requirements for the use of solid biomass and biogas in electricity, heating and cooling (EC, 2010), which is based on a public consultation and was accompanied by an impact assessment. The report makes recommendations on sustainability criteria to be used by countries that wish to introduce a scheme at national level, in order to avoid obstacles to the functioning of the internal market for biomass.

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[1] The text in this chapter is based on various publications that are referred to in the text.

[2] The Directive also contains 'typical values' for greenhouse gas emissions from biofuels. These values cannot be used by bioenergy producers, but can be used by countries when reporting to the EC on the progress in the promotion and use of bioenergy. Unless actual values are used to adapt the fuel chains, only the default carbon intensities and default GHG emission savings can be reported by economic operators.

Default GHG saving values

Default values for the 22 most important bioenergy pathways are given in Annex V of the RED (see Table 3.1). The default values may be used by bioenergy producers to show compliance with the GHG saving criteria. This approach reduces the administrative burden for bioenergy producers because they choose to use the relevant default values instead of calculating their specific actual values.

The default values are set at a conservative level, which makes it difficult for businesses to claim values that are better than the actual values. For example, the default values for the biodiesel pathways from rapeseed and soybean do not pass the 35% minimum GHG saving and palm oil only passes with methane captured at the mill. The default values can be updated to technical and scientific progress every two years.

Also default values for future second-generation biofuels are given. They are much higher compared to the current first-generation biofuels (e.g. 76% for ethanol from farmed wood to 95% for Fischer-Tropsch diesel from waste wood). The default values can be used if no land use change has taken place for cultivation of the raw materials, and when raw materials are cultivated outside the EU or in the EU in specific areas where the typical GHG emissions from cultivation of agricultural raw materials are lower than or equal to the default values for cultivation.

Table 3.1	Overview of bioenergy pathways and default GHG saving values			
Ethanol	**FAME (fatty-acid methylester)**	**HVO (hydrogenated vegetable oil)**	**PVO (pure vegetable oil)**	**Biogas**
Sugar beet 61%	Rapeseed 45%	Rapeseed 51%	Rapeseed 58%	Municipal solid waste (MSW) 80%
Wheat (process fuel not specified) 32%	Sunflower 58%	Sunflower 65%		Wet manure 84%
Wheat (lignite CHP (Combined Heat and Power) 32%	Soybean 40%	Palm oil 40%		Dry manure 86%
Wheat (natural gas steam boiler) 45%	Palm oil (process not specified) 36%	Palm oil (methane capture) 68%		
Wheat (natural gas CHP) 53%	Palm oil (methane capture) 62%			
Wheat (straw CHP) 69%	Waste vegetable or animal oil 88%			
Corn (natural gas CHP) 56%				
Sugarcane 71%				
Source: EC (2009a).				

Actual GHG saving values

Economic operators may also calculate actual GHG saving values if they expect that actual values are lower than the corresponding default values or when no default values are available. Actual GHG saving values must be calculated according to the approach and method defined in the RED. The GHG emissions of bioenergy systems are the sum of emissions from: (1) extraction and cultivation of raw materials, (2) land-use change, (3) processing and (4) transport and distribution. Deductions are made for soil carbon accumulation via improved agricultural management, for carbon capture (a technology that is still under development) and for co-generation of electricity. The emissions are then compared with emissions of fossil fuel to calculate the emission savings values.

The approach and method defined in the RED is explained and demonstrated in detail in the BioGrace project (BioGrace, 2011). This also includes an online Excel-based tool that includes standard conversion and emission values that need to be used when calculating actual GHG saving values. The RED GHG calculation approach and method are further demonstrated in two studies that have been carried out by Ecofys (2010a; 2010b).

Key issues for future research

There are several uncertainties related to the calculation of the GHG emissions of bioenergy systems that are important when evaluating the effectiveness of the RED-FQD GHG saving criteria. Many of these uncertainties are extensively investigated in the literature (Gnansounou et al., 2009; Levasseur et al., 2010; MacLeod et al., 2010; Hoefnagels et al., 2010; Cooper et al., 2011; Kauffman et al., 2011; McKone et al., 2011; Schwietzke et al., 2011; Soimakallio and Koponen, 2011; Sterner and Fritsche, 2011). Some of the key issues are briefly discussed below.

General improvements and updates

The RED-FQD also mention that the default values can be updated to technical and scientific progress every two years. The EC is currently updating the default values. This will include several important updates, among others an update of the fossil fuel comparator. At this moment a default value for gasoline and diesel in the RED is 83.8 g CO_2 per MJ of fossil-carbon based gasoline or diesel, which will probably be increased to 90.3g CO_2 per MJ of fuel following updated calculations of the JRC (Laborde, 2011).

Indirect land use change (iLUC)

ILUC is defined as the result of increased demand for biomass and land for energy crop production; it can result in unintended impacts on biodiversity and carbon stock changes, induced by the changes in land use (e.g. expansion of croplands for biofuels production at the expense of forests). These indirect effects are caused by changes in prices of crops, land, labour, capital, by changes of production, consumption and trade patterns. ILUC can occur with significant time lags and can be distributed through trade of agricultural commodities and biofuels. Especially the conversion of forests to agricultural land is a key concern due to its high above and below ground carbon stocks and its high biodiversity value compared to some other vegetation types. During 2009 to 2011, the EC carried out modelling and analytical exercises and workshops to investigate the nature of iLUC and to provide quantitative estimates of the effects (e.g. Marelli et al., 2011; Laborde, 2011; Fonseca et al., 2011). Based on these results the EC is considering if and how, to include iLUC in the GHG saving targets. In September 2001 the EC decided to postpone the rules that should penalise individual biofuel operators for their indirect climate impacts by up to seven years. This decision is a political compromise designed to protect the interests of the EU biofuels industry, but also to discourage new investments in biofuels that hardly contribute to GHG emission reductions.

Leakage or rebound effects
Another indirect effect that has received little attention so far is the leakage effect (also known as the rebound effect and as indirect fuel use change (IFUC) and indirect output use change (IOUC). The rebound effect is the phenomenon that a biofuel tax credit or biofuel use mandate increases the total consumption of fuel. This occurs because the production and use of biofuels reduces gasoline and fossil oil demand, thereby decreasing the price of gasoline and fossil oil globally and increasing demand for these commodities. In other words, a rebound effect of 25 % means that the use of 1 unit of biofuels increases the use of conventional fuels made from fossil oil by 0.25 units. A positive rebound effect thus leads to a net increase of energy (i.e. biofuel plus fossil fuel) consumption. Without effective global carbon emission ceilings the rebound effect may partially offset the GHG and fossil energy saving of biofuel policies. Estimates of this leakage rebound effect vary between 10 % and 90 % for liquid biofuels for transport (Thompson et al., 2010; Rajagopal et al., 2011; Hochman et al., 2010). These results show that the rebound effect can have a large impact on the effectiveness of biofuels for saving GHG emissions.

Treatment of co-products
Besides the production of biofuels also other products, so called co-products, are produced. Examples are distillers' grains and solubles (DGS), which is a co-product from the production of ethanol from maize. DGS is generally used as animal feed for the nutrition value. Other co-products are used for the production of electricity or in the chemicals industry. The way in which co-products are included is a crucial factor when calculating GHG saving values (Hoefnagels et al., 2010; Eric D., 2006; Wang et al., 2011). The impact of the rebound effect on GHG saving of biofuels is currently studied in more detail at LEI (Smeets et al., 2012).

Two main approaches are commonly applied in LCA studies:

- *Allocation approach*

  In this approach the emissions from energy crop production and processing are allocated to the bioenergy produced and to the co-products of bioenergy production on the basis of the weight, the energy content or the market value of the bioenergy and the co-products. Advantages of allocating on the basis of weight or energy content are that this is relatively easy and that the allocation factors do not change over time (as with market value based allocation). The default and typical values reported in the RED are based on allocation based on energy basis. The main disadvantage of this allocation approach is that it potentially does not accurately reflect the total impact, i.e. by taking into account the indirect effects of the use of co-products.
- *System boundary expansion/substitution approach*

  Allocation can be avoided by taking into account the emissions that are avoided by using co-products of bioenergy production. An example is the use of DGS which avoids the emissions from the production of animal feed. This approach is also recommended by the International Organisation for Standardisation ISO 14040-14049 guideline series (ISO, 2006) for life cycle analysis. A disadvantage of this methodology is that additional calculations are needed to estimate the avoided emissions.

The RED requires the allocation by energy content method. Reasons are as follows: (1) substitution is considered more appropriate for policy analysis than for regulatory purposes, (2) substitution cannot be applied in case of the reference product (petrol and diesel), (3) substitution requires assumptions about the type of product that is substituted, (4) a perverse incentive to maximise co-product production is prevented, (5) a perverse incentive to use co-products for energy purposes is prevented, and (6) allocation based on economic value would create undesirable uncertainties for investors, because compliance with the GHG saving target would than depend on the price of the products replaced by the co-products, e.g. the price of animal feed.

Timeframe for comparison

In the RED methodology a 20-year horizon is taken for equalising the impact of GHG emissions from direct land use changes (dLUC). For comparison, the IPCC uses a default value of 20 years, while Greenpeace aims for a 10-year period. But time is also an important factor when considering energy inputs and outputs and emissions that occur at different points in time. Kendall et al. (2009) emphasise another effect, namely that the effect of a greenhouse gas increases with the time it remains in the atmosphere. Consequently, the suitability of the static LCA method, as introduced in the RED, to assess the climate impacts of bioenergy chains with significant time differences between emissions and sinks or avoided emissions can be questioned. For a more extensive debate on these issues see further (Kendall et al., 2009; Hoefnagels et al., 2010; Levasseur et al., 2010; Schwietzke et al., 2011).

Nitrous oxide emissions
Several methodologies can be applied to estimate nitrous oxide (N_2O) emissions from the use of fertilisers in bioenergy crop production. For a review on this issue CRC (2012).

