

Sustainability of Biofuels: Overview of Issues and Perspectives

– **Brief Study for Nissan** –

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Introduction

Nissan contacted Oeko-Institut in early 2008, and asked for a proposal for a brief study on sustainability issues of biofuels. During a first meeting, background and scope of Nissan's interest in that regard were discussed informally.

Based on a proposal submitted by Oeko-Institut, this brief study was carried out for Nissan to provide information on

- existing studies and guidelines;
- evaluation of methodologies;
- future trends of certification systems.

In a first step, Oeko-Institut compiled an overview of existing sustainability guidelines and studies, focusing on biofuels. The results of this step are given in Section 1.

In Section 2, the most relevant methodologies used to establish sustainability standards are discussed, covering

- greenhouse-gas (GHG) emissions
- biodiversity and land use
- soil and water
- social issues.

In Section 3, some thoughts on the prospective development of certification systems in Germany, the EU, and internationally are presented.

Section 4 deals with further questions of Nissan regarding the most relevant feedstocks in selected countries, and issues of new areas of business and growth for bioenergy industries.

To broaden the view, the final Section 5 presents some remarks on the overall role of biofuels in the context of sustainable mobility.

In the Annex, an overview of key characteristics of existing sustainability certification systems and a brief discussion of the "iLUC factor" approach for potential greenhouse-gas emissions from indirect land use change is given.

1 Compilation of Sustainability Guidelines and Studies Focusing on Biofuels

The rapidly developing area of sustainability requirements for biofuels can be described by two trends:

- Industrial countries develop and establish both mandatory and voluntary sustainability standards for biofuels
- Developing countries – with a few noteworthy exceptions – are subject to those standards, but their majority has yet to consider participation in the discussion, and/or establishing of their own standards.

The following table lists a selection of existing certification schemes dealing with biomass for energy, wood and timber, agricultural products, and specific social aspects.

Table 1 Selected Existing Certification Systems

Biomass for Energy
RSPO* Roundtable on Sustainable Palm Oil
RTRS* Roundtable on Responsible Soy
GGL Green Gold Label (Eugene)
Forestry
FSC Forest Stewardship Council
PEFC Program for Endorsement of Forest Certification
MTCC Malaysian Timber Certification Council
Agriculture and Agricultural Production (mainly organic agriculture)
IFOAM International Federation of Organic Agriculture Movements
SAN Sustainable Agriculture Network
EUREP-GAP Euro-Retailer Produce Working Group -Good agricultural practice
ISQF Safe Quality Food
BIO Organic Farming – EC Label/control system
CCCC Common Code for the Coffee Community
Social Standards
ETI Base Code Ethical Trading Initiative Code of Conduct
FLO Fair-trade Labelling Organisations International
FLP Flower-Label Program

**= RSPO and RTRS are not certification systems specifically meant for bioenergy but palm oil and soybean oil are feedstocks for biofuel even if predominantly used in the food/feed sector*

From this selection and a variety of other initiatives and studies discussed in the literature (IFEU 2008; OEKO 2006; van Dam et al. 2008), the most relevant sustainability criteria for certification systems were derived and shown in the following table.

Table 2 Key Criteria in Sustainability Certification Systems

Environmental Issues

- Greenhouse-gas balance
- Conservation of biodiversity, protection of species/ecosystems
- Soil – erosion, contamination
- Water - depletion, contamination
- Chemicals – nutrients/pesticides
- Genetically Modified Organisms

Socio-economic issues

- Land rights (indigenous people, local communities, ...)
- Freedom of association, collective bargaining
- Labor conditions, worker treatment; wages, health and safety
- Child and/or forced labor, discrimination (sex, age, handicap, religion, race, nationality)
- Poverty reduction and equitable distribution of proceeds
- Fair trade conditions

Source: own compilation based on IFEU (2008); OEKO (2006); van Dam et al. (2008)

With regard to biomass for energy, and especially biofuels, and the perspective of global biofuels trade, it has been argued that only two “core issues” could be subject to **mandatory** sustainability standards (OEKO 2006): Greenhouse-gas emissions, and biodiversity impacts from land use change. The recent decision of the EU on its mandatory sustainable requirements for liquid biofuels gives evidence to this view.

Still, in voluntary standards, or in mandatory schemes not being subject to the international trade rules of the WTO, a larger variety of criteria can be found.

The following matrix is based in an evaluation of the coverage and relevance of various criteria in selected sustainability schemes, and depicts the result in a “traffic-light” color coding.

Figure 1 Evaluation of Selected Sustainability Certification Systems

	BIOMASS			AGRICULTURE						FORESTRY				SOCIAL			ENERGY		
	GGL	RSPO	Basel Crit.	BIO	Bioland	CCOC	EuropeGAP	IFOAM	SAN	Certfor	FSC	MTCC	PEFC	ETI	FLO	FLP	Greenpeace	Grüner Strich	OK Power
Land-use competition																			
Land-use competition (energy vs. competing land uses)	Yellow	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red
Socio-economic issues																			
Social aspects by stakeholder consultation	Red	Green	Green	Red	Red	Red	Yellow	Red	Green	Green	Green	Green	Green	Red	Red	Red	Red	Red	Red
Land rights (indigenous peoples, local communities, ...)	Green	Green	Green	Yellow	Yellow	Red	Green	Yellow	Green	Green	Green	Green	Green	Yellow	Red	Red	Red	Red	Red
Freedom of association, collective bargaining	Red	Green	Green	Yellow	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Labour conditions, basic treatment	Red	Green	Green	Red	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Not permanent employed	Red	Red	Red	Red	Red	Red	Red	Red	Yellow	Green	Green	Green	Green	Red	Red	Red	Red	Red	Red
Child labour, forced labour	Red	Yellow	Green	Yellow	Green	Green	Green	Green	Yellow	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Wages and compensation	Red	Green	Green	Yellow	Green	Green	Green	Green	Yellow	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Health and safety	Yellow	Green	Green	Yellow	Yellow	Green	Green	Green	Green	Green	Yellow	Green	Green	Green	Green	Green	Green	Green	Green
Discrimination (sex, age, handicap, religion, nationality)	Red	Green	Green	Red	Green	Green	Red	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Training – capacity building, development of skills	Red	Green	Green	Yellow	Green	Green	Red	Green	Green	Green	Green	Green	Green	Red	Red	Yellow	Green	Green	Green
Change of way of life, economy and culture, (important: indigenous people)	Red	Green	Green	Red	Red	Red	Red	Yellow	Green	Green	Green	Green	Green	Red	Red	Yellow	Green	Green	Green
Struggle against poverty (Equitable distribution of returns)	Red	Green	Green	Red	Green	Green	Green	Yellow	Green	Green	Yellow	Yellow	Green	Red	Green	Green	Green	Green	Green
Fair trade conditions	Red	Green	Green	Red	Green	Green	Green	Yellow	Green	Green	Green	Green	Green	Red	Red	Red	Red	Red	Red
Complain mechanism	Red	Green	Green	Red	Red	Red	Red	Red	Yellow	Green	Green	Green	Green	White	Red	Red	Red	Red	Red
Others	Grey	Green	Green	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey
Environmental land-use issues																			
Conservation of Biodiversity	Yellow	Green	Green	Red	Green	Green	Green	Green	Green	Green	Yellow	Green	Green	Red	Yellow	White	Red	Red	Red
Protection species/ecosystems	Red	Green	Green	Red	Green	Green	Red	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Soil – erosion	Red	Green	Green	Red	Green	Green	Green	Green	Green	Green	Yellow	Green	Green	Green	Green	Yellow	Red	Red	Red
Water resources – depletion/loss	Green	Green	Green	Red	Green	Green	Yellow	Green	Green	Green	Yellow	Green	Green	Red	Red	Red	Red	Red	Red
Chemicals – nutrients/pesticides (how addressed, what is affected)	Green	Green	Green	Yellow	Green	Green	Green	Green	Green	Green	Yellow	Green	Green	Green	Green	Green	Green	Green	Green
GMOs (genetically modified organisms)	Yellow	Red	Green	Red	Green	Green	Red	Green	Green	Green	Yellow	Green	Green	Green	Green	Green	Green	Green	Green
National land use regulations	Red	Green	Green	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red
High nature values addressed	Yellow	Green	Green	Red	Green	Green	Red	Green	Green	Green	Yellow	Green	Green	Red	Red	Red	Red	Red	Red
Others	Grey	Green	Green	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey
Life-cycle aspects																			
Social-issues in life-cycle addressed	Red	Green	Green	Red	Red	Red	Green	Red	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Energy balance (whole the production chain)	Red	Green	Green	Red	Red	Red	Yellow	Red	Green	Green	Green	Green	Green	Red	Yellow	Green	Green	Green	Green
Removed resources balance addressed (nutrients, organic matter)	Yellow	Red	Green	Yellow	Red	Green	Yellow	Red	Green	Yellow	Green	Green	Green	Red	Red	Red	Red	Red	Red
Water resources – contamination	Green	Green	Green	Green	Green	Green	Green	Green	Yellow	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Soil – contamination	Green	Yellow	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Safeguard subject climate addressed	Yellow	Red	Green	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red
GHG balance: (only CO2 emission / more complex approach)	Red	Yellow	Green	Yellow	Green	Green	Yellow	Red	Green	Green	Green	Green	Green	Red	Red	Red	Red	Red	Red
Air pollution (NOx, SO2, POP, others...)	Red	Green	Green	Yellow	Green	Green	Green	Green	Green	Green	Green	Green	Green	Red	Yellow	Green	Green	Green	Green
Waste management addressed	Red	Green	Green	Red	Green	Green	Green	Green	Green	Green	Green	Green	Green	Red	Yellow	Green	Green	Green	Green

Source: IFEU (2008); color code for boxes: red = not included; yellow= partially covered; green = fully included

As can be seen, there is **no clear pattern** of how to deal with sustainability, but a strong signal is that the globally important aspect of GHG emissions is not (yet) subject to being included in existing certification schemes.

Accordingly, current activities on the sustainability of globally traded biofuels concentrate on GHG emission balances (see Section 2.1.2), with the European Union's criteria in the RES- and FQ-Directives¹, the California Low Carbon Fuel Standard (CARB 2008) and the ongoing work of the GBEP GHG Task Force (GBEP 2008) being the most prominent drivers on that issue.

In parallel, the discussion of a "generic" – and voluntary - sustainability standard for biofuels continues to address a variety of criteria and issues. With the release of the "zero version" standard for sustainable biofuels, the Roundtable on Sustainable Biofuels (RSB) started a global review process aiming to finalize a standard in early 2009 (RSB 2008).

The European Standardization Organization CEN began its work on a voluntary standard for sustainable bioenergy in its Technical Committee 383, and a joint Brazilian/German proposal for a respective standard on the global level was launched in September, and will be decided upon in early 2009 by the International Standardization Organization (ISO) Management Board.

Recently, the Inter-American Development Bank (IDB) released its "Sustainability Scorecard" for screening biomass projects under consideration of funding (IDB 2008). This approach also uses the "generic" RSB criteria for sustainable biofuels.

¹ The EU Renewable Energy Sources Directive (RES-D) includes mandatory sustainability requirements for liquid biofuels and was finally decided upon by the European Parliament in December 2008. A formal vote of the EU Council (with subsequent legally binding text being published in the Official Journal of the EU) is expected in early 2009.

2 Methodologies to Establish Sustainability Standards

As discussed above, the sustainability of biofuels can be broadly separated in two groups of issues: environmental and socio-economic impacts. Both will be addressed briefly in the following sub-sections.

2.1 Environmental Criteria and Standards

From the variety of potential impacts and indicators to evaluate the environmental performance of biofuels, the following list of key impacts and indicators was derived in a recent study (FAO 2009).

Table 3 Possible Impacts and Indicators for Evaluation of Biofuels

Area of concern	Impact	Possible Indicator
Land use	Direct changes in land use patterns	Changes in land cover and speed of change. [Type of use per hectare]
	Indirect changes in land use patterns	Amount and location of production moved elsewhere. [displaced hectares & location]
Climate change	Global warming	GHG emissions [kg CO ₂ eq/MJ]
Soil	Carbon loss	Time series of changes in carbon content of soils [t C/ha in next 20-100 years]
	Nutrient loss	Time series of changes in nutrient content (N, P, K) in soil [kg nutrient/kg soil]
	Soil erosion	Time series of loss of soil [kg/ha*yr]
Water	Water availability for biomass production; groundwater depletion	Water stress, i.e. withdrawals per renewable resources [m ³ /MJ]
Ecosystem resilience	Freshwater and terrestrial toxicity	ecotoxicity potential [kg 1,4-dichlorobenzene/MJ]
	Aquatic eutrophication	Eutrophication potential [kg PO ₄ eq/MJ]
	Terrestrial eutrophication	Eutrophication potential [kg PO ₄ eq/MJ]
Biodiversity	Protection of existing nature	Naturalness; type of land used for bioenergy production – risk approach
	Biodiversity on managed land and changes on landscape level	Agrobiodiversity; type of land used for bioenergy production – risk approach
Other	Acidification	[kg SO ₂ eq/MJ]
	Depletion of natural resources	primary non-renewable energy [MJ/MJ]

Source: own compilation based on FAO (2009)

2.1.1 Land Use Change Impacts

Land use is an important issue of biomass supply from energy crops. The **use of land and its direct and indirect changes** is a key impact for many other environmental as well as socio-economic impacts. The type of land use (e.g. agriculture, nature conservation and forestry) determines partly the impacts on ecosystems and biodiversity. Important in this context are direct land use changes due to biomass production as well as indirect land use changes that occur as agricultural and other uses of land are displaced by biomass production.

Both entail changes in carbon stocks of soil and vegetation which can potentially result in carbon emissions (e.g. logging of natural forests).

Given these interactions, land use change (LUC) impacts are integrated in the description of the other environmental impacts.

2.1.2 Greenhouse-Gas Emissions

The most important reason for pursuing an increased use of energy crops worldwide is their potential to reduce greenhouse gas (GHG) emissions compared to the fossil fuels. Energy crops can offset their life-cycle greenhouse gas “burden” by:

- storing atmospheric carbon in crop roots and soil as organic carbon;
- producing co-products such as protein for animal feed, which could avoid GHG emissions from activities needed to provide feed by other means; and
- displacing fossil fuel

On the other hand, greenhouse gases are emitted in the production life-cycle of energy crops:

- in using fertilizers, pesticides, and fuel in farming,
- conversion/processing, transport and distribution up to combustion of the bioenergy product
- direct and potentially indirect land-use changes.

All these processes can be modeled by GHG emission balances.