- *The IPCC Tier 1 method for fertiliser induced emissions.*[1] Most biofuel LCA studies (including the RED GHG calculation approach) apply the Tier 1 method from the Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories (IPCC, 2006) to account for direct N_2O emissions from fertiliser application. This method assumes that 1% of the N input from N fertilisers and manure result in N_2O-N emissions. This approach is based on fertiliser-induced emission (FIE). FIE is defined as the direct emission from a fertilised plot, minus the emission from an unfertilised control plot (all other conditions being equal to those of the fertilised plot), expressed as a percentage of the N input.
- *The N_2O emission regression analyses model* of Bouwman and co-workers (Bouwman et al., 2002; Bouwman et al., 2002; Stehfest and Bouwman, 2006). The IPCC Tier 1 approach for direct emissions largely ignores the variability of emissions caused by differences in environmental conditions, crop type and its management. Furthermore, the FIE represents the anthropogenic emission caused by N application, although the emission from control plots may differ from the emission of the original vegetation in pre-agricultural times. The N_2O emission from zero-fertiliser plots may exceed those of soils under natural vegetation. Smeets et al. (2009) applied a spatially explicit regression model to calculate the N_2O emissions from various reference land-use types and land used for the cultivation of 1st generation

[1] The IPCC guidelines generally provide advice on estimation methods at three levels of detail, from Tier 1 (the default method which is applicable using standard values) to Tier 3 (the most detailed and data intensive method). All tiers are intended to provide unbiased estimates, and accuracy and precision should, in general, improve from Tier 1 to Tier 3.

bioenergy crops. This model is also used to calculate the IPCC Tier 1 FIE 1% factor.
- *The DNDC model.* The DeNitrification-DeComposition (DNDC) model is a computer simulation model of carbon and nitrogen biogeochemistry in agro-ecosystems and which can be used for predicting crop growth, soil temperature and moisture regimes, soil carbon dynamics, nitrogen leaching, and emissions of trace gases including N_2O. Various studies have been carried out whereby the DNDC model is linked with agriculture economic models, but also other models have been applied (see further CRC, 2012).
- Crutzen et al. (2007) proposed the use of a *global N_2O emission factor*, derived from the relationship, on a global basis, between the amount of N fixed by chemical, biological or atmospheric processes entering the terrestrial biosphere, and the total emission of N_2O using known global atmospheric removal rates and concentration growth of N_2O as a proxy for overall emissions. The total overall conversion factor is estimated at 3-5%. However, these global estimates ignore the variability of emissions caused by differences in crop type and the associated management system, and soil and climate conditions and the impact of the choice of the type of reference land use (i.e., the land use replaced by energy crops). These aspects may cause a substantial overestimation of their N_2O emissions from energy crops, particularly the N_2O emission factor (Smeets et al., 2009).

3.2 High bio-diverse land

The criteria formulated in the RED-FQD require that certain types of land, including high bio-diverse land, are either not permitted, or are only permitted under certain conditions, to be used for the production of biomass for energy. The definition of high bio-diverse land has been subject of debate among experts, policy makers and environmental NGOs. The EC announced that they will establish 'criteria and geographic ranges to determine which grassland shall be covered by point (C)'. These are then to be approved under the comitology procedure with scrutiny.[1] At the time of writing the EC has neither recognised any

[1] Regulatory committees with scrutiny: these must allow the Council and the European Parliament to carry out a check prior to the adoption of measures of general scope designed to amend non-essential elements of a basic instrument adopted by co-decision. In the event of opposition on the part of one of these institutions, the EC may not adopt the proposed measure, although it may sub-

protected areas and nor the criteria and geographic ranges to determine which grassland is covered have been established yet by the EC.

In practice, the high-biodiversity criterion means that an economic operator needs to know the status of the land on 1 January 2008 and, in some situations, the status of the land at the time the raw material was obtained. A detailed approach and methodology to determine the status of land is not included in the RED-FQD. Instead the EC commissioned a study aimed at giving recommendations to economic operators on how to carry out such as assessment (Ecofys, 2010c). An overview is given of various geospatial and non-geospatial datasets that can be used to determine the status of land. Also several practically applicable on-site assessment methods are discussed, because the use of geospatial and non-geospatial land use data is problematic in many cases. The results are summarised below. Similar datasets and methodologies are included in the sustainability schemes that are accepted by the EC.

Geospatial data

Geospatial data include satellite images, digitised maps in raster (grid) format, as well as aerial photography. Ecofys (2010c) carried out a study that includes a list of relevant geospatial datasets. For each data source it is described what the key characteristics are that determine the usefulness for the RED-FQD criteria related to high bio-diverse land and to high carbon stock vegetation and peat land.

Satellite imagery from satellites is often publically available or available at low costs. A disadvantage is that such data often require expert analysis before they can be used to identify the land use and vegetation cover classes that are needed. More important is that this type of data can only be used as an indication of the land use and vegetation cover, because the thematic coverage, temporal coverage (information date) or spatial resolution and scale are insufficient to accurately determine the status of land on 1 January 2008. For example, most global and national scale maps for developing countries are available at 1:250,000 to 1:1,000,000 scales, using satellite data at 500 m to 1,000 m spatial resolution.

The date at which the data are recorded is typically around the year 2000. Further, inconsistencies between datasets and discrepancies between the definitions of land use and vegetation cover used in the RED-FQD and the definitions

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mit an amended proposal or a new proposal.
Source: http://europa.eu/scadplus/glossary/comitology_en.htm.

and resolution used in existing data sources imply that these existing geospatial information sources by themselves will not always allow for a firm conclusion on the land status for the RED-FQD. In those cases, additional information from more recent high resolution geospatial information sources, such as non-geospatial information sources and on-site assessments is needed.

Non-geospatial data

Non-geospatial data do not have specific geo-referenced coordinates, but can take the form of lists, reports, approximate maps and assessments. The degree of confidence offered by such sources related to the land status of a given area is often less than for geospatial data. Moreover, the lack of specific geo-referenced coordinates limits the usefulness of non-geospatial data, although such data can be used as supplementary information sources. The study that was carried out on this issue (Ecofys 2010c) concluded that geospatial and non-geospatial data are potentially insufficient and that on-site assessments are needed to complement the analysis of the status of land.

On-site assessments

Geospatial and non-geospatial data on the land use and vegetation cover are potentially insufficient to allow a firm conclusion on the status of land on 1 January 2008 for the RED-FQD. On-site assessments could provide the necessary additional information. For example, if high resolution satellite data from 2009 show that an area is currently not forested, interviews with local experts or communities could confirm that the land cover did not change significantly since 2008.

Several on-site assessment methods are distinguished (Ecofys, 2010), namely:

1. interviews conducted with stakeholders, communities, local authorities and/or experts;
2. visual inspections, which can, for example, confirm land cover;
3. inventories of species, which can, for example, provide information on whether a wooded area should be classified as primary forest or as other wooded land as defined in the RED-FQD;
4. physical measurements, which can provide detailed information on for example crown cover or on drainage depth in peat land. The latter is relevant for the RED criterion on peat land use.

Key issues for future research
It can be concluded that relatively simple and straightforward approaches and methodologies are available to determine the status of land on 1st January 2008. However, the RED-FQD criteria are potentially insufficient since indirect effects are ignored. The threshold data of 1 January 2008 is arbitrary and the biodiversity value of different vegetation patterns is not considered.

Several studies have been carried out in which the impacts of bioenergy on biodiversity are assessed at a national or international level. Crucial in most of these analyses are the indirect land use change (iLUC) effects. Such complex and aggregated analyses are not discussed further here, because the focus in this study is on the RED-FQD criteria that are operationalised into practically applicable and verifiable thresholds and indicators that can be used by economic operators.

More relevant is the Integrated Biodiversity Assessment Tool (IBAT) in which data on biodiversity indicators are included and that can be applied by bioenergy producers (http://www.ibatforbusiness.org/). IBAT is designed to facilitate access to biodiversity information in order to support business decisions. IBAT combines data from various sources on areas with high biodiversity values and has a global coverage. An advantage of IBAT is that it provides easy access to various data sources on areas with high biodiversity values and that it has a global scope. And although IBAT goes beyond the scope of the RED-FQD criteria it provides a suitable framework for the analyses of the impact of bioenergy production on biodiversity.

Another site identification methodology is called the Responsible Cultivation Areas (RCA) method. This method is aimed at checking compliance with the RED-FQD criteria and it also reduces negative indirect effects. More information about the RCA method can be found in Section 3.3.

3.3 High carbon stock vegetation and peat land

The RED-FQD forbid the use of biomass for energy production if the biomass is obtained from land with high carbon stock and peat land, i.e. land that had one of the following statuses in January 2008 and no longer has that status:
1. Wetlands, namely land that is covered with or saturated by water permanently or for a significant part of the year;
2. Continuously forested areas, namely land spanning more than one hectare with trees higher than five metres and a canopy cover of more than 30%, or trees able to reach those thresholds in situ;

3. Land spanning more than one hectare with trees higher than five metres and a canopy cover of between 10% and 30%, or trees able to reach those thresholds in situ, unless evidence is provided that the carbon stock of the area before and after conversion is such that, when the emissions from the change in carbon stock are included in the GHG saving calculation, the minimum GHG saving threshold is still met.

These criteria do not apply if, at the time the raw material was obtained, the land had the same status as it had on 1 January 2008. Further, the RED-FQD forbids the use of raw material obtained from land that was peat land on 1 January 2008, unless evidence is provided that the cultivation and harvesting of that raw material does not involve drainage of previously undrained soils.

A detailed approach and methodology to determine the status of land is not included in the RED-FQD, but Ecofys carried out a study commissioned by the EC in which recommendations are given about how economic operators can carry out such assessments (Ecofys, 2010c). The results were discussed in the previous section and could be considered as equally suitable for the high carbon stock vegetation and peat land criteria. Further, Ecofys developed an on-site assessment tool called Responsible Cultivation Areas (RCA) that ensures compliance with the RED-FQD criteria and that also avoids negative indirect effects (Ecofys, 2010c).

On-site assessment tool RCA

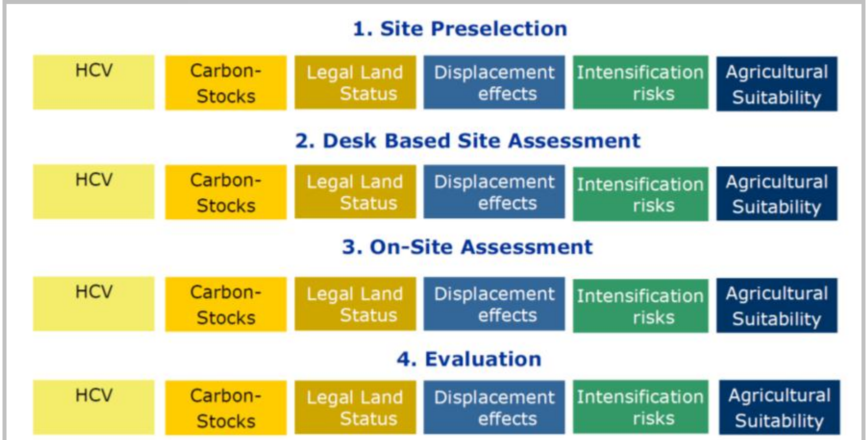
The previous section already discussed the availability of several on-site assessment methods. The Responsible Cultivation Area (RCA) on-site assessment tool was developed by a consortium of Ecofys, the World Wildlife Fund (WWF) and Conservation International (CI) with support from several international oil companies (Ecofys, 2010d).

The RCA methodology consists of two modules, each with its own goal:

1. To put forward a practical voluntary methodology to identify concrete areas and/or production models that can be used for environmentally and socially responsible energy crop production minimising unwanted direct and indirect effects. By following this methodology, parties ensure they select sites that a) meet the sustainability requirements of policies such as the RED-FQD or those of voluntary schemes such as the RSB, and b) have a reduced risk of indirect effects.
2. To put forward a set of criteria and a methodology that enables parties to distinguish bioenergy with a low risk of indirect effects.

The site identification methodology consists of a four-step process (see Figure 3.1). The process starts on a large scale with coarse and readily available information to quickly identify the most promising areas (Site Pre-Selection). Next, a more detailed assessment is performed on these promising areas to further refine the Pre-Selection of promising areas (Desk-Based Assessment). The third step, the On-Site Assessment, involves a verification of the results of the first two steps and aims at filling all remaining knowledge gaps. The final step is the evaluation phase, where all information is evaluated so as to determine whether the area classifies as a RCA and under what conditions.

Figure 3.1 **The four steps in the RCA site selection methodology**



Source: Ecofys (2010d).

Key issues for future research

The key to establishing if an economic operator complies with the RED-FQD criteria is the determination of the land use and vegetation cover on 1 January 2008. Various approaches and datasets are available to execute this issue. It can therefore be expected that the process of validating the status of land will most likely not be a major obstacle, although practical experience is still limited.

An important limitation of the RED-FQD criteria is that no biodiversity indicators are used and that indirect effects are ignored. Another disadvantage is that there is no consensus about definitions of land use and vegetation cover. The use of a broader definition of forests and of other types of land in the RED-FQD would further avoid the risk of negative carbon stock changes (and biodiversity): for further analysis of the definition of forest see Appendix 3.

The discussion about definitions has also emerged in relation to other climate change policies, such as the Kyoto Protocol, the United Nations Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries, and the Clean Development Mechanism (Sasaki and Putz, 2009). In Indonesia, for example, the exemption of pristine forests would allow the conversion of the millions of hectares of logged forest, though these have a certain high biodiversity value (Sheil et al., 2009). At the time of writing the EC has neither recognised protected areas, nor has established the criteria and geographic ranges to determine which grassland is covered. It is thus not exactly clear what 'high biodiversity grassland' means, and this will differ from country to country according to relative biodiversity levels and existing management practices (Campbell and Doswald, 2009). The RED-FQD might provide limited protection for scrubland or open woody-savannahs. This would allow the conversion of natural and extensively used types of grassland, such as much of the South American Cerrado, African savannahs and European grasslands. Finally, the definition of forests as included in the RED-FQD does not provide the protection of all types of wooded vegetation (compare Table A3.1 in the Appendix).

4 Integrating the RED-FQD sustainability criteria in economic models

The goal of this chapter is to discuss how the RED-FQD criteria can be incorporated into economic models in general and specifically the models operated by LEI, such as the ORANGE and MAGNET equilibrium models. ORANGE is an economic model of the Dutch economy that has been used to evaluate the macro-economic impacts of the biobased economy. MAGNET, the Modular Applied GeNeral Equilibrium Tool, (known as LEITAP until 2010), is a global computable general equilibrium model that covers the whole economy and is able to analyse the effect of changes in technological change, oil prices, (inter)national trade and agricultural policies on international trade, production, consumption, prices and use of production factors. Both models are used to evaluate the macro-economic impacts and environmental consequences of the introduction of bio-energy systems.

Currently, the main focus of the multi-sectoral and multi-regional models MAGNET and ORANGE is on describing and simulating the socio-economic impacts of the bioenergy systems, e.g. in terms of value added and employment effects. The question is how far both models already capture relationships along with the principles and criteria assessed to produce sustainable biomass according to the EU energy strategies. In the case that the models are not (entirely) equipped to capture sustainability criteria and corresponding effects, it will be indicated how the models could be improved in order to address them and in order to make it possible to simulate their effects on socio-economic and environmental aspects.

The RED-FQD criteria are operationalised into practically applicable and verifiable thresholds and indicators that can be used by economic operators at the firm level in order to show that they comply with them (see previous chapter). They, however, cannot directly be applied to macro-economic models as these have a much higher aggregation level than the firm level. For example, the criterion that no biomass is allowed to be used for energy production if the area was classified as forest on 1 January 2008 cannot immediately be addressed by MAGNET or ORANGE in their current form. Those models' presentation of the sectoral land use is not that detailed, but that issue could be improved by integrating more specific data from typical land use models such as CLUE and IMAGE.

Another way to enhance the LEI models with RED-FQD aspects is by incorporating the expected impacts of the applied sustainability criteria on the costs and supply of bioenergy. In 2009, a consortium led by the COWI consulting group studied the impact of the sustainability criteria in the RED-FQD (COWI consortium 2009). Two types of impacts seemed to be key. The first type regards the impact on the costs and economic viability of bioenergy production (see Section 4.2), whereas the second type regards the impact on the supply of bioenergy (see Table 4.1). The supply is mainly influenced by the land exclusion criteria, i.e. the criteria that forbid the use of biomass from high biodiversity grassland, high carbon stock vegetation and peat land (see further Section 4.1). Both types are applicable to economic models such as MAGNET and ORANGE.

Table 4.1 The sustainability criteria in the RED-FQD and their potential impact on the supply/availability (A) and the costs (C) of bioenergy

Article	Criterion	Affecting
17(2)	Full-chain GHG emission reduction	AC
17(3)	Exclusion of lands with high biodiversity value a. Primary forest and other wooded land b. Areas designated by law or by the relevant competent authority for nature protection purposes c. Highly bio-diverse grasslands	A
17(4)	Exclusion of lands with high carbon stock that have been converted into e.g. cropland after 1 January 2008, viz: a. wetlands b. continuously forested areas c. semi-forested areas (10-30% canopy cover)	A
17(5)	Exclusion of land that was peatland on 1 January 2008, unless proven that drainage of previously undrained soil is not involved	AC

Source: COWI consortium (2009).

In addition to the criteria listed in Table 4.1, the RED-FQD requires that bioenergy should be produced from crops grown in the EU only when these are cultivated in concordance with the standard requirements for good agricultural practice as provided in the framework of the Common Agricultural Policy. For the EU15 countries, it seems to be self-evident that cultivation practices will meet these requirements, as CAP support payments to farmers also depend on these requirements. For the Central and Eastern European countries of the EU, the situation may be different, but insufficient information was available to allow an analysis of this issues. This aspect is therefore further ignored in this report.[1]

4.1 Impact of the RED-FQD criteria on the supply of bioenergy

Both the GHG saving criterion and the land exclusion criteria can have an impact on the supply of bioenergy as discussed below.

Greenhouse gas saving
All conventional biofuel chains meet the 2010 GHG 35% saving criterion, though some do not meet the thresholds for 2017 (50% for existing installations) and for 2018 (60% for new installations) (see Table 4.2).

Biofuel chains that fall short of the 2018 (new plants) threshold of 60% are:
- wheat ethanol with lignite as process fuel;
- wheat ethanol with natural gas (conventional boiler) as a process fuel;
- biodiesel from rapeseed;
- biodiesel from soy;
- biodiesel from palm (process not specified).

Especially important in the EU context is that neither biodiesel from rapeseed will pass the GHG saving target under the current conditions, nor will soy bean diesel and palm oil diesel meet the 2018 criterion. These biofuels could meet the future GHG saving targets if improvements occur that are not induced by the GHG thresholds, but by other (EU) policies, technological progress and targeted actions to reduce GHG emissions. Examples are the 20% greenhouse gas emission reduction ambitions of the Climate directive and the 20% energy efficiency ambition of the EC. Further, targeted measures can be implemented by bioenergy producers that are specifically aimed at reducing GHG emissions. This aspect has also been investigated in the already mentioned impact study of the COWI consortium (2009). The focus is thereby on first-generation biofuels for transport. The results show that almost all biofuel chains will be able to meet the GHG saving criterion at no or limited additional costs. An exception is the case of biodiesel made from soy, which will most likely not pass the RED-FQD

[1] The text in the remainder of this chapter is taken/derived from various publications that are referred to in the text.

target in 2017. The impact of the RED-FQD GHG saving criteria on costs is further investigated in Section 5.2.

Table 4.2	**Biomass-to-energy chains analysed for the impact of the GHG criterion**
Chain	**Typical GHG reduction (%)**
Wheat ethanol (lignite as process fuel in CHP plant)	32
Wheat ethanol (natural gas as process fuel in conventional boiler)	45
Wheat ethanol (natural gas as process fuel in CHP plant)	53
Corn (maize) ethanol (community produced natural gas as process fuel in CHP plant)	56
Rapeseed biodiesel	45
Soybean biodiesel	40
Palm oil biodiesel (process not specified)	36
Hydrotreated vegetable oil from rape seed	51
Hydrotreated vegetable oil from palm oil (process not specified)	40
Source: COWI consortium (2009).	

Land exclusion criteria

The land exclusion criteria could directly affect the availability of biofuels in the EU27 (COWI consortium 2009). COWI and partners reviewed a number of studies on assessing the potential of biomass energy in the EU in case:

- they claimed that the specified no-go areas were not considered part of the available land resource base for agriculture;
- they claimed that the land types of Articles 17-4 and 17-5 were only used for residues without bringing changes to the status of the land, and if forests were used in a responsible way consistent with Article 17-4.