A prerequisite of GHG balancing is the harmonization of methodologies and important default values; national and international efforts are currently underway to standardize GHG emission for bioenergy systems:

- The EU RES-D includes a “full” methodology as well as default data for most biofuels and fossil reference systems, which is compatible with the German BSO (see Fehrenbach/Fritsche/Giegrich 2008); the methodology is **mandatory** for all EU Member States
- The Global Bio-Energy Partnership (GBEP) Task Force on GHG Accounting² is working on harmonizing GHG methodologies and aims at a joint report of the G8 countries plus several developing countries in early 2009.
- The IEA Bioenergy Task 38 “Greenhouse Gas Balances of Biomass and Bioenergy” works since several years on methods, tools and data³, and contributes to the GBEP GHG Task Force.

2.1.2.1 GHG Balances - System Boundaries

In determining the potential GHG emissions, it is important to consider **all relevant steps in the lifecycle** which includes production of the fuel feedstock, transportation of the fuel feedstock to a processing facility, fuel processing, distribution of the fuel to the retail outlet, and waste treatment.

Many processes produce also **by-products**. For example protein-rich press cake from the production of bio-diesel from oil seeds what can be used as animal fodder displacing soy meal. To guarantee comparability the GHG balancing must include all products and services of biobased scenario (see 2.1.2.2).

Furthermore, growing energy crops may trigger **land use changes** that have to be accounted for. This land use change can be the key of the overall greenhouse gas balance of bioenergy⁴.

2.1.2.2 Method for Co-Product Consideration

Many studies have used **allocation methods**⁵ whereby energy and emissions from a process are allocated to the various products e.g. by mass, energy content, or monetary value. The energy allocation approach is reasonable with respect to the certification process from the standpoint of a regulatory agency. Hence it is most widely used, such as in the proposal of the EU RES-D.

According to the energy allocation method, inputs and outputs is allocated to the co-products by their share of the lower heating value (= net calorific value).

2.1.2.3 GHG Accounting of Land Use and Land Use Change

The expansion of energy crop production is almost always connected with land use change since the production area was mostly likely dedicated to some purpose (i.e. production of food or other crops, settlement, set aside land, forest, natural protection area, set-aside land). Three types of impacts can be distinguished:

- If energy crop production is an **ongoing practice since many years** (at least since the reference year 2005), only changes in the carbon storage in the soil that are attributable to the crop itself as well as emissions of methane and nitrous oxides from fertilizer application have to be accounted for. A change in direct land use does not happen.

² See <http://www.globalbioenergy.org> for results of the GBEP GHG Task Force, and Description of Work.

³ See <http://www.ieabioenergy-task38.org> for an overview of work, and selected publications.

⁴ For a more detailed discussion, see Fargione et al. (2008), Fehrenbach/Fritsche/Giegrich (2008); RFA (2008); Searchinger et al. (2008).

⁵ An alternative to allocation is the substitution method which widens the scope by system expansion to all by-products, or awards "credits" for used co- and by-products based on equivalent production systems.

- **Direct land use change** (dLUC) occurs whenever a new plantation is established, disregarding if cultivation of crops has taken place on that land before, or if the area might have been under forest or other natural and near-to-nature ecosystems.
- **Indirect land use change** (iLUC) can be described as the shift of the land use prior to biofuel production to another area where a land use change occurs (leakage, displacement).

Accounting for direct and indirect land use changes requires a specific consideration. It is complex to obtain reliable information on carbon storage above and below ground. Therefore, IPCC values⁶ are preferred as long as no specific information is available. These factors take into account changes in the carbon stocks of biomass, dead organic matter and soils.

Indirect land use change can be described as the shift of the land use prior to energy crop production to another area where a land use change occurs (leakage, displacement). For purpose of GHG balancing with regard to indirect land use changes, it is not relevant at which location the biomass is actually produced and used, since agrarian markets are global. The estimate of indirectly caused GHG emissions should take all countries into account that trade agrarian products. To date, there is no definitive approach to address this issue; a suitable solution is the “iLUC factor” (see Fritsche/Fehrenbach 2008, and calculations given in Section 5.4).

2.1.2.4 Further Aspects to be considered in GHG Balances

Residues from agriculture (e.g. straw, manure) have to be taken into account for balancing the fertilizer demand and carbon storage calculations. The same applies to nitrogen fixation for subsequent cultivations (e.g. legumes like soy plants) and nitrogen release from previous cultivations. Furthermore, **agricultural activities** concern diesel for machine work, pesticides, fertilizer, slash burning, etc.

GHG calculation for **conversion steps and transport systems** within the biofuel chain is state of the art. Direct emissions, as well as emissions due to energy use (e.g. electricity, process heat, steam) and auxiliary material (e.g. methanol, process agents etc.) have to be accounted including the upstream processes (e.g. production of fertilizer and pesticides).

Bio-based residues and **waste** enter the GHG balancing system **without** upstream emissions. Only the point of handing over the waste from its original system to the biofuel system – the system boundaries – must be clearly defined.

Bio-based waste material must be declared explicitly as waste. If bio-based material does not fulfill these requirements the biomass has to be considered as co-product of

⁶ see IPCC (Intergovernmental Panel on Climate Change) 2006: GHG Reporting Guidelines (Vol. 4) 2006

another system and will be charged with GHG emissions from the other system according to given allocation rules (e.g. straw from grain production or oil seed extraction cake).

In addition, guidelines concerning extraction rates have to be formulated for residues in order to avoid humus depletion or loss of habitats (e.g. through removal of dead wood in forests; see soil and biodiversity sub-sections).

2.1.3 Biodiversity and Land-Use

Besides the loss of habitats, migration corridors and buffer zones (areas adjacent to protected areas) due to land use changes, conflicts between biodiversity and bioenergy crop cultivation are possible, depending upon cultivation form and harvest procedure.

The **conservation of biodiversity** is a key concern of sustainable bioenergy development (UN Energy 2007). The increasing demand for bioenergy could lead to both direct and indirect expansions of cultivated areas, resulting in further habitat loss and negative impacts on biodiversity, especially if forest, grass-, peat- and wetlands are used for feedstock production and if large monoculture plantations are created (CBD 2008).

The implementation of conservation goals for the protection of biodiversity requires strategies and approaches for managing whole landscapes, including areas allocated to both production and protection (Margules/Pressey 2000).

Metrics used within approaches to value biodiversity comprise species and ecosystems (all or targeting priorities like endemic species or endangered ecosystems), communities, ecological and evolutionary processes as well as biodiversity.

Protection of biodiversity can in general be distinguished in the separation of biodiversity from negative human impacts (segregation; e.g., protected areas) and its protection within used areas (integration; e.g., Ecosystem Approach). CBD activities within the Programme of Work on Protected Areas (PoWPA) contribute to improve the situation.

Additional negative impacts on biodiversity from bioenergy production as a new emerging issue **need to be mitigated**.

The strength of a risk mitigation strategy is that it is straightforward in considering various conservation approaches at different scales and geographical situations.

Setting up standardization scheme for biodiversity aspects is – nationally as well as internationally – still in progress. This will be the largest challenge and prior work for the further development of sustainability schemes to be embedded in existing international processes (CBD 2008).

2.1.4 Soil

The use of bioenergy could lead to soil erosion, and overuse of irrigation, agrochemicals, and heavy harvesting equipment might degrade fertile soils⁷. Furthermore, soil degradation can have major impacts on other environmental concerns, e.g. surface and groundwater quality, climate change due to losses in soil carbon stock, food safety as a result of declining soil fertility etc. To prevent soil degradation from agricultural changes, improved agronomic practices will play a key role in mitigating negative environmental impacts (EEA 2006, RS 2007).

Major soil degradation processes caused by agriculture are (Ecologic 2003, FAO 2004):

- **Physical degradation:**
 - Erosion (caused by water and wind)
 - Compaction

- **Chemical Degradation:**
 - Organic matter decline
 - Nutrient decline
 - Pollution (eutrophication and acidification due to fertilizer use, salinization⁸ and pesticides)

- **Biological degradation:**
 - Biodiversity decline⁹

Most degradation processes result finally in the loss of organic matter (erosion and mineralization directly, the other processes indirectly by decline in biotic activity). The loss of organic matter is important not only because the soil is an important carbon sink but also because soil organic matter is critical for soil productivity.

Though global soil data like Harmonized World Soil Database are very valuable for many purposes on a global scale (Nachtergaele et al. 2008), but in most cases more site-specific information on soil conditions will be needed to decide whether a cultivation systems guarantees soil conservation or not.

⁷ On the other hand, adequate bioenergy cropping systems could be operated on degraded land thereby increasing soil carbon, and helping to restore such land for sustainable use.

⁸ Salinization is often caused by irrigation and therefore part of the risk mitigation strategy of agricultural water use (see chapter "Agricultural Water Use").

⁹ Decline of soil biodiversity is part of the chapter "Biodiversity". Natural habitats will be identified as "no go areas" whereas the conservation of agricultural edaphon has to be part of good agricultural practice.

By now, there is no elaborated methodology for an adequate assessment for soil protection by energy crops for an environmental standardization scheme.

2.1.5 Agricultural Water Use

Developments in the agricultural sector for food and non-food crops will have important implications for water usage and availability (RS 2007). In this context, water demand for bioenergy feedstock production could lead to a serious increasing of agricultural water use worldwide, since bioenergy crops optimized for rapid growth are likely to consume more water than natural flora or many food crops. In some countries (e.g. Mediterranean, several African countries), this could lead to further water stress in regions where water is already scarce and highly variable throughout the years and induce increased competition over water resources (Berndes 2002+2008; OECD 2008; MNP 2008a).

Especially irrigation has led to water scarcity, as well lowering of water tables and water levels in rivers and lakes. Increased water abstraction due to irrigation has caused salination and contamination of water and soil, and loss of habitats (e.g. wetlands from building dams and reservoirs – see EEA 2006).

Furthermore, competition between agricultural, industrial, domestic and environmental water requirements could be intensified by bioenergy production and processing (OECD 2008, EEA 2006).

The contamination of water resources with fertilizer and pesticides is closely linked to Good Agricultural Practice (GAP) which has to be considered for each cropping system and respective Agro-Ecological Zones. The formulation of elements of a GAP for energy crops is in the focus of environmental standards for biofuels - but details are not worked out by now.

In the foreground of bioenergy use water quantity impacts are related to water scarcity or water stress caused by the water abstraction of energy crops and by the water consumption from downstream processing.

Sustainable bioenergy production will have to consider water balances on the basin scale and should only withdraw available surplus from natural water flows, thus respecting the regional capacity of water sources, and implicitly protecting wetland habitats (e.g. peatlands, river food plains).

To mitigate potential negative impacts on local or regional water bodies and hydrologic cycles from biomass production, national and international policy frameworks to develop the bioenergy sector should focus three key issues (see following table).

The amount of **land that is available** for bioenergy cropping should be determined on the base of biodiversity criteria as well as those of soil conservation and current land-use. For these areas, cropping systems that protect natural water resources need to be evaluated. The choice of biomass crops, especially in arid areas, should

aim for low water demanding crop types that do not require irrigation (EEA 2006). Hence, the **standard case** for energy crops should be represented by **rainfed** cultivation. **Choice of crops** should consider the following aspects and criteria:

- Optimal cropping systems, e.g. agro-forestry systems in dry regions, new biomass crop mixes, farming practice increasing soil organic carbon and water holding capacity
- No drainage of wetlands, e.g. by planting moisture-tolerant crops on sites where waterlogging can occur
- No irrigation, e.g. by planting drought-tolerant crops at water stresses locations where low soil water potentials can occur
- Crops with high crop water productivity (CWP) or high water use efficiency (WUE) should be used to optimize the yields within available water resources (assessment of these factors for different crops at different climate and soil type is needed)
- Complying with **area water demand** limits, representing maximal values for the water withdrawal per unit of area that subsequently gives a limitation to potential yields

In case **irrigation** is used, a **hydrologic impact assessment** has to be performed to give evidence on compliance with actual water resource conservation. The water availability for energy crop production should be determined on a basin-scale in order to assure the examination of related upstream and downstream water availability and needs (MNP 2007).

On a basin-scale areas with areas with water scarcity should be identified. For these areas it has to be proofed if cultivation systems with low water abstraction and residual extraction rate with positive influence on water holding capacity of soils.

In a situation of severe water scarcity, priority has to be given for food and fodder production.

By now, there is no elaborated methodology for an adequate assessment of water use by energy crops for an environmental standardization scheme.

2.2 Social Issues and Criteria

2.2.1 Food Security

Social issues play a major role in the implementation of bioenergy projects. It is necessary to integrate the impact analyses and to consider all socio-economic and environmental impacts of bioenergy chains before deciding on the implementation of a specific project in a given setting.

A potential conflict area is often seen in the competition between land use for food production and land use for bioenergy production. This complex is tightly linked to the overall land-use issues, but has a special quality insofar as *food security* is concerned. Still, available analysis of this issue clearly indicates that in general, bioenergy cropping is *not* a cause of hunger, nor a direct driver of food insecurity.

Quite contrariwise, bioenergy crops could well be a means to *alleviate* poverty, and to *increase* food security through income generation (Faaij 2008; FAO 2008a, Widmann 2008). The food production world-wide is balanced, i.e., enough food of sufficient quality is available, but there is an unequal access to food within developing countries (WBGU 2004). Food security is not a problem of production, but a problem of *distribution*.

But related to the land ownership issue (see below), a switch to large-scale bioenergy crop production might have locally adverse impact as well.

Within the last three years rising food prices shot up by estimated 80 percent. Of course, biofuels are not responsible for all price increase - a number of factors contribute to that, including (Oxfam 2008, Mitchel 2008):

- shifting consumption patterns – as incomes increase in emerging markets, people are eating more meat and dairy products (China, India)
- rising oil prices, which push up the costs of inputs such as fertilizers as well as transport and storage costs;
- climatic events such as the drought in Australia, which lost 60 percent of its wheat crop last year and almost 98 per cent of its rice crop; and
- speculative and investor activity has also increased and could have contributed to food price increases;
- weather-related production shortfalls have been identified as a major factor underpinning world cereals prices;
- export bans and restrictions fueled the price increases by restricting access to supplies;
- While maize displaced soybeans in the U.S., other oilseeds displaced wheat in the EU and other wheat exporting countries.

The large increases in biofuels production in the U.S. and EU were supported by subsidies, mandates, and tariffs on imports. Without these policies, biofuels production would have been lower and food commodity price increases would have been smaller. Biofuels production from sugar cane in Brazil is lower-cost than biofuels production in the U.S. or EU and has not raised sugar prices significantly because sugar cane production has grown fast enough to meet both the demand for sugar and ethanol. Removing tariffs on ethanol imports in the U.S. and EU would allow more efficient producers such as Brazil and other developing countries, including many African countries, to produce ethanol profitably for export to meet the mandates in the US and EU (Mitchel 2008).

Regarding future bioenergy expansion over the medium and long run, recent analysis indicates that there will be significant regional differences in land-use impacts, concerned agro-commodities, and potential food security consequences (Faaij 2008; Rosegrant et al. 2008), and the role of future technology improvements (e.g., 2nd generation biofuels) is crucial. Furthermore, the potential positive food security impacts for (rural) farmers must be valued against negative impacts for the urban poor (FAO 2008b).

2.2.2 Energy Supply

Energy is one key element to reduce poverty and hunger. Achieving the UN Millennium Development Goals imply access to modern forms of energy, especially electricity, and “modern” biofuels. Bioenergy can help to diversify agriculture and improve food security (FAO 2008a), and to contribute to sustainable development (FAO 2008b). Energy supply safety in the region of biomass production should not suffer from biomass trading activities (Lewandowski/Faaij 2004).

2.2.3 Land Ownership

Besides questions of land use, there is the fundamental issue of land ownership structures, i.e. of property to be used for bioenergy crop cultivation. If an industrialized form of bioenergy crop cultivation takes place, then the land required will most probably be controlled by large land owners, or (trans)national companies.

This might conflict with the right to democratically regulate land access, and the implementation of human rights guaranteeing sufficient food. Depending upon the social situation and historical developments, the requirements of industrial-style cultivation of bioenergy crops could come into conflict with the requirements of diversified agriculture driven by family businesses, cooperatives, and rural communities aiming at supplying food and income for the local population. Similarly, conflicts between small and large land owners could arise, as large.

Access to land is a fundamental precondition in realizing the potential role of agriculture in reducing poverty. Unfortunately, one of the side effects of biofuel targets – particularly those set in the absence of any requirements for companies to

behave responsibly – is a ‘scramble to supply’, in which companies or rich and powerful investors rush to buy up new land, potentially displacing vulnerable communities whose rights to the land are poorly protected. This can sometimes be a violent process. Frequently, though by no means always, these may be indigenous people (the UN has identified 60 million at risk of displacement by biofuels).⁷⁶ More often than not, they will be women, who are more vulnerable than men to displacement as a result of systematic and pervasive discrimination within land tenure systems throughout the developing world (Oxfam 2008)

Land ownership should be equitable, and land tenure conflicts should be avoided. Through clearly defined, documented and legally established tenure or use rights, conflicts can be avoided. To avoid leakage effects, poor people should not be removed or displaced from land they use for sustaining their livelihood. A well-being community guarantees economic and social development.

2.2.4 Human Health

The cultivation of bioenergy crops could cause not only land use conflicts, but also direct impacts regarding human health, depending on the type of crop being cultivated, and the harvesting procedures.

Unnecessarily substances or risk of injuries impact human health and safety. Pesticides are the primary cause of health risks for agricultural workers. Especially with the cultivation of sugar cane and palm oil, air pollutants caused by field burning could cause adverse health effects.

Workers are not educated about the health risk of using pesticides. Application of pesticides by airplane leads to drifting of pesticides into the dales and damages the crops and the animals of peasants (Bickel/Dros 2003). Harvesting is a dangerous work caused by the use of sharp tools, cutting and planting green cane causes skin irritations. Burned cane can also cause skin irritation. Smoke and polluted environment endangers health. Control of the plantation and the upcoming weed has a negative impact for health through residues of toxins. Medical care is often not available on the plantations. Furthermore aspects impact human health like exposition to the sun, insects and snakes and uncomfortable positions during work (Zamora et al. 2004).

A safe and healthy work environment comprised aspects like machine and body protection, sufficient lighting, fire drills. Periodic training of all workers to perform their tasks according to the work requirements on health protection is useful (Lewandowski/Faaij 2004).

2.2.5 Labor Conditions and Rights of Children

Labor conditions comprise aspects like wages, illegal overtime, children work or slavery. In the following, some problematic aspects of biomass farming are described. Workers on plantations have increased in relation to the number of

permanent workers, who are exposed to greater risks. Women often help their husbands: Neither they do enter a contract with the company nor do they receive compensation. Domestic estate companies do not provide working tools and safety equipment to the workers. Permanent workers in foreign estates working tools are supplied with working tools; there is no safety training for workers in foreign companies. Some migrant workers have to pay for recruiting agencies and to sign contracts which are often in a foreign language. In many cases migrants sign whatever they are offered from the companies.

The duration of a working day is often about 12 or 14 hours with a high pressure on production quotas.

As regards labor conditions it is important to protect workers against forced labor, unequal paying and illegal overtime. Minimum wages, rights of pregnant woman, elimination of child labor should include in a social view on biomass production. Often children and women work on the field. Especially for them it is necessary to reword standards for sustainable and also social biomass farming.

Existing indicators in the division of socio economic standards are management rules. Formulating "good practice" or management rules exist in the agricultural sector. They are available for different forms of farming, like organic agriculture. A monitoring system for social impacts is not necessary especially for bioenergy production. Existing labor standards (ILO Standard) are transferable.

The following selection demonstrates general indicators for chosen criteria (RSB 2008):

- priority for food supply and food security;
- biofuel production shall not violate land rights;
- human and labor rights, share of proceeds, ensure well-being of workers;
- avoiding health impacts from bioenergy cropping;
- rural and social development to benefit small scale land owners etc.

3 Perspectives on the Development of Certification Systems

The future demand for liquid biofuels will increase (GBEP 2007; IEA 2007), most prominently driven by oil prices, and blending mandates (or quota) which are introduced by more and more governments (see following figure).

Figure 2 Biofuel Blending Mandates and Quota

Country	Mandate
Australia	E2 in New South Wales, increasing to E10 by 2011; E5 in Queensland by 2010
Argentina	E5 and B5 by 2010
Bolivia	B2.5 by 2007 and B20 by 2015
Brazil	E22 to E25 existing (slight variation over time); B2 by 2008 and B5 by 2013
Canada	E5 by 2010 and B2 by 2012; E7.5 in Saskatchewan and Manitoba; E5 by 2007 in Ontario
China	E10 in 9 provinces
Colombia	E10 existing; B5 by 2008
Dominican Republic	E15 and B2 by 2015
Germany	E2 and B4.4 by 2007; B5.75 by 2010
India	E10 in 13 states/territories
Italy	E1 and B1
Malaysia	B5 by 2008
New Zealand	3.4 percent total biofuels by 2012 (ethanol or biodiesel or combination)
Paraguay	B1 by 2007, B3 by 2008, and B5 by 2009
Peru	B5 and E7.8 by 2010 nationally; starting regionally by 2006 (ethanol) and 2008 (biodiesel)
Philippines	B1 and E5 by 2008; B2 and E10 by 2011
South Africa	E8-E10 and B2-B5 (proposed)
Thailand	E10 by 2007; 3 percent biodiesel share by 2011
United Kingdom	E2.5/B2.5 by 2008; E5/B5 by 2010
United States	Nationally, 130 billion liters/year by 2022 (36 billion gallons); E10 in Iowa, Hawaii, Missouri, and Montana; E20 in Minnesota; B5 in New Mexico; E2 and B2 in Louisiana and Washington State; Pennsylvania 3.4 billion liters/year biofuels by 2017 (0.9 billion gallons)
Uruguay	E5 by 2014; B2 from 2008-2011 and B5 by 2012

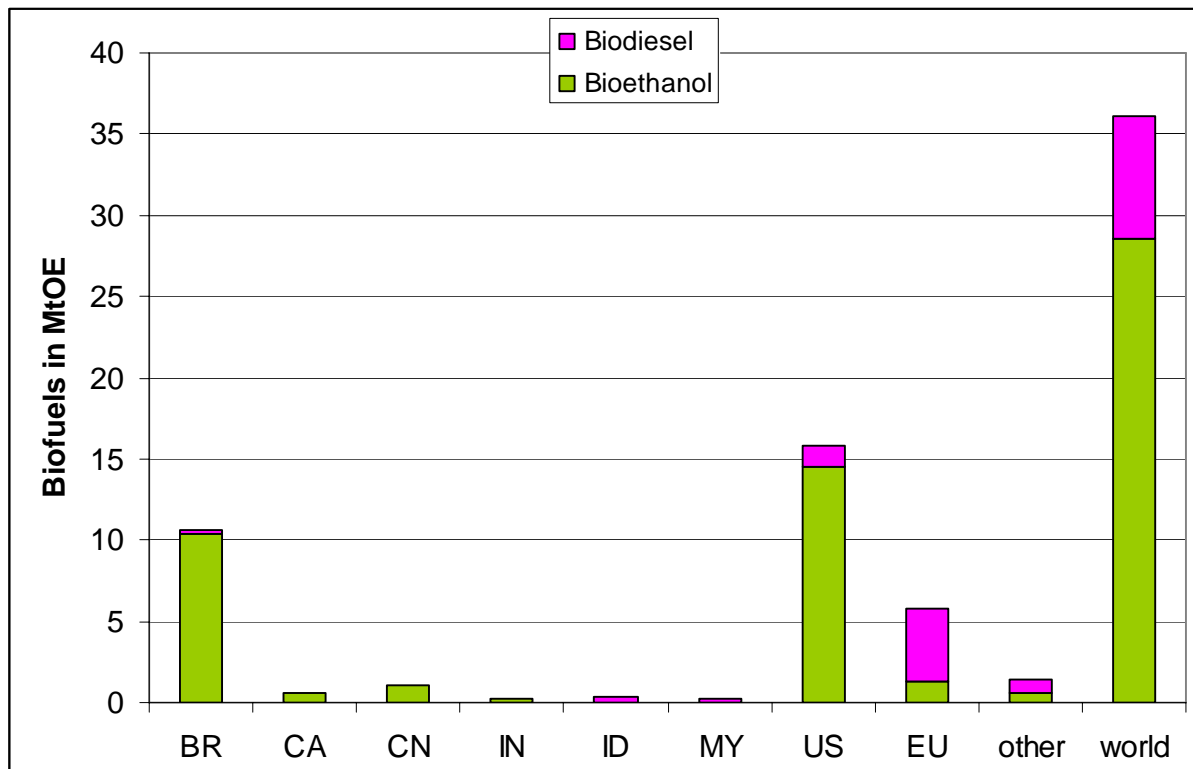
Note: Table shows binding obligations on fuel suppliers; there are other countries with future indicative targets that are not shown here; see the Biofuels Policies section, page 27. Mandates in some U.S. states take effect only in future years or under certain future conditions, or apply only to portions of gasoline sold. *Source:* All available policy references, including the IEA on-line Global Renewable Energy Policies and Measures database and submissions from report contributors.

Source: REN21 (2008)

With governments creating biofuels markets through quota systems or financial incentives, they will also face pressure to regulate those markets to minimize negative tradeoffs, e.g. for climate change, biodiversity, or food security (FAO 2008a).

Based on current production and trade trends (see following figures), one can estimate which country of region will be more or less interested in certifying sustainable biofuels.

Figure 3 Global Biofuel Production in 2007



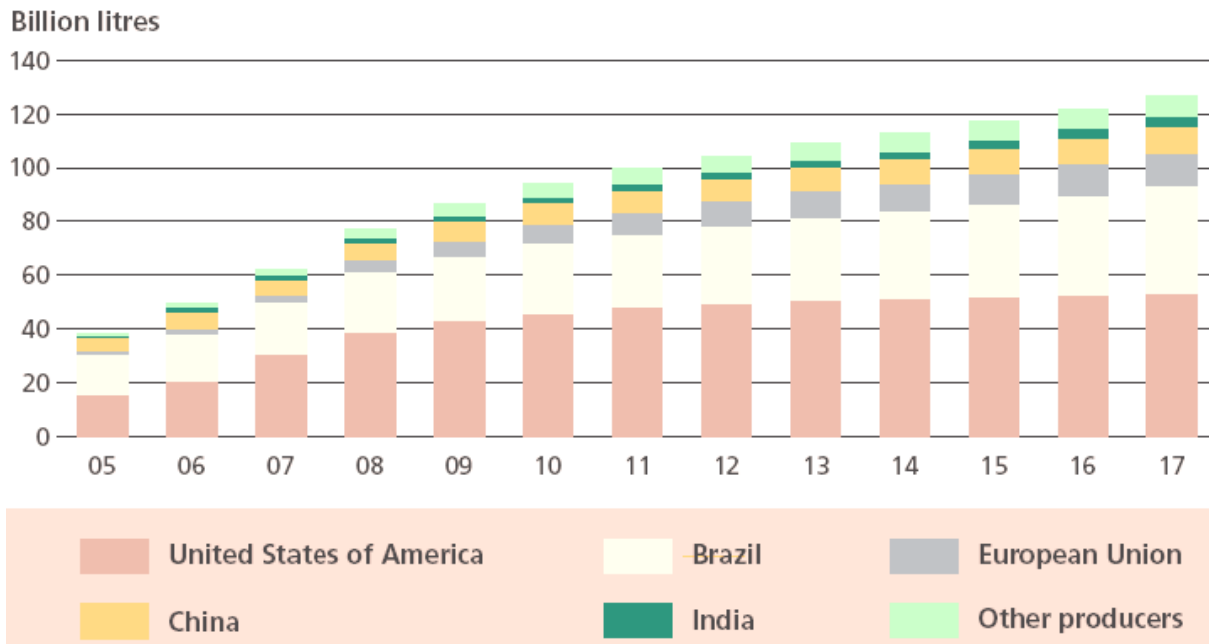
Source: FAO (2008b)

The FAO data underline that globally, **ethanol** is the dominant biofuel, with major markets in Brazil, and the USA.

Biodiesel has a far smaller share, and finds its prime market in the EU.

China, India and the US produce EtOH mainly for their domestic markets (see next figure), and will most probably continue to do so in the next decades, as the following figure indicates.