All the reviewed studies assessed the availability of crops on the basis of (existing) agricultural land. Overall, they concluded that the land exclusion criteria will not substantially reduce the potential or costs of agricultural crops in the EU, as the biofuel potential from various types of land that are allowed to be used for biofuel production in the EU according to the RED-FQD criteria is sufficient to meet the demand. Further, the impact of sustainability criteria on the potential of bioenergy in the rest of the world had been investigated. Given the size of the projected imports and the considerably larger order of magnitude of global potentials, it can be concluded that the demand for biomass for energy production in the EU can easily be met without compromising the land exclusion criteria.

These results are supported by many other potential studies. During the past years more than 250 studies have been carried out in which the potential of bioenergy is assessed at a worldwide, continental, national or subnational level (see further the results of the Biomass Energy Europe (BEE) project available at http://www.eu-bee.com/). The results obviously vary per region, but the potential of bioenergy worldwide and in the EU is sufficient to meet the future demand of bioenergy, even when natural vegetation and high bio-diverse areas are excluded. Also the potential from degraded, low productive areas and various other types of non-forest and non-agriculture land is substantial (Hoogwijk et al., 2005; Smeets et al., 2007; Dornburg et al., 2010; Wicke et al., 2011; Nijsen et al., 2011).

The latest IPCC report on renewable energy led to similar conclusions for the global demand and supply of bioenergy in the year 2050 (Chum et al., 2011).

4.2 Impact of the RED-FQD criteria on the costs of bioenergy

In this section the impact of the RED-FQD criteria on the costs of biofuels is evaluated. The sustainability requirements in the RED-FQD require market agents to incur basically two types of costs across the supply chain (COWI consortium, 2009) and other costs (Johnson et al., 2011; NL Agency and NL Energy and Climate Change, 2012):

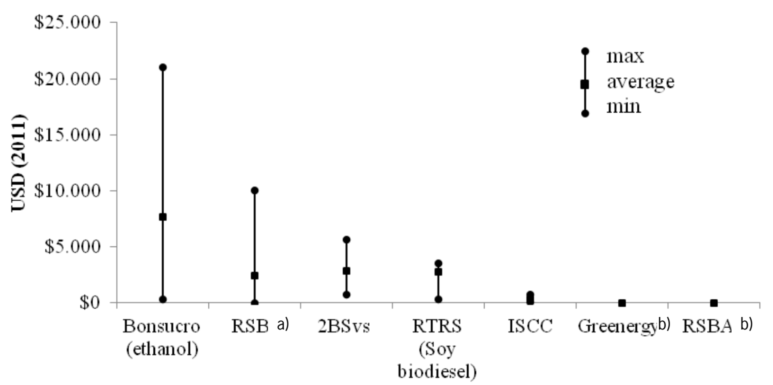
Costs related to the *certification process*:

- *certification fees*
  Costs levied by the certifying entity; the fee structure might be fixed or be based on the quantity certified or various combinations;
- *information costs*
  Related to gathering and analysing data (e.g. biodiversity status of land, estimation of carbon stocks);
- *auditing fees*
  Costs incurred in monitoring visits and assessments by external agents (auditors) to guarantee neutrality;
- *changes to management systems*
  Related to the tracking of products, quality control and integration of new data and analysis with production processes, including both those processes that remain unchanged and those that have been modified;

- *changes in the production chain of bioenergy*
  Involves the *internal adaptation costs*, i.e. those actions and costs associated with improved agricultural practices (e.g. lower impact tillage), more efficient equipment (e.g. engines or mills) and better controls (e.g. exhaust from industrial mills).

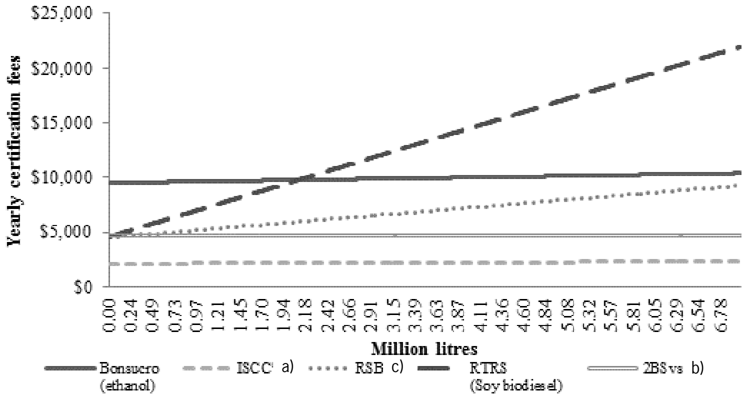
Costs of certification of bioenergy
In most schemes certification fees are split into a membership fee (mandatory, optional or bundled to benefits depending on the certificate) and a quantity-dependent fee (e.g. euro per litre of certified product). Some schemes require companies to become members in order to access the certification services (e.g. Bonsucro and Round Table on Responsible Soy Association (RTRS)). Others stimulate membership by linking membership to lower fees per unit output (International Sustainability and Carbon Certification (ISCC)), while others do not require mandatory membership for certification seekers (Roundtable on Sustainable Biofuels (RSB) and 2BSvs). An estimation of the ranges charged for membership fees for each certificate is given (see Figures 4.1 and 4.2) The estimations are based on the minimum, maximum and average membership fees charged by each scheme, which depend on their respective methodologies. Fees are generally based on property sizes, amount of feedstock processed or yearly financial turnovers (Johnson et al., 2011; Pacini and Assunção, 2011).

Figure 4.1 **Minimum, maximum and average membership fees for different biofuel sustainability certificates recognised by the EC in July 2011**



Source: Johnson et al. (2011).

Figure 4.2	Estimated yearly certification fees for 5 of the 7 schemes (in USD), including average membership costs and quantity-dependent fees (up to 7 million litres of certified sustainable product per year), including auditing costs of 1,800 USD per 2 days



a) For ISCC, the quantity-dependent component has been considered as an average of the fees applicable for members and non-members. b) 2BSvs scheme has a fixed component based on annual trade volume with no quantity-dependent fee. c) RSB simulations based on estimated costs for sugarcane ethanol, and may differ for other feedstocks.
Source: Johnson et al. (2011).

Estimates of the total costs and the costs per unit volume can be based on the assumed feedstock and the certification scheme. Soya and sugarcane ethanol are used as examples, because these are the most important biofuels that the EU is importing. The two private schemes (RSBS and Greenergy) are not included as participation is limited to their business partners.

The initial costs or membership fees range from zero up to 10,000 USD for the five schemes considered. The largest fee is for Bonsucro, which is not surprising given the fairly large economies of scale in sugarcane production. The fee structure for three of the five schemes (Bonsucro, ISCC, 2BSvs) is almost flat with respect to the volume supplied, while the fee structure of RSB and RTRS depends on the quantity.

The overall impact of the direct costs of certification is less than 2% of the production costs, assuming large-scale production systems (Johnson et al., 2011). These values are also confirmed by case studies on soy bean production in Argentina, jatropha in Tanzania and sugar cane production in Brazil (NL Agency and NL Energy and Climate Change, 2012). For example, in Brazil the production costs of ethanol are 0.35 euro per litre at the mill and the direct certification costs will represent 0.3% to 0.6% of total production costs (NL Agency and NL Energy and Climate Change, 2012). It can therefore be concluded that the costs of certification of bioenergy will most likely have a limited impact on the production and use of bioenergy.

Certification costs are not included in the multi-sectoral models MAGNET and ORANGE. However, these costs can be estimated on the bioenergy sector level, which in turn could be implemented in MAGNET and ORANGE. Herewith the models become useful to simulate the economic effects in case that e.g. more or less stringent certification rules concerning bioenergy will be targeted.

Costs of adjusting bioenergy production systems

In this section the costs of management planning and practices to meet the requirements of the certification standards are evaluated. These indirect costs of meeting the land exclusion criteria are not known exactly. Only general and fragmented information and guesstimated values based on case studies are available (NL Agency and NL Energy and Climate Change, 2012). These results suggest that the costs to producers can be substantial, especially in the first year of certification; up to a 30% increase in some cases. The total impact on production costs is much lower, after the first year and when the administrative procedures have been implemented and the status of land has been established. Another key aspect is the size of the plantation. The impact of indirect certification costs for large-scale producers are expected to be much lower per unit output than for small-scale producers. This conclusion is supported by a survey from ICONE mentioned in the report of NL Agency, which estimated the indirect costs for RTRS compliance in Brazil at 4.5 euro per tonne soy for a farmer owning 50 ha. For comparison, the price of soy in Brazil is 275 euro per tonne. Apart from the costs, certification may also generate benefits. Various sustainability schemes include good agricultural management and efficiency improvements. For example, Principle 2 of RSB requires for example 'planning, monitoring and continuous improvement (transparent and consultative impact assessment, and economic viability)', while Bonsucro requires 'continuously improvement of key areas of the business' including promoting economic sustainability'. Also external benefits may be realised. These benefits include meeting demands of the market and thereby market access, impact on image and branding and a direct price premium. The exact benefits are however not exactly known. According to the NL Agency report the market basically determines the premium for certified material. In case supply falls short, premiums increase. In case of oversupply, premiums decrease or they are not paid at all.

Based on the analyses above we assume that the indirect costs of certification per unit of biofuel will most likely be limited to a few per cent increase, although an exact figure could not be calculated.

The indirect costs of compliance with the GHG saving criteria are assessed in the study of the COWI consortium (2009). For the chains that did not meet the GHG saving thresholds by baseline developments (such as the EC Climate Direct and the Energy Saving Directive), additional measures can be implemented. The following changes are considered:

- The introduction of combined heat and power systems in wheat ethanol production on the basis of natural gas boilers. This is considered cost-effective as such (also for existing installations).
- The use of biomethanol in rapeseed biodiesel production instead of the use of petro-chemical methanol.
- The introduction of biomethanol in soy production for existing installations by 2017.
- The phasing out of soy biodiesel for new 2018 installations and replacement for 80% by rapeseed biodiesel and for 20% by sunflower.
- The additional introduction of methane capture in palm oil production on the basis of Clean Development Mechanism (CDM) projects.

The resulting impact of these changes on the GHG saving value and on the costs is shown in Table 4.3. The only biofuel chain that will most likely not be able to meet the 2017 GHG saving 50% target for existing plants and the 60% target for new facilities in 2018 is biodiesel from soy. The other chains require additional investments. With 38 million euro the overall costs seem high, but are negligible considering the total 14 billion litres of biofuel produced in the EU in 2009. Though the additional costs are less than 1% of the production costs, they can be implemented in the determined biofuel chains of the MAGNET or ORANGE socio-economic models.