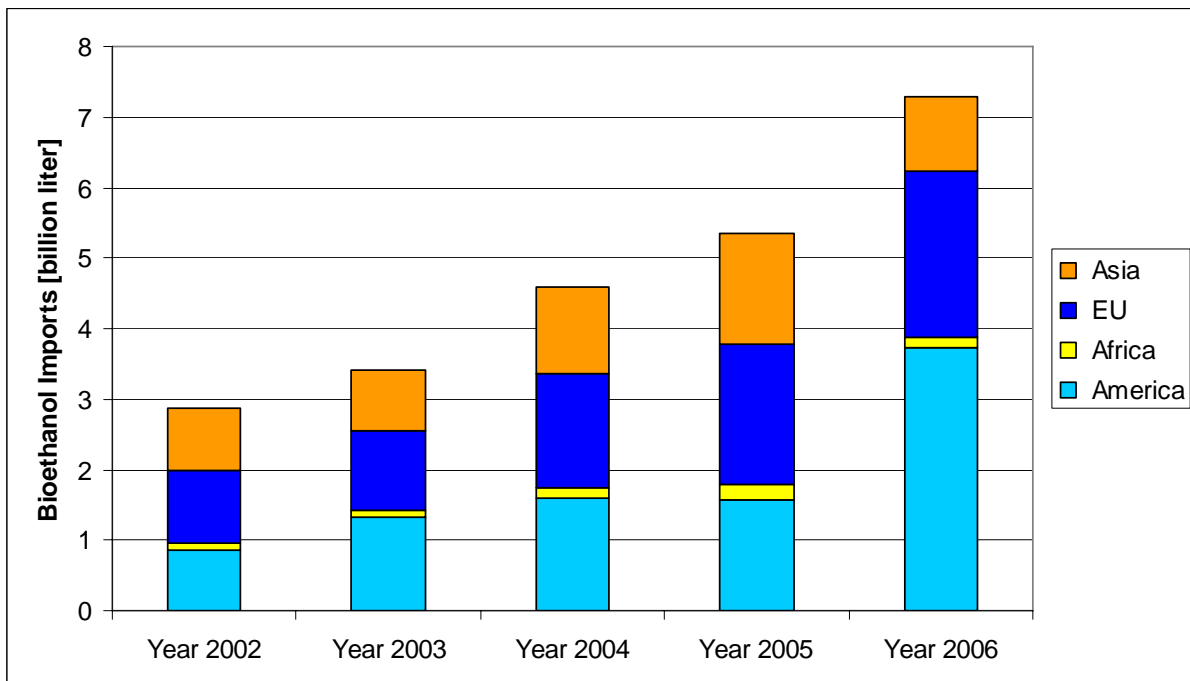
Figure 4 Trends of Ethanol Production in World Regions



Source: FAO (2008b)

Besides the major producers of ethanol, it is also relevant to consider the imports:

Figure 5 Development of Ethanol Imports in World Regions

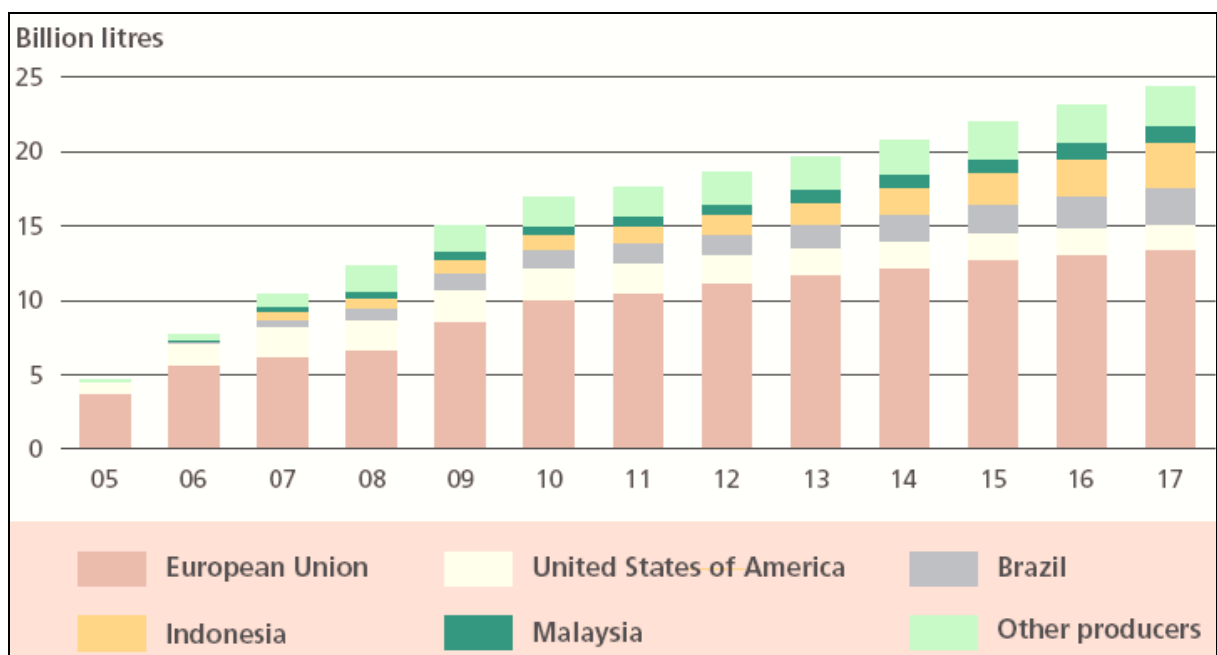


Source: GBEP (2007)

Since several years, the US and the EU are the most prominent **importers** of ethanol, and their rising domestic biofuel quota will further increase net imports.

As regard biodiesel, the pattern is different (see following figure): the EU is the most prominent producer and user, with minor imports from other regions. Indonesia and Brazil will also expand their biodiesel production (and exports).

Figure 6 Trends of Biodiesel Production in World Regions



Source: FAO (2008b)

As can be seen from these trends, the global markets for certified biofuels will remain in the EU (biodiesel), and the US (ethanol).

The European Union’s sustainability criteria will, together with the California Low Carbon Fuel Standard, determine the “rules” under which biofuels can be exported to both prime markets. As it is most likely that the EU scheme will come legally into force by 2010, it will set the standard for others. By that time, the CEN TC 383 will be operational, and possibly extended to a global ISO standard.

The US domestic market and imports will be regulated by the new administration in 2010 at the latest. It is most likely that the US will follow the EU scheme in substance, though not necessary in detail (e.g. level of GHG reduction).

Brazil will introduce its sustainability standard for ethanol in 2009, thus creating a benchmark for other developing countries being interested in exports (e.g. Argentina, Indonesia, Mozambique, and South Africa).

It needs to be seen if China and India will engage in sustainability requirements for biofuels in their (growing) domestic markets – with India announcing a 20% domestic quota for biodiesel by 2017, there will be a clear need to safeguard this market pull by adequate regulation.

4 Further Questions of Nissan

4.1 Most Promising Biofuel Feedstocks from which Country?

The most promising feedstocks are

- biogenic residues and wastes, which are available in **all** countries, and
- perennial feedstocks from marginal and degraded lands.

The availability of degraded and marginal lands for biomass production is an issue under debate¹⁰.

An indicative figure of the respective potentials of bioenergy is given in Section 5.1.

From available data, one can conclude that Brazil and Indonesia offer significant amounts of degraded land from which sustainable biofuel feedstock production could be possible – in the case of Brazil, this would be ethanol, and in Indonesia, it would be palmoil.

There is other land in East Africa (e.g., Mozambique) which could be used to grow either crop.

4.2 New and Growth Areas of Business in the Future Bioenergy Industries

In addition to the thermal gasification route for biofuels and bioelectricity, there are several areas which have high prospects for future bioenergy:

- catalysts and enzymes for pre-treatment of lignocellulosic ethanol feedstocks
- algae and tailored bacteria for biogas, H₂ or bio-oil

Algae and bacteria could be grown on land, using photo-reactors, and might even partially sequester carbon from CO₂ in fossil powerplant exhausts.

¹⁰ For details on that discussion and related work, see the input papers, presentations and outcome of the Joint International Workshop" held at Paris, June 30/July 1, 2008 available at http://www.bioenergywiki.net/index.php/Joint_International_Workshop_Mapping

5 Biofuels in the Context of Sustainable Mobility

It has been argued that the key issues of sustainable mobility are reductions in energy demand for vehicles through increased efficiency, modal shift, and overall “sufficiency” (i.e. reductions in overall mobility demand).

In addition to that, the **choice of fuel** is another option to reduce the environmental, economic and social impacts of the transport sector. In that regard, three principal alternative fuel options also related to the propulsion technologies under developing are currently discussed:

- biofuels from various feedstocks and conversion routes;
- hydrogen from a range of primary energy sources with several hydrogen production/distribution pathways; and
- electricity from a variety of primary energy sources.

All options can deliver energy input for a sustainable mobility future **only if** they stem from renewable sources, and if they have better environmental and social profiles than those of fossil fuels¹¹.

5.1 Biofuels: Cure or Disaster?

The global energy scenario¹² implies that in the long-term, bioenergy – and biofuels - can play only a limited role. This is due to the comparatively low overall conversion efficiency: only some 3-4% of the solar energy input is stored in the plant material, i.e. the heating value of the biomass grown. Thus, the land-use efficiency in terms of net energy yield per hectare is at least 2 times lower than current solar-to-electricity technologies, and, with rising solar conversion efficiencies in the longer-term, this factor might well become close to one order of magnitude.

Still, one has to recognize that the growth of biomass is a “natural” phenomenon, and that photosynthesis is less a means to store energy¹³ but to provide highly organized and structured matter which can be used for a myriad of applications – from food and feed to newspaper and textiles up to building materials and as recently discussed fuels. In that regard, biomass is unique: no other renewable energy source offers similar characteristics, and a long-term perspective requires consideration of the “double nature” of biomass as being a material and an energy carrier.

¹¹ Economic impact of alternative fuels is difficult to determine without considering vehicle technology, and mobility demand. Given the long-term view assumed here, the economics of fossil fuel alternatives must be measured against significantly rising fossil energy costs.

¹² Source: IEA (2007), IPCC (2007), UNPD (2004) and WBGU (2003)

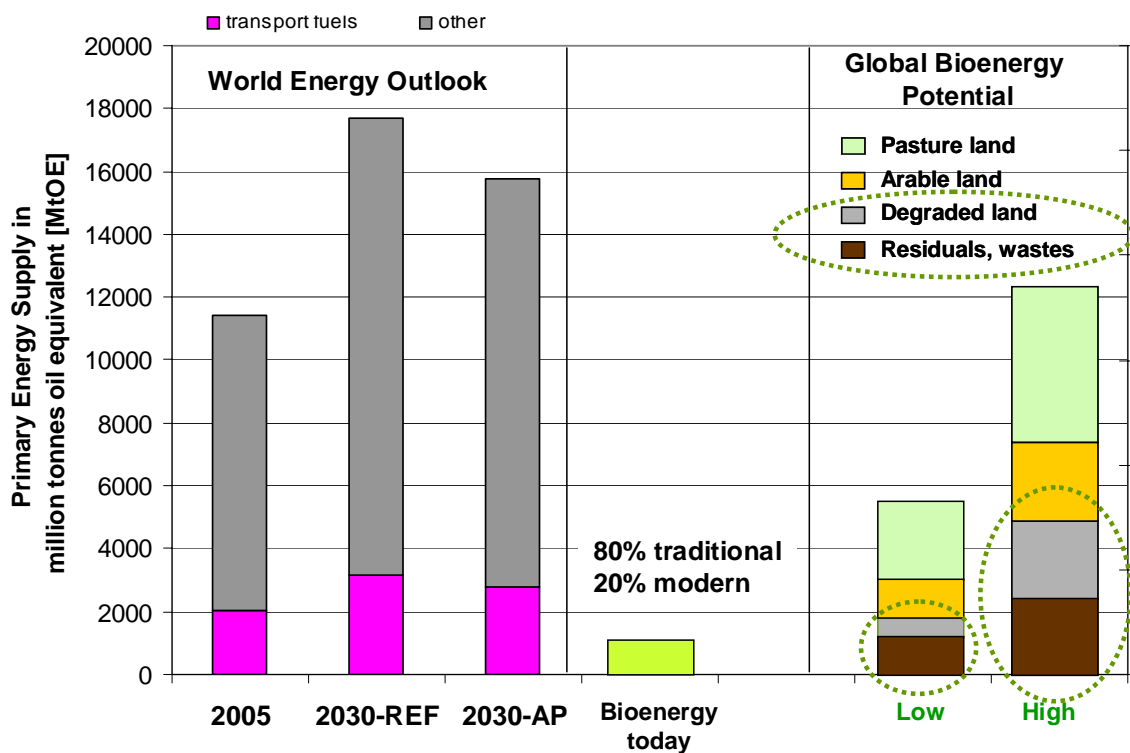
¹³ In the long-run, “artificial” photosynthesis might be possible with a conversion efficiency of approx. 10 to 15%. This could drastically narrow the gap to solar electricity systems.

Though bioenergy is seen by some to be a panacea for a range of energy, environment and poverty problems, the sustainability performance of bioenergy depends on where and how it is produced, processed, and used.

Given the substantial – though restricted – global potential for sustainable provision of bioenergy, it could significantly contribute to transport fuel needs (see Figure 7). However, sustainability aspects of the use of bioenergy depend on the developments in agriculture and forestry, as well as the overall dynamics of the food, feed and fiber markets. Its potential is further depending on the impact of global climate change, and the regionally differentiated adaptation measures to adjust to that change.

The linkage between energy and biomass from agriculture and forestry has been described as a crucial “nexus”, a complex interaction of various driving forces, with massive feedback loops which make projections a matter of large uncertainty (UN 2007). Current science allows to depict the order of magnitude to which bioenergy could sustainably contribute to the world’s energy needs without compromising food, feed, and fiber requirements. A low figure can be derived from pessimistic assumptions on agricultural productivity, moderate energy and high commodity prices, and severe climate change impacts especially on soils, and precipitation patterns. The high figure assumes optimistic values of productivity increases, both high energy and agricultural commodity prices, and successful adaptation to climate change.

Figure 7 Global Energy Supply and Sustainable Bioenergy Potential



Source: own compilation based on IEA (2007) and Best et al. (2008)

The long-term sustainable supply potential of biofuels is significant, and about half of the potential comes from residues and wastes. About 200 ExaJoules (EJ) of primary energy could be supplied sustainably which translates under optimistic long-term technology assumptions into approx. 150 EJ of transport fuel equivalents, taking only the potential of biofuel feedstocks from residues and wastes, and degraded land into account. This would represent more than the long-term transport fuel need in a global “sufficiency and efficiency” scenario.

Biofuel are on the rise: Among renewable energies, biofuels dominated venture capital and private equity investments in 2006 - with approx. \$ 3 billion far more than investments into solar energy (about \$ 2 billion; see UNEP 2007). This increase in biofuel production and financing is driven by energy security and climate change concerns (Steenblik 2007).

With the rising use of biofuels, their positive and possibly negative impacts became an issue of research, and debate: While proponents of biofuels underline the potential for cleaner and less greenhouse-gas intensive fuels, and economic opportunities for farmers and rural communities, opponents argue that biofuels risk damaging biodiversity, marginalizing indigenous and local communities and possibly create more greenhouse gas emissions than they prevent (CBD 2008). The dominant factors determining cost, environmental, biodiversity and social impacts of biofuels are

- the characteristics of the land used for producing biofuel feedstock (forestland, cropland, marginal or degraded)¹⁴ and
- the feedstock conversion process employed, including the feedstock characteristics (crop, grass, woody, residues/wastes).