Table 4.3	Summary of biofuel chains not meeting the 60% threshold by 2018, improvement options and related costs				
Biofuel chain	**Autonomous GHG emission reduction**	**Improve-ment option**	**Resulting GHG emission reduction**	**Additional costs for the year 2020 (linear baseline)**	**Additional costs for the year 2020 (2015 biodiesel peak)**
Ethanol from wheat (NG boiler)	54% (2018)	Shift to NG CHP	62% (2018)	0	0
Biodiesel from rapeseed	55% (2018)	Biomethanol in processing	62% (2018)	€13m	0
Biodiesel from soy	43% (2017)	Biomethanol in processing	50% (2017)	€18m	€23m
Biodiesel from soy	44% (2018)	Shift to rape, sunflower	>62% (2018)	€15m	0
Biodiesel/HVO from palm (p.n.s.)	45/47% (2017) 43/47% (2018)	Methane Capture	>62/68% a) (2018)	€15m	€15m
Total additional costs				€61m	€38m

a) 62% and 68% are the current typical values for respectively biodiesel and HVO from palm with methane capture at oil mill. 2017 and 2018 values have not been calculated but will be above these values.
Source: COWI consortium (2009).

The results presented in the previous sections show that the current RED-FQD sustainability criteria have a negligible effect on the costs and supply of the production of bioenergy. From this perspective, one could conclude that there is no immediate need to adjust economic models like MAGNET and ORANGE in order to capture the impact of the RED-FQD criteria. This situation might however change in the future due to concerns about the insufficient way that the RED-FQD sustainability criteria are operationalised into practically applicable and verifiable thresholds and indicators. Some issues were already briefly discussed in the previous sections, such as the various methodological issues related to measuring the GHG saving of biofuels and the impact of iLUC on the biodiversity and carbon stock changes. Moreover, there are other topics that are not included in the RED-FQD, but which are crucial in the debate about the sustainability of biofuels. Especially the impact of bioenergy production on food prices and food security is a sensitive and much discussed topic. It is uncertain if additional criteria will be included in the RED-FQD and how these criteria will be operationalised, in particular due to the lack of scientific consensus complex issues, such as iLUC and food price effects. Related to this situation, in September 2001 the EC decided to postpone the rules that would penalise individual biofuel operators for their indirect climate impacts by up to seven years. A last complicating factor is that the RED-FQD criteria are designed to be applicable by economic operators, while iLUC effects and other complex indirect economy wide effects are difficult to be operationalised at a company or plantation level.

In respect with capturing indirect effects of the bioenergy production on e.g. food prices and food security, the socio-economic models MAGNET and ORANGE can play a role. From their origin, these multi-sectoral and multi-regional CGE models are well-equipped to analyse the socio-economic impacts of allocating biomass over food, feed, fuels and functional materials for the chemical industry. Moreover, the already mentioned rebound effect (see Section 4.1) is another typical topic that can be examined with these CGE models due to their capacity to capture both the own (direct impact) sector effects of bioenergy production and its effects on other regional sectors (indirect impacts).

5 Summary and conclusions

This report looks at measures for sustainable bioenergy, in particular sustainability criteria as applied by the EU RED-FQD requirements, and how to operationalise these. The EU sustainability criteria are explicitly defined for biofuels and biomass; other materials such as waste and residues used to generate renewable energy are not considered and the criteria also do not apply to solid and gaseous biomass used in electricity, heating and cooling. The sustainability criteria include greenhouse gas savings, land with high biodiversity value and land with high carbon stock. The EU sustainability criteria thus do not cover aspects relating to the socio-economic principles of sustainability, but the Member States have to report about socio-economic impacts every two years. For conformity assessment, economic operators have to provide information on the compliance with the criteria (Article 18(3) RED, Article 7c(3), respectively) as well as apply adequate standard of independent auditing (RED Article 18(3) FQD) and a mass balance system to ensure compliance along the supply chain (Article 18(1) RED) (chain of custody). The European Commission has approved seven private certification schemes that firms can use in order to demonstrate compliance with the EU sustainability requirements for bioenergy. Many more systems are currently reviewed by the EC.

The EU focuses on four sustainability criteria, but there is no census about the definition of criteria, indicators and measurement methods. With regard to the EU sustainability criteria, for example, a potentially important issue is that the definition of land use and vegetation cover, which excludes certain vegetation types, such as other wooded land, but also trees outside forests. Also regional differences in biodiversity levels and management practices prevailing in the respective country are not considered. These complexities point towards the issue of more local definitions of sustainability criteria.

Measuring sustainability

For the quantitative analysis, one main challenge is the measurement of sustainability. Next to defining sustainable criteria, indicators and measurement methods are crucial. There are various approaches of measuring sustainability, and we have outlined the main challenges with regard to the EU sustainability criteria. A multitude of different and partially incompatible systems have already emerged (Van Dam et al., 2010), although it can be expected that voluntary

schemes that are not linked to EC or national biofuel-supporting policies will gradually disappear. An overall agreement on the scientific measurement of sustainability criteria has not been established. For example, there are several approaches for calculating GHG saving or carbon stock. Similarly, not all aspects of land use changes are taken into account in the definition and analysis of sustainability impacts. For land use changes, it is crucial to find indicators that are verifiable and can be readily applied by economic operators that have to prove their compliance with land use aspects of the sustainability criteria and/or provide evidence about land use effects of their activities. Especially with regard to land use, matters are complex, and as already mentioned, there is a lack of scientific consensus about definitions, indicators and measurement.
In the quantitative analysis, sustainable bioenergy are incorporated in models. This involves modelling sustainable bioenergy in terms of depicting sustainable on the one hand, but can also include efforts of depicting measures that promote sustainable bioenergy such as feed-in tariffs, premium prices for suppliers and so on. Measures for promoting sustainable bioenergy are typically formulated in quantity (for example targets, quotas or restrictions) or value terms (for example premium prices, subsides or tax exemptions); if not they can usually be translated into quantity and/or value terms such that incorporating them in a simulation model seems to be rather straight forward. Depicting sustainable bioenergy on the other hand is a much more complex and challenging task.

Impact analysis

Main challenges occur in the analysis of impacts. One main issue in the analysis relates to indirect effects, in particular indirect land use change (iLUC), which results from an increase of demand for biomass and consequently land for energy crop production; for example the impact on biodiversity and carbon stock changes induced by the land use changes. Such iLUC effects can occur with significant time lags and are in some cases triggered by trade of agricultural commodities as inputs into biofuel production and/or biofuel trade. In addition, rebound effects arise when biofuel use leads to less demand for gasoline/fossil oil, thereby decreasing the price of gasoline/fossil oil and thus consequently resulting in more consumption of gasoline/fossil oil. The total consumption of energy (fossil energy plus bioenergy) can thus be expected to be rather large in comparison to the consumption of fossil energy only. This rebound effect obviously impairs the effort of greenhouse gas saving, which was the initial goal and ambition. A similar line of reasoning can be developed for the effects on food prices and food security, which have been widely discussed.

In order to capture indirect effects of bioenergy production on food prices and food security, for example, computable equilibrium models such as MAGNET and ORANGE can be used. These multi-sectoral/multi-regional models are well-equipped to analyse the socio-economic impacts of allocating biomass over food, feed, fuels and well as functional materials for the chemical industry. Moreover, rebound effects could be examined in simulation models since they capture both the effects on the own sector (direct impact) and the effects on other sectors and regions (indirect impacts). Given the current state of model development, Table 5.1 summarises how the various issues of sustainability can be incorporated in computable equilibrium models simulation models. This refers to the current versions of the MAGNET and ORANGE model but additions to the respective models are suggested for later versions that will be developed in order to improve the analysis of sustainable bioenergy.

Research questions for policy issues

Further research is necessary to better address the challenges with regard to the definition of criteria for sustainable bioenergy, indicators as well as measurement and analysis in order to ascertain impacts. Policy makers are particularly interested in the impact of policies for sustainable bioenergy, and improving the analysis of sustainable bioenergy seems to be particularly relevant for answering policy-related questions about sustainable bioenergy. For policy-making, main questions are also related to the direct and indirect impacts of bioenergy but also ask about the policy measures to be used for promoting sustainable bioenergy. For example, what effects do respective policy measures for sustainable bioenergy actually have on GHG emissions, biodiversity, water and so on? Do they help to achieve the transition from a fossil-based economy to a bio-based economy?

Another topic focuses on the international context, raising questions about competiveness and the possibility of imposing sustainability criteria on the production in other countries in order to achieve a level-playing field. With regard to land use changes the following questions are discussed: What effects do policy measures for promoting sustainable bioenergy, such as the EU RED-FQD, have on the (indirect) land use and (indirect) land use changes? What effect do land use changes have on the environment? What are the socio-economic impacts? Is it possible to manage issues of indirect land use changes by adopting sustainable policies or land use (management) planning policies?

A large number of studies have already been carried out on the issue of land use changes, but policy issues still need to be addressed. For example an urgent question for policy making is about the potential to realise biomass supply chains with a low iLUC and food security impact, for example by using degraded areas or by increasing the production efficiency of agriculture, or by integrating bio-energy, agriculture and land use policies.