Depending on the feedstock used, where and how it is grown and the manner in which it is processed, the greenhouse gas balance, energy yields and environmental impacts of biofuels differ significantly, but many aspects correspond to the environmental impacts of “common” agriculture (FAO 2008; RS 2007).

On the positive side, the need for greater amounts of feedstock will create employment opportunities, and thereby may increase rural incomes as the harvesting of biomass tends to be a labor-intensive process (UNEP 2008a). However, the large-scale production of biofuels tends to favor industrial agricultural practices.

5.1.1 Biofuels from 1st Generation Technologies

Ethanol as a substitute for gasoline is currently the dominating biofuel on the global scale. Suitable biogenic feedstocks contain high shares of sugar, or starch which is catalyzed into simple sugars, and then fermented into ethanol.

¹⁴ Note that biogenic residues and wastes do not impose land-use or land-use changes.

Sugar cane in particular stands as the feedstock that already provides a large amount of ethanol in Brazil. Other crops which can be converted into ethanol are cassava, maize, potatoes, sorghum, sugar beet and wheat¹⁵. The conversion of their starch content into sugar has a high process energy demand, so that the cost of the product is quite high. Ethanol from fermenting starch- or sugar-rich plant material is called “1st generation” because it already exists, has proven efficiencies, and established economics.

Biodiesel is another 1st generation biofuel technology: oilseed-yielding plants like castor, cotton, palm, rape, soy, etc. offer a feedstock from which vegetable oils can be derived by physical and chemical treatment (milling/refining). The oil can then be processed further into fatty acid methyl esters (FAME), also known as biodiesel¹⁶.

1st generation biodiesel can also be derived from perennial plants such as *Jatropha* which show comparatively low yields, but need only minor inputs so that their overall costs might be moderate if land and labor costs are low. *Jatropha* can be grown on marginal and even degraded land, and needs only little irrigation during the first years.

5.1.2 Biofuels from 2nd Generation Technologies

In the next decade, it will become possible to use a far greater range of lignocellulosic plant materials (so called 2nd generation feedstocks) for biofuel production. These feedstocks include perennials such as grasses and woody plants, and residues from agriculture and forestry as well as wastes from households, food/feed/fiber processing, and possibly algae. These 2nd generation biofuel technologies differ technology-wise, but are similar in the following respects:

- To extend the biofuel yield, the whole plant material is to be used as a feedstock.
- The feedstock is to come from “non-food” perennial crops (in principle, woody biomass and tall grasses) and lignocellulosic residues and wastes (e.g. woodchips from forest thinning and harvest residues, surplus straw from agriculture).

Cellulosic biomass from fast-growing perennial crops such as short-rotation wood and tall grass crops require less agrochemical inputs. Furthermore, the root systems of perennials remain in place after harvest so that these crops, compared to annual ones, reduce erosion, and could increase carbon storage in soil. However, high

¹⁵ There are far more plant species which could be suitable feedstocks for ethanol production, including perennial crops, but their yields, costs, and emission features are not well known (see EEA/JRC 2006).

¹⁶ Another route for biodiesel is to “hydrotreat” unprocessed bio-oils (from castor, cotton, palm, soy etc.) so that no transesterification is needed to stabilize the biodiesel.

biomass yields will typically be achieved only on good soils with sufficient water supply. The 2nd generation biofuels can be divided into two groups:

- enzyme-enhanced fermentation for ethanol from lignocellulose, and
- gasification + synthesis (Fischer-Tropsch) for biodiesel.

Both routes are currently under development, and might become commercially available in the 2020 timeframe. There might also be hybrid schemes which combine the two routes.

In the longer-run, 2nd generation technologies could also enhance the output of 1st generation systems, especially sugarcane-based ethanol and biodiesel from palmoil, as they allow to make use of plant residues which currently cannot be converted into biofuels.

5.1.3 Biogas as an “in between” Biofuel

Biogas can be upgraded to substitute natural gas (SNG) so that it can be fed into existing natural gas pipeline systems (both locally, nationally, or even for cross-border trade). Alternatively, it can be compressed into “green” compressed natural gas (BioCNG) to be used in gas-engine vehicles (buses, cars, trains, trucks etc.). Bio-SNG can be “blended” with natural gas in any mixture.

Biogas – at least in Europe - has developed in the last years far beyond the mere fermentation of residues like dung, liquid manure, or organic household wastes: nowadays, it can be derived from “modern” bioenergy crops such as maize, wheat, and even more interestingly from mixed or *double cropping* farming systems which can integrate various plant varieties into their rotation, and give net energy yields comparable to palm oil, or sugarcane plantations.

Nevertheless, current markets for CNG vehicles are, with only few exceptions, rather small. In the longer-term, though, BioCNG vehicles could be an attractive option.

5.2 Costs of Biofuels and their Competitiveness

The costs of biofuels need to be compared with those of their fossil fuel competitors, which will develop over time, and will depend also on e.g., factoring in greenhouse-gas emissions. Biofuel costs depend on yields, land price, interest rates, and cost of workforce, dynamic effects such as scale and learning curves, but also economic feedbacks from agricultural markets, land use policies, and sustainability requirements.

Most forms of biofuels feedstocks have alternative uses and may be highly valued as animal feed or fuel, especially in marginal areas. Infrastructure requirements might also add to the cost of biofuels. Smaller, poorer and/or landlocked developing countries face the highest costs due to smaller scale, lack of market access, and undeveloped infrastructure. These factors limit the commercial viability of potentially cheap feedstocks.

For starch-based 1st generation ethanol, costs depend not only on feedstocks, but also on revenues from byproducts. Ethanol from sugarcane (Brazil case) illustrates that improved feedstock and technology learning fostered by longer-term commitment can bring production costs down to the point where (unsubsidized) ethanol becomes competitive at an US\$ 50/bbl oil price level (WB 2005). The “learning curve” in Brazil for bio-ethanol took about 20-25 years from program inception to technical maturity. With oil in the US\$ 100/bbl range, even starch-based ethanol in larger plants, and sugarcane ethanol from less efficient production could be economically competitive.

Similar to ethanol, SVO and biodiesel from oil plants are established and proven technologies, their costs depend heavily on feedstock (>80 percent for FAME), and revenues from by-products (cake, glycerin).

With such a high dependency on feedstock costs and price volatility in competing uses, 1st generation biodiesel is a less attractive option unless palm oil is considered, or new conversion processes like hydrogenation become less costly.

On the other hand, cost for small-scale biodiesel from low-input systems like jatropha grown on low-cost marginal or degraded land with low-cost labor could be competitive with fossil diesel if production efficiency is high and by-product markets are developed.

The economy of 2nd generation biofuels (biomass-to-liquid = BtL, and lignocellulosic ethanol) can currently be judged only from small pilot plants. Clearly, a drawback of the BtL route is the strong dependence on scale-up: to be competitive, capacity has to be in the order of a small oil refinery (approx. 1 million tonnes per year). In addition, the economics rely on low feedstock costs, and successes in cost reduction for gas cleaning, and catalytic conversion. Cost projections indicate that in the longer-term, BtL from biomass residues could become cost effective at oil prices of US\$ 80/bbl, while BtL from energy crops might need a level beyond US\$ 100/bbl.

With the development of genetically improved bacteria for *enzyme* production, the operating cost of lignocellulosic ethanol plants could be reduced drastically. Nevertheless, this route still depends on milling, heat and acid, but at less demanding conditions than today, and needs sophisticated process control. As the enzyme production today is well away from costs needed to make lignocellulosic ethanol competitive, significant improvements are needed – but which are conceivable in principle. As lignocellulosic ethanol can make use of (nearly) the whole biomass of its feedstock (using lignin parts for process energy), its economy will be more interesting than today’s starch-based 1st generation ethanol. Expectations are that costs could come down to a US\$ 70/bbl oil equivalent level within the next decade if biomass residues are used, and for dedicated crops such as perennial grasses, the competitive costs level might be in the range of US\$ 100/bbl oil.

5.3 Biomethane: from Biogas to “Green” Gas

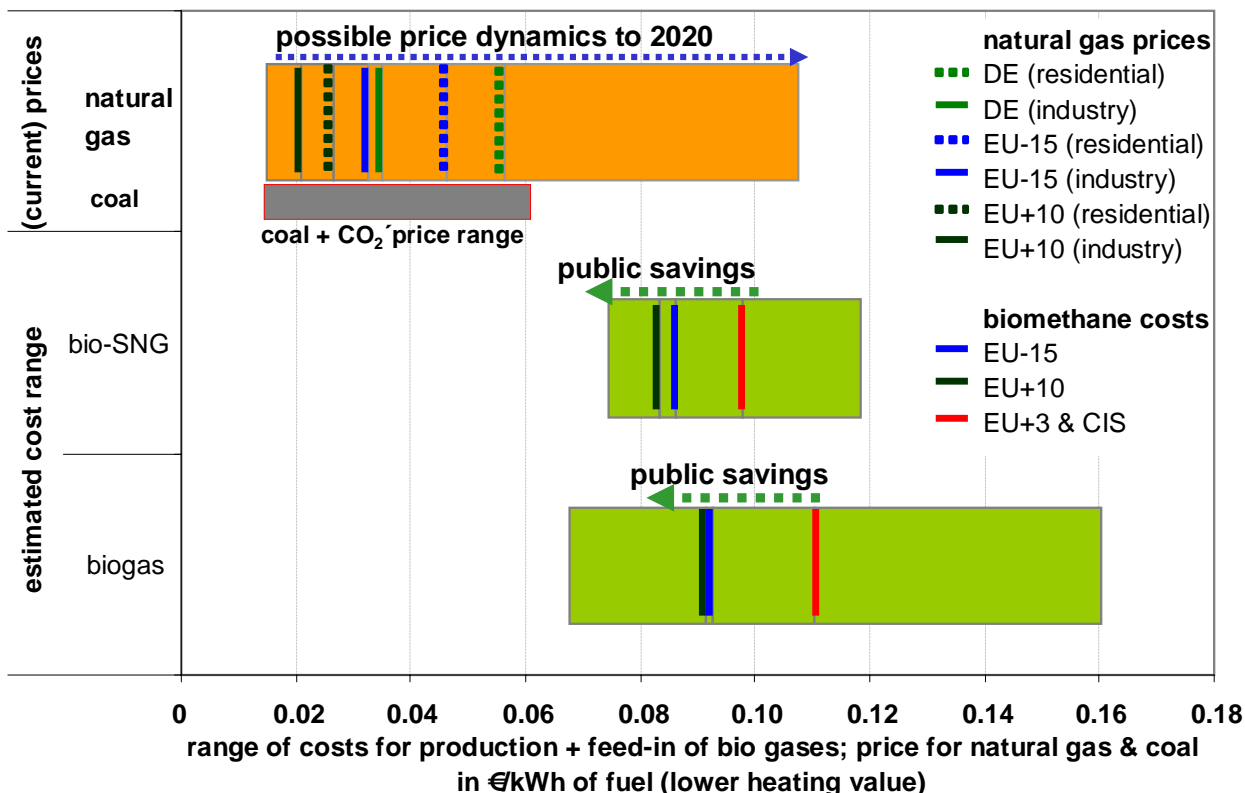
In addition to liquid biofuels and renewable electricity, processed biogas from fermenting agricultural residues and wastes, or energy crops, or from gasification of biomass and subsequent syngas production is called “biomethane” – a high-methane substitute for natural gas.

Biomethane can be fed into gas pipeline systems, thus being available for use in stationary applications (e.g., combined heat and power generation), but also as a transport fuel if it is compressed – it then competes as BioCNG with compressed natural gas (CNG) used in cars, busses, and trains.

The environmental performance of biomethane depends mainly on its origin (feedstock) which could be rather favorable in case of residues and wastes, and cultivation practices such as double cropping, or short-rotation coppice as a feedstock for syngas production.

The economic performance of biomethane could also be more interesting than (most) liquid biofuels, getting close to competition with natural gas in the near future (see following figure).

Figure 8 Costs of Biomethane and Prices Ranges of Natural Gas and Coal



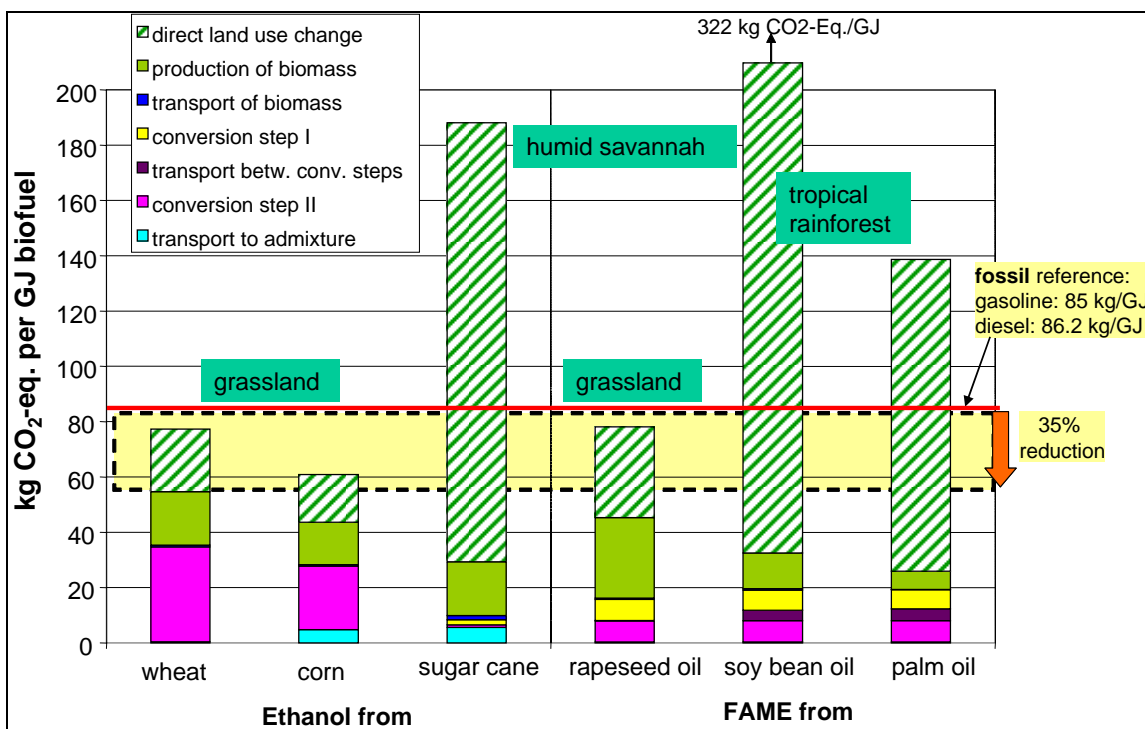
Source: OEKO/IE (2007); data refer to EU conditions

5.4 Environmental Performance of Biofuels

Today's 1st generation biofuels – with the exception of sugarcane ethanol and palmoil biodiesel – show a 25 to 50% reduction of GHG emissions compared to their fossil competitors, if overall life-cycles are taken into account. Sugarcane ethanol and palmoil-based biofuels perform better, with up to 90% reductions.

The beneficial greenhouse gas balance for those crops is dampened through GHG emissions from land-use change associated with feedstock production. A direct land use change is given whenever a crop scheme is planted in an area where this form of cultivation has not taken place before. The area might have been covered by forest or other natural and near-to-nature ecosystems, but it might also have been idle or set-aside land. The quantification of direct land-use changes can be based on carbon content data from IPCC default (tier 1) or country-specific (tier 2) values¹⁷. The results of such calculations are shown in the following figure.

Figure 9 Life-Cycle GHG Emissions of Biofuels and Impacts from Direct Land-Use Change



Source: Fehrenbach/Fritsche/Giegrich (2008)

¹⁷ This is valid for above-ground carbon. Less is known for the below-ground carbon balances of land-use changes, and very few data exist on the changes in N₂O emissions.

As can be seen, the GHG emissions changes drastically if conservative assumptions are made for direct land-use change. If biofuel feedstocks are grown on low-carbon soils, the impact can be positive, though: for example, perennial plants such as short-rotation coppice store carbon in their root system so that a biological sequestration takes place and GHG emissions are reduced.

It must be considered further that in principle, expansion of (biofuel) crop production on arable or pasture land could be associated with indirect land use change which can be described as the shift of the land use prior to biofuel production to another area where land use change occurs due to maintaining the previous level of (e.g., food) production (see e.g. Fehrenbach/Fritsche/Giegrich 2008; Searchinger et al. 2008).

For this displacement, the so-called “iLUC” factor (for indirect land-use change) has been proposed to quantify the indirect GHG emissions. An indicative order of magnitude for the iLUC factor is given below.

Table 4 Life-Cycle GHG Emissions of Biofuels and Indirect Land-Use Change

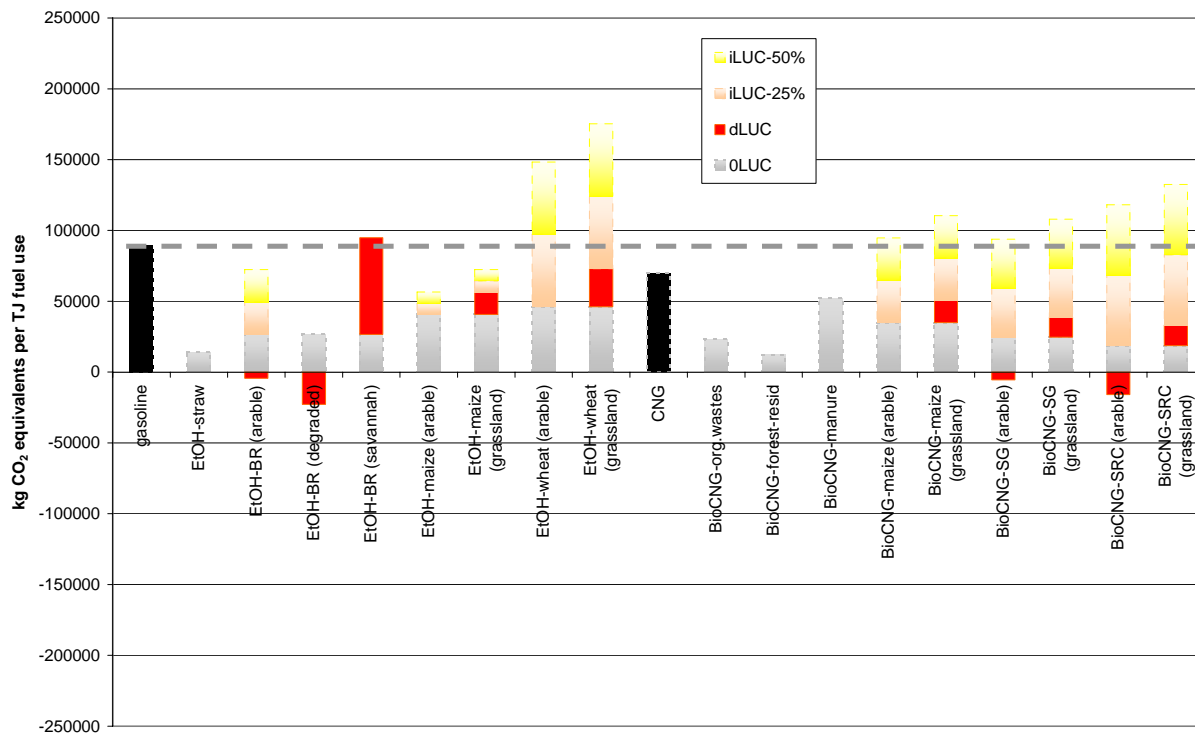
biofuel route, life-cycle	kg CO _{2eq} /GJ with iLUC factor			relative to fossil diesel/gasoline,		
	including conversion/by-products, without direct LUC			including conversion/by-products		
	max	med	min	max	med	min
Rapeseed to FAME, EU	260	188	117	201%	118%	35%
palmoil to FAME, ID	84	64	45	-3%	-25%	-48%
soyoil to FAME, Brazil	101	76	51	17%	-12%	-41%
sugarcane to EtOH, Brazil	48	42	36	-44%	-52%	-59%
maize to EtOH, USA	129	101	72	50%	17%	-16%
wheat to EtOH, EU	144	110	77	67%	28%	-11%
SRC/SG to BtL, EU	109	75	42	26%	-13%	-51%
SRC/SG to BtL, Brazil, tropical	34	25	17	-61%	-71%	-80%
SRC/SG to BtL, Brazil, savannah	59	42	25	-32%	-51%	-71%

Source: Fritsche/Hennenberg (2008)

Even if no direct land-use change is assumed, the iLUC factor will worsen the GHG balance, depending on its level of application: with a high level of 50% risk to induce indirect land-use change, rapeseed, wheat and maize will not be reducing GHG emissions compared to their fossil fuel competitors, and for a 25% risk level of the iLUC factor, only ethanol from sugarcane, and 2nd generation BtL would still allow a GHG reduction.

This calculation was recently extended in a study for WGBU which explicitly considered direct LUC (both positive and negative) and the iLUC factor on the “low” (i.e. 25%) and high (i.e. 50%) level. The results are shown in the following figures.

Figure 10 Life-Cycle GHG Emissions of Bioethanol and Biomethane Including Indirect LUC



Source: OEKO (2008); dLUC= direct land-use change (LUC); iLUC= indirect LUC; CNG= compressed natural gas; SG= switchgrass; SRC= short-rotation coppice

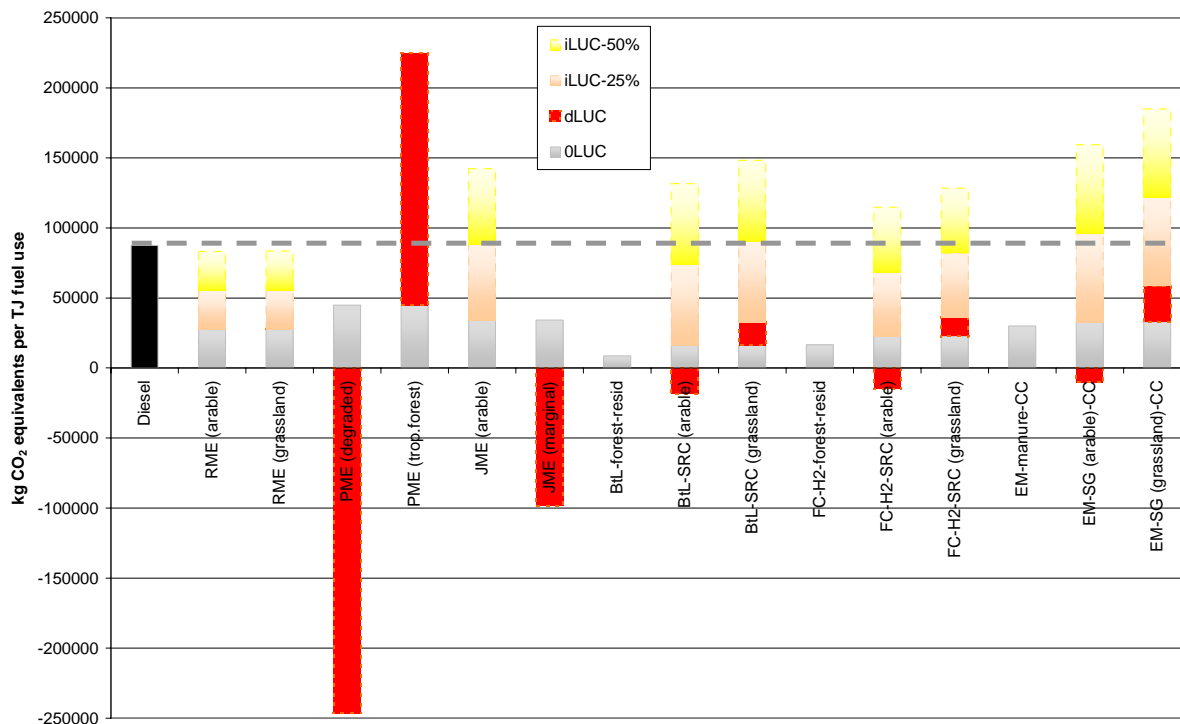
Compared to gasoline, lignocellulosic ethanol from straw and BioSNG from forest residues as well as from organic wastes would perform best, as there is no risk of LUC-related GHG emissions.

Ethanol from sugarcane in Brazil would allow a 40% net reduction even for a 25% iLUC level, and could achieve even higher reductions if grown on degraded land. If, on the other hand, ethanol would stem from sugarcane grown on converted savannah, there would be no net GHG reduction due to high dLUC emissions.

Ethanol from maize (corn) grown on arable land would allow approx. 35% net GHG reduction if direct and indirect LUC-emissions were included. If grown on converted grassland, the net reduction would be 10-15% only. Ethanol from wheat would not achieve net GHG reductions indirect LUC is considered.

Also BioCNG from switchgrass (SG) or short-rotation coppice (SRC) would not allow net GHG reductions if the iLUC 50% emission factor is taken into account.

Figure 11 Life-Cycle GHG Emissions of Biodiesel, Bio-H₂/FC and Bioelectricity Including Indirect LUC



Source: OEKO (2008); dLUC= direct land-use change (LUC); iLUC= indirect LUC; RME= rapeseedoil methyl ester; PME= palmoil methyl ester; BtL= biomass-to-liquid; SRC= short-rotation coppice; FC= fuel cell; H₂= hydrogen; EM= electro-mobility; SG= switchgrass; CC= combined-cycle

For biodiesel from rape, jatropha and palm oil, no net GHG reduction occurs if the 50% iLUC level is taken into account – but if jatropha and palmoil stem from marginal or degraded land, they achieve significant net savings due to increased carbon reductions from direct LUC.

Interestingly, advanced biofuels such as BtL, BioH₂ + fuel cell cars, and electric cars show net GHG savings only if they use feedstocks from residues and wastes. If their feedstock comes from biomass cultivation on arable land, they achieve moderate GHG reductions for the 25% iLUC level, but none if the feedstock comes from converted grasslands, or if the 50% iLUC level is assumed.

These examples demonstrate that both the direct LUC (for marginal/degraded land) and the indirect LUC (for arable/grassland) have a dominating impact on the GHG emission level of bioenergy in general and biofuels in particular.

Restrictions for Biofuels because of Competition for Land and Water

Whatever the GHG balance, biofuel feedstock production could also impact biodiversity positively or – if unregulated – negatively (CBD 2008). In that regard, the clear definition of areas suitable for feedstock production, and the promotion of production schemes compatible with agrobiodiversity are urgently needed (FAO 2008b).

Arable land to grow biofuels on is a scarce resource, and might become even scarcer in the long-term, with a growing global population, changing diets, and impacts from climate change. Furthermore, biofuel feedstock cropping needs water, and thus competes with water demand for feed and food crops. Both factors could restrict global biofuel development.

On the other hand, feedstock cultivation for biofuels can make use of non-edible plants such as short-rotation coppice, and can take place on land unsuitable to food and feed production (e.g., jatropha on degraded lands). Plant varieties and cropping schemes with low water demands are more feasible for bioenergy production than for food and feed schemes, thereby, in principle, reducing competition.

Still, all options to minimize or avoid competition of biofuel feedstocks with food and feed crops will lead to higher production costs, as feedstock yields will be reduced by minimal irrigation, marginal soil fertility, and low-input farming.

5.5 Summary: Which Biofuels Can Deliver in the Future?

Given the wide range on cost and GHG emission profiles of biofuels, and the rather large uncertainties in future developments of feedstock cropping systems and downstream conversion, one can assume that in the longer-term, only few biofuel systems will be competitive in terms of their sustainability profile:

- biofuels derived from residues and wastes,
- biofuels derived from perennial plants (sugar-cane and palm for 1st generation, and perennial grasses and short rotation coppices for 2nd generation) from land with low carbon soils – especially marginal and degraded lands, and
- bioCNG derived from high-productive multiple harvest no-till schemes.

The role of residues and wastes, and – hence – the role of 2nd generation biofuels will become key, as this routes allow to convert “non-competing” biomass feedstocks into biofuels. Biomethane is an important option for all biomass feedstocks – its role will be mainly restricted by available (natural) gas infrastructure, and respective vehicles. Growing biomass for material use first, and making use of the energy content of biomaterials only after their product “life” has ended offers superior performance in terms of resource and land-use efficiency and greenhouse-gas reduction. With rising oil prices, fossil-fuel based materials (e.g., plastic, textiles) will become more expensive, thus creating high-value opportunities for bio-based products.

Converting bio-residues and wastes into modern energy and transport fuels can start today with biogas, and could use “2nd generation” technologies in the future.

Hydrogen and Electricity: Versatile Transport Fuels?

Currently, about 200 EJ of primary energy – mainly oil – is used for liquid transport fuels (IEA 2007). This may increase to 300 EJ by 2030, and 400 EJ until 2050 (IPCC 2007). Meanwhile, global primary energy demand for **all** energy services (electricity, heat, and transport) could be in the order of 750 EJ by 2030, and reach 1,000 EJ by 2100. This demand could nearly double in a business-as-usual scenario without major energy efficiency efforts – therefore, **efficiency** in all sectors is a key issue.