Table 5.1	**Overview on methods to applying RED-FQD sustainability aspects in simulation models.**
RED-FQD	**Applicable in computable equilibrium models (MAGNET, ORANGE)**
GHG saving criteria	*Current* (2012) versions: not applied *Later* versions: GHG savings could be simulated by enhancing the models with technical progress, which will influence the cost structure of bioenergy sectors
Land exclusion criteria	*Current* (2012) versions: applicable via manipulating the asymptote of the land supply function *Later* versions: enhance the land supply function by accounting for more detailed land use data available from specific land allocation models
Certification costs	*Current* (2012) versions: not applied *Later* versions: certification costs could be simulated by enhancing the models with estimated certification costs, which will increase the expenditures of bioenergy sectors to other business sectors. Certification costs could decrease/increase due to assessing less or more stringent certification rules
Rebound effect	*Current* (2012) versions: in principle, these type of models are able to analyse direct and indirect socio-economic impacts, e.g. the impact of bioenergy sectors on the fossil oil sector *Later* versions: enhancing the models with differing bioenergy chains (first and second generation), technical progress aspects, policy targets, substitution effects between fossil oil and bioenergy
Food price and food security effects	*Current* (2012) versions: in principle, these type of models are able to analyse the socio-economic impacts of different allocation of biomass over food, feed, fuels and functional materials *Later* versions: enhancing the models with differing bioenergy chains (first and second generation), technical progress aspects, policy targets

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Appendix 1

Definition of biomass, bioenergy, biofuels and biomaterials

- *Biomass*, as defined by the EU, is a biodegradable fraction of products, waste and residues from agriculture (including vegetal and animal substances), forestry and related industries, as well as the biodegradable fraction of industrial and municipal waste (EC, 2009a).
- *Biomaterials* are renewable industrial raw materials and derived processed products produced from biomass. Biomaterials produced from agricultural biomass mainly include industrial oils, starch and sugar, fibres and high-value low-volume products (OECD, 2004).
- *Agricultural biomass* is a subset of biomass produces directly from agricultural activities, such as cereal grains, sugar crops, oilseeds, arable crops and crops by-products, grasses, farm forestry and livestock by-products (OECD, 2004).
- *Bioenergy* is renewable energy produced from biomass fuels when used to produce heat and/or power and transport fuels. Bioenergy produced from agricultural biomass includes liquid or gaseous biofuels (e.g. bioethanol, biodiesel and biogas), biopower for electricity and bioheat, mainly generated from solid biomass (OECD, 2004).
- *Biomass fuels* are solid, liquid or gaseous fuel produced by conversion of biomass. Examples include bioethanol from sugar cane or corn, charcoal or woodchips, and biogas from anaerobic decomposition of wastes (OECD, 2002). In this report the term 'biofuels' is used for liquid biofuels for transport (ethanol and biodiesel).
- *Solid biofuels* are defined as organic, non-fossil material of biological origin used directly as fuel or converted into other forms before combustion. Included are wood, vegetal waste (including wood waste and crops used for energy production), animal materials/wastes, sulphite lyes, also known as 'black liquor' (an alkaline spent liquor from the digesters in the production of sulphate or soda pulp during the manufacture of paper where the energy content derives from the lignin removed from the wood pulp) and other solid biomass (IEA, 2002).
- *Gaseous and liquid biofuels:* (1) gaseous biofuels are derived principally from the anaerobic fermentation of biomass and solid wastes and combusted to produce heat and/or power. Included in this category are landfill gas and

sludge gas (sewage gas and gas from animal slurries) and other biogas; (2) liquid biomass, which includes bio-additives such as ethanol and bio-diesel, is also included in this category (IEA, 2002).

- *Biogas* is a mixture of methane and carbon dioxide in the ratio of 7:3 that is produced by the treatment of animal dung, industrial wastes and crop residues. It is used as an alternative source of energy (UN, 1997).
- *Bioethanol* is a biofuel produced from sugar-rich plants (such as sugar cane, maize, beet, cassava, wheat, sorghum) or starch (FAO, 2008).
- *Biodiesel* is a biofuel produced from various feedstock including vegetable oils (such as palm oil, oilseed, rapeseed, jatropha and soybean), animal fats or algae (FAO, 2008).

Appendix 2

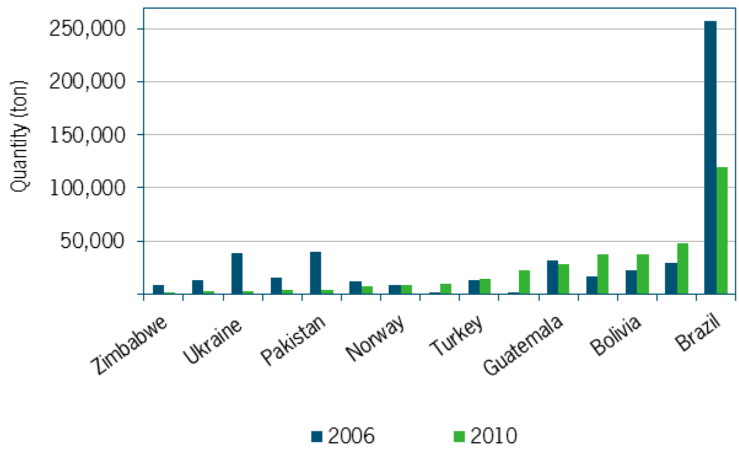
Can the EU produce all of this biomass domestically?

In 2007, domestic supply of biomass in the EU was about around 1,000 TWh primary energy (excluding supply of biomass for biofuel conversion). About 75% of the biomass originated from forestry or indirectly from industry by-products (Hogan et al., 2010). The remainder is mostly waste, more specifically recovered wood, municipal solid waste, manure and sewage. Agricultural residues and energy crops are other biomass inputs. They represented less than 2% of the total supply (Hogan et al., 2010).

Hogan et al. (2010) calculate that the supply of primary energy from biomass needs to be between 1,850 and 3,400 TWh, depending on how the biomass is being used, in order to meet the EU targets of 1,650 TWh of final energy consumption from biomass heat and power by 2020. Projections for the Member States show that renewable energy will grow at a faster pace in the years up to 2020 than in the past. It is expected that 12 Member States will exceed their own targets and be able to provide surpluses for other Member States (EC, 2011a).

Since transport fuels are traded relatively easily, Member States with low endowments will be able to obtain biomass for transport fuels from elsewhere. That is why it is it is likely that the EU will meet its biofuel target through a combination of domestic production and imports (EC, 2008). As shown in the figure below, Brazil was by far the biggest importer of bio-ethanol to the EU during 2006-2010. Within the EU Member States, the Netherlands, Italy and Sweden imported most bioethanol in 2010, closely followed by Belgium and France.

Figure A2.1	EU ethanol import according to country of origin (2006, 2010)



Note: HS Code 2207.
Source: Eurostat Comext.

Appendix 3

The protection of forests and various definitions of forests

The definition of forests in the RED-FQD is almost the same as the definition used by the United Nations Food and Agricultural Organisation in the Forest Resource Assessment (FRA) 2005 (UNFAO 2005). But other definitions are also commonly used (see the table below).

Table A3.1	**Parameters of definitions of 'Forest'**				
		UNFCCC	**CBD**	**FRA**	**EU-RED-FQD**
Binary parameters (1=presence; 0= absence)	Young stands	1	1	1	1
	Temporarily unstocked areas	1	0	1	0
	Non-forest land uses	0	1	1	0
	Agroforestry	0	?	1	0
Threshold Parameters	Min. area (ha)	0.05-1.0	0.5	0.5	0.5
	Min. height (m)	2-5	5	5	5
	Crown cover (%)	10-30	10	10	10
	Temporary (years)	n/a	n/a	~10	n/a
	Strip width (m)	n/a	n/a	20	n/a

Sources: Adjusted from UNFAO, IPCC, CIFOR, IUFRO, UNEP (2002); UNFAO (2005), CBD (2001), EC (2009) and UNFCC (2001).

In the definition of forests in RED-FQD, temporarily unstocked areas, non-forest land uses and agro-forestry are not mentioned and therefore these areas are available for bioenergy (except for areas with trees that are able to reach to reach the RED-FQD thresholds in situ). Potentially also important for biodiversity and carbon stock changes are other types of wooded land of less than 0.5 ha, or with trees below a minimum height of 5 m in situ, or with a crown cover of less than 10 %. Data about the extent of these areas are not available, except for areas defined in the Forest Resource Assessment 2005 (UNFAO 2005) as:

- Other wooded land: 'Land not classified as forest, spanning more than 0.5 ha; with trees higher than 5 m and a canopy cover of 5-10%, or trees able to reach these thresholds in situ; or with a combined cover of shrubs, bushes and trees above 10 % cover. It does not include land that is predominantly under agricultural or urban land use.'

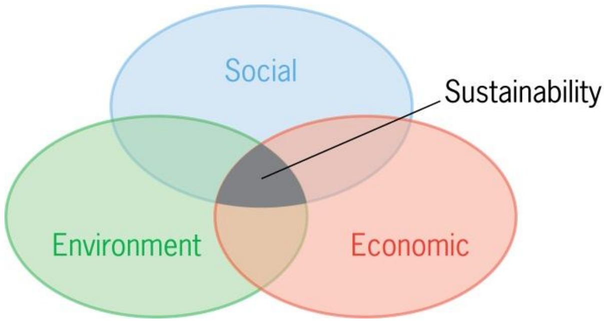
- Other land with tree cover: 'Land classified as other land, spanning more than 0.5 ha with a canopy cover of more than 10% of trees able to reach a height of 5 m at maturity. Includes: groups of trees and scattered trees in agricultural landscapes, parks, gardens and around buildings, provided that the area, height and canopy cover criteria are met; includes tree plantations established mainly for other purposes than wood, such as fruit orchards. Other land is hereby defined as all land that is not classified as forest or other wooded land. Other land includes agricultural land, meadows and pastures, built-up areas, barren land, et cetera; areas classified under the subcategory other land with tree cover.'

Globally, the land area of forests, other wooded land and other land with tree cover is 3952, 1375 and 75 Mha (UNFAO, 2005). The area of other land with tree cover is rather small, and the biodiversity value of these areas is likely to be low. Also the carbon stock is probably low compared to forests. Moreover, land with groups of trees and scattered trees in agricultural landscapes are anyway not very suitable for the production of biomass for biofuels, let alone parks and gardens. More important are areas classified as other wooded land with vegetation type being similar to tropical forests but with a lower canopy cover. Important regions in this category are Oceania and Africa, with forests and other wooded land of 206 and 430 Mha (Oceania), and 635 and 406 Mha (Africa), respectively. For Asia and South America these figures are 283 and 29 Mha and 832 and 129 Mha.

Appendix 4

'Triple Bottom Line' sustainability principles

Figure A4.1 **'Triple Bottom Line' sustainability principles**



Appendix 5

World biofuel production by region and selected countries, 2001-2009 (1,000 litre/day)

Region/Country	Bioethanol		Biodiesel		Total Biofuels	
	2001	2009	2001	2009	2001	2009
North America	18,927	116,406	89	5,601	19,016	122,007
United States	18,307	113,432	89	5,236	18,396	118,668
Central and South America	31,582	75,746	32	9,210	31,614	84,956
Brazil	31,413	71,513	0	4,405	31,413	75,919
Europe	382	9,862	3,203	27,442	3,585	37,304
Asia & Oceania	477	8,735	16	6,125	493	14,860
Other: Africa, Eurasia and the Middle East	32	273	0	618	32	892
World	51,399	211,022	3,340	48,996	54,739	260,019

Source: US Energy Information Administration (EIA).