The amount of renewable energy which could be converted into either electricity or hydrogen is restricted by cost and environmental impacts. An estimate of the longer-term global renewables potential within sustainability boundaries shows that excluding biomass, there is approx. 500 EJ available, which could be translated into some 200 – 400 EJ of transport fuel equivalents, depending on the conversion route, and vehicle technologies assumed. This means that all **non-biomass** renewables could meet the future long-term transport demand if more efficient transport systems are developed and implemented. This clearly is not a valid assumption – biofuels could, as described – play **some** role in a sustainable global energy system, so that it will be a mix of renewable energy carriers used to meet transport energy demands.

Liquid biofuels will continue to play a major role as an aviation fuel, and possibly also for road freight transport by trucks – for those transport systems, fuel cell or electric drives are unsuitable due to weight restrictions.

One might consider also H₂ production from direct biological processes such as genetically altered algae, or bacteria. For this, a sound sustainability assessment is not (yet) possible.

5.6 Sustainable Transport Fuels

In the medium-term, sustainability requirements for all biomass will have to be implemented globally. More feedstock production using degraded lands with more productive systems (e.g. salt-tolerant and drought-resilient species), more sustainable feedstock production using multiple cropping schemes, and agro-forestry, algae and bacteria for bioenergy production (fermentation etc.) will favor more sustainable biomass provision. Research of environmentally sound direct H₂ production from algae and bacteria is another aspect which should be supported. On a longer time scale, also solar-thermal and geothermal electricity generation, as well as environmentally sound offshore wind and wave should be aimed for.

Given the huge range of possibilities for future transport energy provision, one can clearly derive on conclusion: Whatever mix of sources, carriers, and conversion systems there may be, the **private economic cost of transport fuels will be far higher than those of today.**

Therefore, the **role of efficiency** becomes critical, not only in terms of environment, but also in terms of affordability. Only by the interaction of an extensive tapping of vehicle related efficiency potentials, the shift to cleaner travel modes and the reduction of transport demand, the thus significantly reduced energy demand of the transport sector could be transformed to a high degree into renewables regardless weather if the carrier is liquid, gaseous or electric.

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Annex I: Overview of Key Sustainability Certification Schemes

Description	Sustainability Requirements
<p>In December 2007, the German Bioenergy Sustainability Ordinance (BSO) which is linked to the German Biofuel Quota Law has been decided by German government. Currently in hold by the European Commission, it will be revised according to the European Directive on the promotion of the use of energy from renewable sources. Only sustainable biofuels, as defined in the Ordinance, will count towards the national quota of biofuels.</p> <p>Also the revised Renewable-Energy-Act and a new Renewable Heat Act came into force in January 2009 which covers also sustainability requirements for the feedstock. The respective standards and certification systems will be implemented by ordinances to be passed in early 2009.</p>	<p>In the German ordinance the whole life chain – including direct land use change – is considered.</p> <p>Current included principles cover the following environmental issues:</p> <ul style="list-style-type: none"> • Significant contribution to greenhouse gas mitigation (for biofuels at least 30% improvement, 40% from 1 January 2011); • Effects from direct land use changes (competition) have to be considered; • Loss of habitats of high conservation value shall be prevented; • Loss of biodiversity shall be prevented (incl. criteria considering farmland biodiversity); • Negative impacts on soil, water and air shall be minimized; <p>The ordinance will be adapted to the regulations of the EU RES Directive.</p> <p>Ongoing R&D projects propose social-economic and environmental requirements, and make recommendations to indirect land use change.</p>
<p>Netherlands: Certification system for biofuels was first discussed in a report issued in 2003 by NOVEM, the Netherlands Agency for Energy and the Environment.</p> <p>The scheme proposed was inspired from a certification system for the Electricity market.</p>	<p>Criteria for Sustainable Biomass Production' have been published (July 2006). In the system that was developed sustainability criteria for 2007 are distinguished from those for 2011. In the criteria for 2007 minimum requirements have been formulated to prevent unacceptable biomass flows from being used. The criteria for 2011 have been tightened and are aimed at providing an active protection of nature and the environment and of the economic and social circumstances. The criteria and indicators have been divided into six themes. The first three themes are specific themes, relevant for biomass. The last three themes relate to the triple P approach (people, planet, profit), which are the starting-points for corporate social responsibility.</p> <p>The six themes are the following:</p> <ul style="list-style-type: none"> ▪ Greenhouse gas balance; ▪ Competition with food, local energy supply, medicines and building materials; ▪ Biodiversity; ▪ Economic prosperity; ▪ Social well-being; ▪ Environment.

Description	Sustainability Requirements
	<p>In April 2007 NOVEM published “Testing Framework for Sustainable Biomass”. The Dutch government is considering imposing minimum sustainability requirements and.</p>
<p>UK Renewable Transport Fuel Obligation (RTFO)</p> <p>Starting in 2008 the RTFO, implemented by the UK Department of Transport, places an obligation on fuel suppliers to ensure that a certain percentage of their aggregate sales is made up of biofuels.</p> <p>5% of all UK fuel sold on UK forecourts is required to come from a renewable source, by 2010. Biofuel producers will have to report on the green-house gas balance, and environmental impact of their biofuels. This information will be used to develop sustainability standards, which may be imposed on any extension of the RTFO.</p>	<p>Sept. 2007 - Seeking information from suppliers on carbon savings and sustainability impacts of their biofuels for RTFO;</p> <p>Oct. 2007 – Parliament approved RTFO;</p> <p>With the RTFO the UK government intends to set targets for:</p> <ul style="list-style-type: none"> ▪ the level of greenhouse gas savings from biofuels used to meet the RTFO; ▪ the proportion of biofuels from feedstock grown to recognized sustainability standards; ▪ and the amount of information to be included in sustainability reports. <p>In 2008 RTFO standard (i.e. minimum blending mandate) has been set; 2010 – 5% of all UK fuel renewable; April 2010- UK Government will reward RTFO biofuel based on the amount of carbon the fuel saves; April 2011- UK Government will reward biofuels only if they meet appropriate sustainability standards.</p> <p>The government has currently asked the Low Carbon Vehicle Partnership to explore the feasibility of a voluntary labeling scheme, allowing responsible retailers to show that the biofuels they supply are genuinely sustainable</p>
<p>US Low Carbon Fuel Standard (LCFS) issued on January 18, 2007, calls for a reduction of at least 10 percent in the carbon intensity of California's transportation fuels by 2020.</p>	<p>The LCFS instructs CalEPA to coordinate activities between the University of California, the California Energy Commission and other state agencies to develop and propose a draft compliance schedule to meet the 2020 target.</p> <p>In August 2007, UC Berkeley published A Low-Carbon Fuel Standard for California, Part 2: Policy Analysis.</p> <p>Directed ARB to consider initiating a regulatory proceeding to establish and implement the LCFS. In response, ARB identified the LCFS as an early action item with a regulation to be adopted and implemented by 2010.</p>
<p>US Renewable Fuel Standard program (EPA) began on September 1, 2007.</p> <p>Congress set the minimum volume of renewable fuel that must be used in the U.S. each year through 2012.</p> <p>Parties meet their obligation by acquiring credits generated by renewable fuel producers and importers which correspond to the type/volume of renewable fuel</p>	<p>Gasoline refiners and importers are required to use 5.4 Bgal of renewable fuel in 2008.</p> <p>Annual volume requirement will increase to 7.5 Bgal in 2012.</p> <p>Beginning in 2013, the 2.5:1 extra credit will be phased out and a minimum volume of cellulosic biomass ethanol will become part of the annual standard for gasoline refiners and importers.</p>

Description	Sustainability Requirements
<p>they produce/import.</p> <p>Program creates incentive for second-generation ethanol production by allowing cellulosic biomass and waste-derived ethanol producers and importers to generate credits at a rate of 2.5 per gallon for their fuel versus 1 credit per gallon for corn- and other starch-based ethanol.</p>	<p>Beginning in 2013, EPA, in coordination with USDA and DOE, must determine the applicable volume for the renewable fuel standard for the year 2013 and subsequent calendar years.</p> <p>Also beginning in 2013, gasoline refiners and importers will have to meet the 250 million gal cellulosic biomass ethanol standard.</p>
<p>EU Directive on the promotion of the use of energy from renewable sources (RES-D) In January 2007 the European Commission sets out in the Renewable Energy Road Map the long-term strategy for renewable energy in the European Union (EU). In December 2008, the RES-D establish an overall binding target of a 20% share of renewable energy sources in energy consumption and a 10% binding minimum target for biofuels in transport to be achieved by each Member State.</p>	<p>The RES-D creates a number of mandatory environmental sustainability criteria for biofuels and other bioliquids:</p> <ul style="list-style-type: none"> • the greenhouse gas emission saving from the use of biofuels and other bioliquids taken into account shall be at least 35%, rising to 50% by 2017 • biofuels and other bioliquids taken into account shall not be made from raw material obtained from land with recognized high biodiversity value • biofuels and other bioliquids taken into account shall not be made from raw material obtained from land with high carbon stock • agricultural raw materials cultivated in the Community and used for the production of biofuels and other bioliquids shall be obtained in accordance with the minimum requirements for good agricultural and environmental condition • Social requirements are not included, but reporting obligations for the EU and Member States on social impacts are established.
<p>The Forest Stewardship Council (FSC) is an international organization that brings people together to find solutions which promote responsible stewardship of the world's forests. FSC is an international standard, developed and reviewed according to the ISEAL Code of Good Practice for Setting Social and Environmental Standards. This ensures that FSC certification does not constitute a technical barrier to trade under the rules of the World Trade Organization.</p> <p>Compliance is determined at the Criterion level, and indicators to the P&C are developed by FSC accredited national initiatives and by certification bodies for use in the absence on nationally developed ones.</p> <p>FSC has an Accreditation Program which is in charge of providing accreditation services to certification bodies and National Initiatives. The Accreditation Program is based on international standards and complies with ISO 17011 requirements. Project funding for FSC is provided by various foundations and companies around the globe. Core funding is derived from membership and accreditation fees.</p>	<p>Based on FSC's 10 Principles and 56 Criteria for Forest Stewardship, the scope involve environmental, silvicultural, social and economic issues.</p> <p>These principles are global – they can apply to any forest around the world – and they assure:</p> <ol style="list-style-type: none"> 1. Compliance with laws and FSC principles; 2. Tenure and use rights and responsibilities; 3. Indigenous peoples' rights; 4. Community relations and worker's rights; 5. Multiple benefits from the forest; 6. Assessment of environmental impact; 7. Management planning; 8. Monitoring and assessment of management impact; 9. Maintenance of high conservation value forests; 10. Responsible management of plantations Principles for Forest Stewardship.

Description	Sustainability Requirements
	<p>Three product labels:</p> <ol style="list-style-type: none"> 1) FSC pure label for 100% certified product group; 2) FSC mixed label with a minimum threshold of 10% certified and 60% post consumer content; and 3) FSC recycled label for product groups with 100% post consumer content. <p>It prohibits use of sources that are illegally harvested and derived from a high conservation value forest.</p> <p>Since 1994 over 99 million hectares in 75 countries have been certified (over 34 million hectares in North America) according to FSC standards while several thousand products are produced using FSC certified wood and carrying the FSC trademark. FSC operates through its network of National Initiatives in 40 countries.</p>
<p>IFOAM Norms: Started in 1972 by the president of the French farmer's organization to ensure a future of worldwide organic agriculture. IFOAM is comprised of a variety of committees each with specific mandates. The IFOAM General Assembly is the main decision-making body. IFOAM groups together 750 organic institutions worldwide and ensures some equivalency of standards in 108 countries. It elects the World Board for a three year term. The World Board appoints members to official committees, working groups and task forces based upon the recommendation of the IFOAM membership, and IFOAM member organizations also establish regional groups and sector specific interest groups.</p> <p>IFOAM label is a means of guaranteeing fair and orderly trade of organic products.</p> <p>Accreditation facilitates equivalency of organic certification bodies worldwide by confirming whether they meet IFOAM's international norms.</p>	<p>IFOAM Basic Standards (IBS) cover social, economic and environmental sustainability) and establish the requirements for certification bodies seeking IFOAM accreditation. Democratically and internationally adopted, they reflect the current state of organic production and processing methods. These standards should not be seen as a final statement, but rather as a work in progress to contribute to the continued development and adoption of organic practices throughout the world. The IBS are structured as "standards for standards." They provide a framework for certification bodies and standard-setting organizations worldwide to develop their own more detailed certification standards which take into account specific local conditions.</p>
<p>Better Sugarcane Initiative BSI is a collaboration of sugar retailers, investors, traders, producers and NGOs who are committed to sustainable sugar by establishing principles and criteria that are applied in the sugar growing regions of the world through regionally specific strategies and tools.</p>	<p>BSI is establishing Technical Working Groups (TWGs) - teams of technical and scientific experts - with global representation. These TWGs will assess Better Management Practices being used by sugar growers across the globe under three categories:</p>

Description	Sustainability Requirements
<p>The BSI aims to reduce the impact of sugarcane production on the environment in measurable ways that will also enable sugar production in a manner that contributes to social and economic benefits for sugar farmers and all others concerned with the sugar supply chain.</p> <p>The goal is to reduce farm and other sugar processing impacts, through the encouragement of better management practices (BMP's).</p>	<ul style="list-style-type: none"> • Environment and agronomy. • Social and community. • Milling and co-products. <p>Based on good practice achievements around the world, the TWGs will develop a set of universally-applicable guidelines for consideration by the BSI membership. The guidelines will follow the Quadruple Bottom Line approach which seeks to:</p> <ul style="list-style-type: none"> • Minimise the effects of sugarcane cultivation and processing on the off-site environment. • Maintain the value and quality of resources used for production, such as soil, health and water. • Ensure production is profitable. • Ensure that production takes place in a socially equitable environment. <p>Guidelines requiring further consideration will be tested in different cane-growing scenarios around the world to ensure that they are practical and achievable, and have the desired effect of improving the economic, environmental and social sustainability of sugarcane farming.</p>
<p>European Green Electricity Network (Eugene) is an independent network that pursues no commercial interest and acts to bringing together non-profit organisations such as national labelling bodies, experts from environmental and consumer organisations, and research institutes.</p> <p>The Intelligent Energy Europe project, "Clean Energy Network for Europe (CLEAN-E)", was designed to accompany the establishment of new green electricity product labels and the improvement of existing ones in selected EU Member States. The CLEAN-E project has supported the efforts of Eugene and correspondingly Eugene has served as the major point of orientation for the project. Among other things the project has explored the development of ecological minimum standards for biomass.</p>	<p>Eugene has created a standard of quality for green power to provide a benchmark for environmental labelling schemes.</p> <p>The Eugene Standard applies to geothermal, wind, solar, electric, hydropower and biomass energy and is given to defined 'eligible sources.' Eligible sources for biomass include dedicated energy crops, residual straw from agriculture, etc.</p> <p>Specific criteria for eligible biomass resources, such as production methods, are not specified by the standard.</p> <p>The studies undertaken by the project are meant to support the possible certification of biomass and included a proposal of biomass criteria for application by the Eugene Standard.</p> <p>The project has published a report evaluating the experiences with the pilot application of the developed biomass standards.</p>
<p>EurepGAP started in 1997 as an initiative of retailers belonging to the Euro-Retailer Produce Working Group</p>	<p>It provides standards for fruit and vegetables, flower and ornamentals, integrated farm assurance, integrated aquaculture,</p>