Appendix 6

World biofuel production by region and selected countries, 2001-2009

Region/Country	**Bioethanol production change 2001-2009 (%)**	**Biodiesel production change 2001-2009 (%)**	**Share bioethanol total biofuels 2001-2009 (%)**	**Share biodiesel total biofuels 2001-2009 (%)**
North America	515	6,193	97.5	2.5
United States	520	5,783	97.6	2.4
Central and South America	140	28,681	94.5	5.5
Brazil	128	440,500	97.1	2.9
Europe	2,482	757	18.5	81.5
Asia & Oceania	1,731	38,181	77.8	22.2
Other: Africa, Eurasia and the Middle East	753	61,800	65.3	34.6
World	311	1,367	87.5	12.5

Source: US Energy Information Administration (EIA).

Appendix 7

Sources and forms of bioenergy

Bioenergy form / Bioenergy source	Biofuels (Transport energy)	Biopower (Electricity)	Bioheat (Heat)	Biogas (Gas)	Link to agricultural markets
Agricultural commodities	*Ethanol* (grains, sugar crops, edible part of other starchy commodities); *Biodiesel* (vegetable oils); *Biogas* (grain);	*Biogas* (grains); *Combustion* (n/a);	*Biogas* (grains); *Combustion* (n/a);	*Biogas* (grains);	Direct and indirect competition with other uses; by-products of biofuel compete with feed crop production
Residues and wastes from agriculture and food industry	*Biodiesel* (used cooking oil, animal fats); *Second generation ethanol* (straw, non-edible part of starchy commodities); *Biogas* (manure, crop residues, etc.);	*Biogas* (manure, crop residues, etc.); *Combustion* (straw, kernals, husks, etc.);	*Biogas* (manure, crop residues, etc.); *Combustion* (straw, kernals, husks, etc.);	*Biogas* (manure, crop residues, organic waste, etc.);	Co-production with agri-cultural or food products; Potential competition with other uses;
Forest products	*Second generation ethanol* (wood);	*Direct combustion* (wood);	*Direct combustion* (wood);		Potential competition with agri-cultural land use;

Source: OECD (2010).

Bioenergy form / Bioenergy source	**Biofuels (Transport energy)**	**Biopower (Electricity)**	**Bioheat (Heat)**	**Biogas (Gas)**	**Link to agricultural markets**
Forest residues	*Second generation ethanol* (wood chips);	*Direct combustion* (wood chips);	*Direct combustion* (wood chips);		Little
Dedicated biomass crops	*Second generation ethanol* (grasses, poplar trees, etc.); *BTL*[1] (any biomass); *Biogas* (any biomass);	*Biogas* (any biomass); *Direct combustion* (wood, wood chips);	*Biogas* (any biomass); *Direct combustion* (wood, wood chips);	*Biogas* (any biomass);	Competition with land use for agri-cultural commodity production;
Industrial wastes	*Biogas*	*Biogas*	*Biogas*	*Biogas*	Little
Municipal wastes	*Biogas*	*Biogas*	*Biogas*	*Biogas*	Little

Source: OECD (2010).

Appendix 8

General sustainability principles and criteria

General sustainability principles	General EU criteria: EU Sustainable Development Strategy (EC, 2001)	General UN criteria: WCED (1987)
Environmental sustainability	- Biodiversity - Natural resources - Reduction of greenhouse gas emissions - Pollution (water, air, soil) - Climate change issues - Energy efficiency - Development of clean technology - Waste management - Sustainable transport	- Biodiversity - Natural resources - Carrying capacity - Clean air and water - Ecosystem integrity
Economic sustainability	- Sustainable consumption - Sustainable production - Corporate Social Responsibility - Urban and local development - Sustainable tourism - Integration of environmental concerns in business decision-making - Sustainable trade	- Services - Households needs - Industrial growth - Agricultural growth - Efficient use of labour
Social sustainability	- Social equity - Community cohesion - Equal opportunities - Demography - Management of migration and cultural diversity - Development of human capital and skills - Flexicurity a) - Health	- Equity - Participation - Empowerment - Social mobility - Cultural preservation

a) The EU defines flexicurity as an integrated strategy aimed at simultaneously improving flexibility and security in the labour market.
Source: EC (2007).

Appendix 9

EU sustainability criteria, indicators, verifiers and guidelines with respect to biomass according to RED

Guideline: EU Renewable Energy Directive (RED)
Environment principles
Criteria: *A minimum GHG saving* (Articles 17) **Indicators**: - *Article 17(2)* at least 35% GHG emission reduction of biofuels compared to fossil fuels, measured throughout the entire chain produced by installations that are in operation on or after 1 January 2017[5]. 50% GHG emission reduction after 2017 and 60 % GHG emission reduction after 2018. The greenhouse gas emission saving from the use of biofuels and bioliquids shall be calculated in accordance with Article 19(1). - *Article 17(1)* GHG saving criterion applies only to waste and residues, other than agricultural, aquaculture, fisheries and forestry. **Verifiers**: - *Article 18 en 22* deals with the verification. - *Article 22(1)* by 31 December 2011 (and every two years thereafter) reporting by Member States on net greenhouse gas emission saving due to the use of energy from renewable sources.
Criteria: *Protection of high biodiversity* (Articles 17) **Indicators**: - *Article 17(3)* a) primary forest and other wooded land of native species, where there is no clearly visible indication of human activity and the ecological processes are not significantly disturbed; b) areas designated: (1) by law or by the relevant competent authority for nature protection purposes; (2) for the protection of rare, threatened or endangered ecosystems or species recognised by international agreements or included in lists drawn up by intergovernmental organisations or the International Union for the Conservation of Nature; c) highly bio-diverse grassland that is: (1) natural, namely grassland that would remain grassland in the absence of human intervention and which maintains the natural species composition and ecological characteristics and processes; or (2) non-natural, namely grassland that would cease to be grassland in the absence of human intervention and which is species-rich and not degraded, unless evidence is provided that the harvesting of the raw material is necessary to preserve its grassland status;

Guideline: EU Renewable Energy Directive (RED)

Environment principles

Verifiers:

- *Article 17, 18 en 22* deals with the verification.
- *Article 17(7)* the EC shall, every two years, report to the European Parliament and the Council, in respect of both third countries and Member States that are a significant source of biofuels or of raw material for biofuels consumed within the Community, on whether the country has ratified and implemented: (1) the Cartagena Protocol on Biosafety and (2) the Convention on International Trade in Endangered Species of Wild Fauna and Flora.
- *Article 22(1)* by 31 December 2011 (and every two years thereafter) reporting by Member States on estimated impact of the production of biofuels and bioliquids on biodiversity.

Criteria: *Avoid use and loss of high carbon-stock land* (Articles 17)

Indicators:

- *Article 17(4)*
  a) land that is covered with or saturated by water permanently or for a significant part of the year;
  b) continuously forested areas, namely land spanning more than one hectare with trees higher than five meters and a canopy cover of more than 30%, or trees able to reach those thresholds in situ;
  c) land spanning more than one hectare with trees higher than five metres and a canopy cover of between 10% and 30%, or trees able to reach those thresholds in situ, unless evidence is provided that the carbon stock of the area before and after conversion is such that, when the methodology laid down in part C of Annex V is applied, the conditions laid down in Paragraph 2 of this article would be fulfilled.

Verifiers:

- *Article 17 and 18* deals with the verification.
- *Article (17(5)* biofuels and bioliquids shall not be made from raw material obtained from land that was peat land in January 2008, unless evidence is provided that the cultivation and harvesting of that raw material does not involve drainage of previously un-drained soil.

Criteria: 'Cross compliance' with environmental requirements under the CAP(Article 17)

Indicators:

- *Article 17(6)* biofuel production must comply with the 'cross compliance' rules already in force under the heading 'Environment' in part A and in point 9 of Annex II to Council Regulation (EC) No 73/2009 of 19 January 2009 establishing common rules for direct support schemes for farmers under the common agricultural policy and establishing certain support schemes for farmers (EC, 2009c) and in accordance with the minimum requirements for good agricultural and environmental condition defined pursuant to Article 6(1) of that Regulation.

Guideline: EU Renewable Energy Directive (RED)

Environment principles

Verifiers:

- *Article 18* deals with the verification

Criteria: *Waste management* (Articles 17)

Indicators:

- *Article 17(1)* waste and residues, other than agricultural, aquaculture, fisheries and forestry, only need to fulfil the GHG criterion.

Verifiers:

- *Article 18 and 22* deal with the verification.
- *Article 22(1)* by 31 December 2011 (and every two years thereafter) reporting by Member States on promotion of use of renewable energy including from wastes and residues and development and share of biofuels made from wastes and residues.

Criteria: *Soil, water and air protection* (Articles 17)

Indicators:

- *Article 17(7)* the EC shall, every two years, report to the European Parliament and the Council, in respect of both third countries and Member States that are a significant source of biofuels or of raw material for biofuels consumed within the Community, on national measures taken to respect the sustainability criteria set out in Article 17.2 to 17.5 and for soil, water and air protection.

Verifiers:

- *Article 18 and 22* deal with the verification.
- *Article 22(1)* by 31 December 2011 (and every two years thereafter) reporting by Member States on estimated impact of the production of biofuels and bioliquids on water resources and water quality.

Socio- economic principle of sustainability

Criteria: *Food availability and access* (Articles 17)

Indicators:

- *Article 17(7)* the EC shall, every two years, report to the European Parliament and the Council on the impact on social sustainability in the Community and in third countries of increased demand for biofuel, on the impact of Community biofuel policy on the availability of foodstuffs at affordable prices, in particular for people living in developing countries, and wider development issues.

Verifiers:

- *Article 18 and 22* deal with the verification.
- *Article 22(1)* by 31 December 2011 (and every two years thereafter) reporting by Member States on changes in commodity prices and land use within the Member State associated with its increased use of biomass and other forms of energy from renewable sources.

Guideline: EU Renewable Energy Directive (RED)
Environment principles
Criteria: *Employment, wages and labour conditions* (Article 17) **Indicators**: - *Article 17(7)* reports should state, both for third countries and Member States that are a significant source of raw material for biofuel consumed within the Community, whether the country has ratified and implemented the following conventions of the International Labour Organisation, concerning labour conditions - No 29, 87, 98, 100, 105, 111, 138, 182; **Verifiers**: - *Article 18* deals with the verification.
Criteria: *Land tenure/access and displacement* (Article 17(7)): **Indicators**: - *Article 17(7)* Reports shall address, both for third countries and Member States that are a significant source of raw material for biofuel consumed within the Community, the respect of land-use rights. **Verifiers**: - *Article 18* deals with the verification.
Source: EC (2009a).

Appendix 10

Brief overview of provisions of the EU Renewable Energy Directive and the Fuel Quality Directive

Renewable Energy Directive	**Fuel Quality Directive**
Article 2: Definitions	Not included
Article 5: Calculation of the share of energy from renewable sources	Not included
Article 17: Sustainability criteria for biofuels and bioliquids	Article 7b: Sustainability criteria for biofuels
Article 18: Verification of compliance with the sustainability criteria for biofuels and bioliquids	Article 7c: Verification of compliance with the sustainability criteria for biofuels
Article 19: Calculation of the greenhouse gas impact of biofuels and bioliquids	Article 7d: Calculation of life cycle greenhouse gas emissions from biofuels
Article 21: Specific provisions related to energy from renewable sources in transport	Not included
Article 24: Transparency platform a)	Not included b)
Annex III: Energy content of transport fuels	Not included
Annex V: Rules for calculating the greenhouse gas impact of biofuels, bioliquids and their fossil fuel comparators	Annex IV: Rules for calculating life cycle greenhouse emissions from biofuels

a) Available online at: http://ec.europa.eu/energy/renewables/transparency_platform_en.htm; b) Where documents are relevant for the Fuel Quality Directive, the EC intends to publish them also on the Fuel Quality Directive's website.
Source: EC (2010c).

Appendix 11

EU sustainability criteria for biofuels, bioliquids, solid and gaseous biomass

Measures	**Criteria for biofuels a) (FQD), biofuels and bioliquids b) (RED)**	**Criteria for solid c) and gaseous d) biomass (According to RED Article 17(9))**
Principles	**Binding**	**Non-binding**
Environmental	**Criteria e)**: *A minimum GHG saving* (Articles 17(1) , 17(2) and 22(1)) **Indicators**: - *Article 17(2)* at least 35% GHG emission reduction of biofuels compared to fossil fuels, measured throughout the entire chain produced by installations that are in operation on or after 1 January 2017. f) 50% GHG emission reduction after 2017 and 60 % GHG emission reduction after 2018. The greenhouse gas emission saving from the use of biofuels and bioliquids shall be calculated in accordance with Article 19(1). - *Article 17(1)* GHG saving criterion applies only to waste and residues, other than agricultural, aquaculture, fisheries and forestry. - *Article 22(1)* by 31 December 2011 (and every two years thereafter) reporting by Member States on net greenhouse gas emission saving due to the use of energy from renewable sources.	The same conditions *Exceptions:* - GHG criterion is not applied to waste and residues - applies only to larger installations >1 MW

Measures	Criteria for biofuels a) (FQD), biofuels and bioliquids b) (RED)	Criteria for solid c) and gaseous d) biomass (According to RED Article 17(9))
Principles	**Binding**	**Non-binding**
	Criteria: *Protection of high biodiversity* (Articles 17(3), 17(7) and 22(1)) **Indicators**: - *Article 17(3):* a) primary forest and other wooded land of native species, where there is no clearly visible indication of human activity and the ecological processes are not significantly disturbed; b) areas designated: (1) by law or by the relevant competent authority for nature protection purposes; (2) for the protection of rare, threatened or endangered ecosystems or species recognised by international agreements or included in lists drawn up by intergovernmental organisations or the International Union for the Conservation of Nature; c) highly bio-diverse grassland that is: (1) natural, namely grassland that would remain grassland in the absence of human intervention and which maintains the natural species composition and ecological characteristics and processes; or (2) non-natural, namely grassland that would cease to be grassland in the absence of human intervention and which is species-rich and not degraded, unless evidence is provided that the harvesting of the raw material is necessary to preserve its grassland status; - *Article 17(7)* the EC shall, every two years, report to the European Parliament and the Council, in respect of both third countries and Member States that are a significant source of biofuels or of raw material for biofuels consumed within the Community, on whether the country has ratified and implemented: (1) the Cartagena Protocol on Biosafety and (2) the Convention on	The same conditions *Exceptions:* - applies only to larger installations >1 MW

Measures	Criteria for biofuels a) (FQD), biofuels and bioliquids b) (RED)	Criteria for solid c) and gaseous d) biomass (According to RED Article 17(9))
Principles	**Binding**	**Non-binding**
	International Trade in Endangered Species of Wild Fauna and Flora. - *Article 22(1)* by 31 December 2011 (and every two years thereafter) reporting by Member States on estimated impact of the production of biofuels and bioliquids on biodiversity.	
	Criteria: *Avoid use and loss of high carbon-stock land* (Articles 17(4) and 17(5)) **Indicators** - *Article 17(4):* a) land that is covered with or saturated by water permanently or for a significant part of the year; b) continuously forested areas, namely land spanning more than one hectare with trees higher than five meters and a canopy cover of more than 30%, or trees able to reach those thresholds in situ; c) land spanning more than one hectare with trees higher than five metres and a canopy cover of between 10% and 30%, or trees able to reach those thresholds in situ, unless evidence is provided that the carbon stock of the area before and after conversion is such that, when the methodology laid down in part C of Annex V is applied, the conditions laid down in Paragraph 2 of this article would be fulfilled. - *Article (17(5)* biofuels and bioliquids shall not be made from raw material obtained from land that was peatland in January 2008, unless evidence is provided that the cultivation and harvesting of that raw material does not involve drainage of previously undrained soil.	The same conditions *Exceptions:* - applies only to larger installations >1 MW

Measures	Criteria for biofuels a) (FQD), biofuels and bioliquids b) (RED)	Criteria for solid c) and gaseous d) biomass (According to RED Article 17(9))
Principles	**Binding**	**Non-binding**
	Criteria: 'Cross compliance' with environmental requirements under the Common Agricultural Policy (Article 17(6)) **Indicators**: - *Article 17(6)* biofuel production must comply with the 'cross compliance' rules already in force under the heading 'Environment' in part A and in point 9 of Annex II to Council Regulation (EC) No 73/2009 of 19 January 2009 establishing common rules for direct support schemes for farmers under the common agricultural policy and establishing certain support schemes for farmers (EC, 2009c) and in accordance with the minimum requirements for good agricultural and environmental condition defined pursuant to Article 6(1) of that Regulation	The same conditions *Exceptions:* - applies only to larger installations >1 MW
	Criteria: *Waste management* (Articles 17(1) and 22(1)): **Indicators**: - *Article 17(1)* waste and residues, other than agricultural, aquaculture, fisheries and forestry, only need to fulfil the GHG criterion. - *Article 22(1)* by 31 December 2011 (and every two years thereafter) reporting by Member States on promotion of use of renewable energy including from wastes and residues and development and share of biofuels made from wastes and residues.	The same conditions *Exceptions:* - no GHG criterion for waste and residues - applies only to larger installations >1 MW

Measures	Criteria for biofuels a) (FQD), biofuels and bioliquids b) (RED)	Criteria for solid c) and gaseous d) biomass (According to RED Article 17(9))
Principles	**Binding**	**Non-binding**
	Criteria: *Soil, water and air protection* (Articles 17(7) and 22(1)) **Indicators**: - *Article 17(7)* the EC shall, every two years, report to the European Parliament and the Council, in respect of both third countries and Member States that are a significant source of biofuels or of raw material for biofuels consumed within the Community, on national measures taken to respect the sustainability criteria set out in Article 17.2 to 17.5 and for soil, water and air protection. - *Article 22(1)* by 31 December 2011 (and every two years thereafter) reporting by Member States on estimated impact of the production of biofuels and bioliquids on water resources and water quality.	The same conditions *Exceptions:* - applies only to larger installations >1 MW
Socio-economic	**Criteria**: *Food availability and access* (Articles 17(7) and 22(1)) **Indicators**: - *Article 17(7)* the EC shall, every two years, report to the European Parliament and the Council on the impact on social sustainability in the Community and in third countries of increased demand for biofuel, on the impact of Community biofuel policy on the availability of foodstuffs at affordable prices, in particular for people living in developing countries, and wider development issues. - *Article 22(1)* by 31 December 2011 (and every two years thereafter) reporting by Member States on changes in commodity prices and land use within the Member State associated with its increased use of biomass and other forms of energy from renewable sources.	The same conditions *Exceptions:* - additional monitoring of the origin of biomass g) - applies only to larger installations >1 MW

Measures	Criteria for biofuels a) (FQD), biofuels and bioliquids b) (RED)	Criteria for solid c) and gaseous d) biomass (According to RED Article 17(9))
Principles	**Binding**	**Non-binding**
	Criteria: *Employment, wages and labour conditions* (Article 17(7)) **Indicators**: - *Article 17(7)* reports should state, both for third countries and Member States that are a significant source of raw material for biofuel consumed within the Community, whether the country has ratified and implemented the following conventions of the International Labour Organisation, concerning labour conditions - No 29, 87, 98, 100, 105, 111, 138, 182;	The same conditions *Exceptions:* - applies only to larger installations >1 MW
	Criteria: *Land tenure/access and displacement* (Article 17(7)) **Indicators**: - *Article 17(7)* Reports shall address, both for third countries and Member States that are a significant source of raw material for biofuel consumed within the Community, the respect of land-use rights.	The same conditions *Exceptions:* - applies only to larger installations >1 MW

a) Liquid and gaseous fuels used in transport; b) Liquid fuels used in in electricity, heating and cooling; c) Solid fuels used in electricity, heating and cooling; d) Gaseous fuels used in electricity, heating and cooling; e) This criterion covers direct land change only; f) Installations that were in operation on 23 January 2008 are exempted from complying this criterion until 1 April 2013; g) Under the FQD (Article 7a(1)a) there is a requirement on Member States to report information on the country of origin of all road transport fuels (fossil and renewable) and where they are purchased. Under the RED there is no requirement to make that information public.
Source: EC (2010), EC (2009a), EC (2009b) and EC (2009c).

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LEI report 2012-057