Description	Sustainability Requirements
<p>(EUREP). It has subsequently evolved into an equal partnership of agricultural producers and their retail customers. The organization's mission is to develop widely accepted standards and procedures for the global certification of Good Agricultural Practices (GAP).</p> <p>Governance is by sector specific EurepGAP Steering Committees which are chaired by an independent Chairperson.</p> <p>The Technical and Standards Committees working in each product sector approve both the standard and the certification system. These committees have 50% retailer and 50% producer representation creating an effective and efficient partnership in the supply chain.</p>	<p>coffee.</p> <p>While biomass production is not specifically mentioned in any of these standards, it appears integrated farm assurance would be the most relevant.</p> <p>Standards cover both social and environmental issues.</p> <p>Accreditation granted by an independent third party certification body that has been approved by EUREPGAP.</p>
<p>The PEFC (Programme for the Endorsement of Forest Certification schemes) is an independent, non-profit, non-governmental organization founded in 1999, which promotes sustainably managed forests through independent third party certification, acting as a global umbrella organization for the assessment of and mutual recognition of national forest certification schemes developed in a multi-stakeholder process.</p> <p>PEFC allows certification and labeling of forest based products which cover both wood based (timber, paper) as well as non-wood forest products.</p> <p>PEFC has in its membership 35 independent national forest certification systems of which 23 to date have been through a rigorous assessment process involving public consultation and the use of independent assessors to provide the assessments on which mutual recognition decisions are taken by the membership.</p> <p>PEFC is primarily funded by PEFC National Governing Bodies. Current members are Australia, Austria, Belgium, Brazil, Canada, Chile, Czech Republic, Estonia, France, Finland, Ireland, Italy, Luxembourg, Malaysia, Norway, Portugal, Russia, Slovak Republic, Spain, Sweden, Switzerland, UK, and USA.</p>	<p>Standards cover social, economic, silvicultural and environmental development issues.</p> <p>In February 2002 PEFC launched on the web the World's first Interactive Database on Forest Certification which allows customers to gain valuable information on the origins of the timber they are buying and which carries a PEFC logo.</p> <p>North American SFI system and German forest and Austrian scheme have been endorsed.</p> <p>These 23 systems account for more than 200 million hectares of certified forests (monthly updated statistics are available on the website) producing millions of tons of certified timber to the market place making PEFC the world's largest certification system.</p>
<p>The stated goal of the Round Table on Responsible Soy</p>	<p>In November of 2006, a final draft of the principles of the Round</p>

Description	Sustainability Requirements
<p>(RTRS) is to promote economically viable, socially equitable and environmentally sustainable production, processing and trading of soy.</p>	<p>Table on Responsible Soy was approved. The RTRS has put forth three main principles:</p> <ul style="list-style-type: none"> ▪ economic responsibility, ▪ social responsibility, and ▪ environmental responsibility <p>each with a number of sub-principles.</p> <p>Currently, the RTRS is inviting nominations for participation in the RTRS Principles, Criteria and Verification Development Group (DG). The DG is tasked with producing a set of verifiable principles, criteria and indicators that define responsible production at early stages of processing of soy beans and with developing a verification system.</p> <p>It facilitates discussions on biomass and biofuels certification among stakeholder groups, promoting certification initiatives by providing a forum for developing principles, criteria and indicators, and carrying out pilot studies to better understand the implication of certification implementation. Additionally, these efforts may have the advantage of being able to develop sustainability schemes and achieve results in relatively short time frames in comparison to multilateral/international processes, which are inherently long and complex.</p>
<p>Roundtable on Sustainable Biofuels (RSB) is an international initiative by the Ecole Polytechnique Fédérale de Lausanne (EPFL) Energy Center. Its aim is to bring together farmers, companies (i.e., BP, Shell, Toyota), non-governmental organization (i.e., Forest Stewardship Council, NWF, WWF), experts (UC Berkeley; Michigan State University), governments (Swiss Federal Office of Energy; Swiss State Secretariat for Economic Affairs), and intergovernmental agencies (UNCTAD) concerned with ensuring the sustainability of biofuels production and processing.</p>	<p>In June 2007 the RSB released its "Draft Global Principles for Sustainable Biofuels Production" for global stakeholder feedback and discussion:</p> <ol style="list-style-type: none"> 1. legality (biofuel production shall respect all applicable laws of the country in which they occur, and all international treaties and agreements to which the country is a signatory); 2. consultation (biofuel projects shall arise through fully transparent, consultative and participatory processes); 3. climate change and greenhouse gases (biofuels shall contribute to climate stabilization by reducing GHG emissions as compared to fossil fuels through their life cycle); 4. human and labor rights (biofuel production shall not violate human rights or labor rights, and shall ensure decent work and the well-being of workers); 5. socio-economic development (biofuel production shall not violate land or water rights, and shall contribute to the social and economic development of local, rural and indigenous peoples

Description	Sustainability Requirements
	<p>and communities);</p> <p>6. food security (biofuel production shall not impair food security);</p> <p>7. conservation (biofuel production shall not directly or indirectly endanger wildlife species or areas of high conservation value);</p> <p>8. soil (biofuel production shall not directly or indirectly degrade or damage soils);</p> <p>9. water (biofuel production shall not directly or indirectly contaminate or deplete water resources);</p> <p>10. air (biofuel production shall not directly or indirectly lead to air pollution);</p> <p>11. biotechnology (if biotechnologies are used in biofuels production, they shall improve the social and/or environmental performance of biofuels, and always be consistent with national and international biosafety and transparency protocols).</p> <p>In October 2007 RSB published a second version of principles for comments. According to the RSB, the 11 draft principles are highly aspirational, and represent an ideal performance of biofuels. Their purpose is to indicate the ideal scenario towards which stakeholders should be progressing. In Sept. 2008, draft criteria and indicators ("Zero Version Sustainability Standard") were published.</p>
<p>"Roundtable on Sustainable Palm Oil (RSPO)," established 2004 under Article 60 of the Swiss Civil Code with a governance structure that ensures fair representation of all stakeholders throughout the entire supply chain. The seat of the association is in Zurich, Switzerland, while the secretariat is currently based in Kuala Lumpur. RSPO's objectives are to promote the use and growth of sustainable palm oil through cooperation within the supply chain and open dialogue with its stakeholders.</p> <p>It was agreed that in order to promote the use of sustainable palm oil it would be necessary to have a mechanism for linking the palm oil being used by RSPO members and other responsible users (including industrial users of palm oil based substances) with the oil palm plantations being managed in accordance with the RSPO</p>	<p>In September 2006 (updated March 2007) RSPO published the RSPO Draft Verification Systems.</p> <p>The guidance document defines indicators and guidance for each criterion. Indicators are specific pieces of objective evidence that must be in place to demonstrate or verify the criterion is being met. The guidance consists of useful information to help the grower/miller and auditors understand what the criterion means in practice, including in some cases specific guidance for national interpretation of the criterion and application by small stakeholders. Dialogue among stakeholders has resulted in a set of 8 principles defined by criteria, indicators, and guidance for national interpretation. They include social (1), economic (1) and environmental (2) standards for sustainable palm oil production adopted in Nov. 2005:</p> <p>1. commitment to transparency;</p>

Description	Sustainability Requirements
<p>criteria.</p> <p>RSPO is managed by an Executive Board comprised of sixteen members, designated by the General Assembly for a period of two years. Members include representatives of Oil palm growers, Palm oil processors and/or traders, Consumer goods manufacturers, Environmental/nature conservation NGOs, Retailers, Banks/investors, Social/development, NGOs. The decisions are made on consensus basis.</p>	<ol style="list-style-type: none"> 2. compliance with applicable laws and regulations; 3. commitment to long-term economic and financial viability; 4. use of appropriate best practices by growers and millers; 5. environmental responsibility and conservation of natural resources and biodiversity; 6. responsible consideration of employees and of individuals and communities affected by growers and mills; 7. responsible development of new plantings; 8. commitment to continuous improvement in key areas of activity. <p>In June 2007, the principles were applied for an initial pilot implementation period of two years from the date of adoption to enable field testing and thereby allow the indicators and guidance to be improved, including guidance for application by smallholders; national interpretations have also been commenced during this period.</p> <p>In Nov. 2007 the final draft National Interpretation of RSPO Principles and Criteria for Sustainable Palm Oil Production was published.</p>

Annex II: The “iLUC factor” Approach

In contrast to analytical approaches to determine GHG emissions from potential indirect land use change which make use of econometric models, a **deterministic** approach has been developed by Oeko-Institut to include potential GHG emissions from indirect land use change in **regulatory policies** for biofuels. This approach has first been called “risk adder” (Fehrenbach/Fritsche/Giegrich 2008), but was renamed to “**iLUC factor**” to reflect its applicability in both “malus” and “bonus” schemes for GHG accounting¹⁸.

Background of the iLUC factor

In a **strict** definition, indirect land use change could occur for all biomass feedstocks derived from land which has been used previously for food/feed production, or from land which has the potential to be used for food/feed production. In that regard, **all** arable land used for **additional** biomass feedstock production will induce indirect land use change due to displacement, even if such displacement is hypothetical only¹⁹.

A more “loose” definition assumes displacement from bioenergy feedstock production only for land which **actually was used** previously for food/feed or fiber production, thus excluding set-aside and abandoned land as well as biomass feedstocks derived from intensified land use which gives higher yields.

In **both** definitions, biomass feedstocks derived from biogenic wastes and from abandoned and degraded land have a zero displacement risk, thus inducing **no indirect** land use change.

The iLUC factor approach uses the “loose” definition of indirect land use change risks, as it is meant to be practically applicable in **regulating** GHG emissions from biofuels, and not to reflect all analytically possible (including hypothetical) situations.

Key Considerations for the iLUC factor

The iLUC factor approach assumes that the **potential** release of CO₂ from land use change caused by displacement is a function of the land used to produce agro products for export purpose, as only trade flows will be affected by displacement.

¹⁸ A “malus” system will **add** a certain amount of GHG emissions from indirect land use change to those biofuels which are derived from feedstocks with a **non-zero** risks for displacement, while a **bonus** system would **credit** zero-risk biofuels (e.g. from wastes, or degraded land) with the amount of indirect GHG emissions they **avoid**.

¹⁹ The underlying hypothesis of the strict definition is that **any** arable land has potential to be used for food/feed production, so that its **opportunity value** would be reduced by using it for biomass feedstock production.

Next, the estimation takes into account that **all** countries trading agro-products across borders might be subject to LUC from displacement, so that displacement can impact different land with different (above- and below-ground) carbon stocks.

Countries participating in global trade are potentially incited to increase food/feed production to “balance” the global market if increased feedstock production for biofuels displaces previous food/feed production through respective land use.

The iLUC factor as a **deterministic** approach aims to describe **average impacts**. For that, the share of land utilized for producing the amount of food/feed displaced by increased biofuel feedstocks production is derived from the share of land used by each country for agro commodity exports, taking into account country-specific yields (based on FAO data for 2004/2005). For that, the share of land use of each export country can be determined by using the key commodities (rapeseed, maize, palmoil, soy, and wheat), and the countries/regions can be simplified to reflect Brazil (BR), the European Union (EU), Indonesia (ID), and the United States of America (US).

With the shares of land potentially affected derived from the share of land used for the selected agricultural commodity exports, and explicit assumptions on which land use change will be most likely (e.g. grassland to maize), the respective IPCC-based **direct** land use change factors for carbon releases can be coupled with the regional land use shares of each agro commodity. From that, an **average** CO₂ emission factor per ha of displaced land can be derived, and discounted over a time horizon of 20 years.

This calculation gives the **theoretical average iLUC factor as 20 t CO₂/ha/year**. This full iLUC factor would have to be applied if the risk for displacement from a certain amount of biofuel feedstock production would be 100%.

The iLUC factor: Practical Levels

In reality, however, the risk will be lower, as biofuel feedstocks come from a variety of sources, and circumstances (use of set-aside and abandoned land, intensification of existing cultivation schemes, etc.) which change over time. Therefore, the iLUC factor should be dynamic, i.e. the more biofuel feedstocks are produced, the higher the cumulative risk of displacement will become for the average biofuel feedstock.

To derive **indicative** values for the iLUC factor, i.e. numbers reflecting the order of magnitude, the following cases were defined:

- “low level”, assuming that 25% of all non-zero risk biofuels are subject to the theoretical full iLUC factor, which gives 5 t of CO₂/ha/year
- “medium level”, meaning a 50% share of all non-zero risk feedstocks are subject to the theoretical full iLUC factor, resulting in 10 t of CO₂/ha/year, and

- “maximum level”, representing a 75% share²⁰ of non-zero risk biofuel feedstocks, i.e. 15 t of CO₂/ha/year.

To translate the low, medium or high iLUC factor to a given biofuel, the land-based values given above (t CO₂/ha/year) are divided by the fuel-specific yield (GJ_{biofuel}/ha/year), resulting in energy-specific emission factors (t CO₂/GJ_{biofuel}).

The key simplifying assumption of the iLUC factor approach to avoid complex modeling of agricultural markets is that **current patterns** of land use for the production of traded agricultural commodities are an adequate proxy to derive global **averages** of potential GHG emissions from indirect LUC.

This does **not** indicate which land is **likely** to be affected by displacement in the future. As noted in Fehrenbach/Fritsche/Giegrich (2008), one might argue that the **incremental** (marginal) displacement might well affect mainly land that is cheapest and easiest, which could be high-carbon stock land.

In that regard, the iLUC factor is nothing more than a first proxy – and not necessarily a conservative one - meant to offer a practical approach for policy makers to address potential GHG emissions from indirect LUC.

The iLUC factor concept is still under development and discussion, and could be refined further to reflect more specific situations and timeframes than just the global averages of land use patterns and feedstock production in the year 2005.

²⁰ The maximum case is **not** 100% of the theoretical iLUC factor as it is assumed that in the longer-term, 25% of all biofuels come from **yield increases** for which the “loose” definition assumes a zero displacement risk. The 25% figure is derived from an average yield increase of 1% per year until 2030, starting in the base year 2005.