CLASSIFICATION, CERTIFICATION AND STANDARDIZATION INCLUDING LIFECYCLE ASSESSMENTS OF BIOFUELS

Introduction

This chapter will develop first the prerequisites and secondly the steps for standardization and certification of biofuels. It will first lay down the classification of biofuels as a fundamental for imposing technical or sustainability standards upon the production and consumption of biofuels.
Our focus will be on biofuels for the transport sector however the same steps apply horizontally to other biomass for energy purposes.

1. Classification

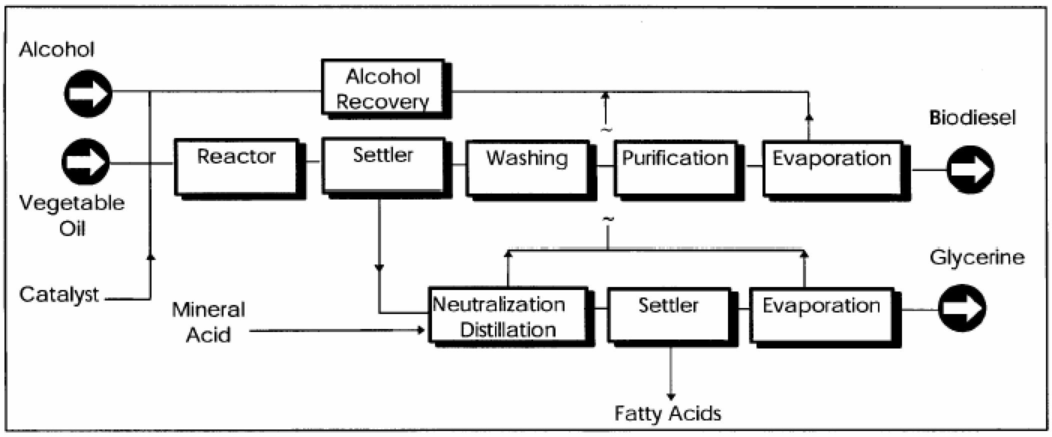
In a simplified manner, biofuels can be sub-divided into two large categories: biodiesel and bioethanol. This division puts forward the key properties of the two products. On one hand biodiesel (which replaces diesel in cars) is produced from oil rich plants (e.g. rapeseed, sunflower, algae, etc.) by mixing the vegetable oil (90%) with methanol (10%) in the process called trans-estherification; on the other hand bioethanol (which replaces petrol in cars) is also known as an alcohol and is produced through the fermentation of sugars from cereals (wheat, maize, etc.) or sugary feedstocks (sugar cane, sugar beet).

Already from the above separation one can distinguish two different markets: one product tackles the diesel based car pool while the other goes into the petrol cars segment. Also the raw materials are separated and the actual commodities are traded upon different demand-supply curves sets.

Secondly, each product category encloses a mix of production techniques and feedstocks. For clarity, we shall refer to the main techniques that are applied to the most common feedstocks that we already enlisted above. Nonetheless the marginal new feedstock will be mentioned as well.

Biodiesel production techniques

Biodiesel is commonly produced worldwide as "Fatty Acid Methyl Ester" (FAME), derived from recycled or virgin vegetable or animal fats and oils.
The production of biodiesel (FAME) can be summarized as follows[1]:



Although the trans-estherification process doesn't imply a complicated chemical reaction, it is particularly difficult to conduct it properly, which calls for the highest industrial standards to ensure the quality of biodiesel. Today, biodiesel produced or marketed in Europe should meet the specifications of the CEN standard EN 14214.

[1] The graph provides a sort of « average » scheme for biodiesel production. It must be specified that the processing of biodiesel can differ from one production unit to the other, EBB, 2007.

However, new production techniques or pathways have been recently developed. These are sometimes referred to as “second” generation biodiesel:

Hydro-treated vegetable oils (HVOs): New technologies provide for the hydrogenation of vegetable oils (HVOs) and animal fats into a paraffinic biodiesel, which presents near identical chemical properties with conventional diesel. Although hydro-treated vegetable oils in Europe are produced in free-standing facilities, this process can build on existing oil refinery infrastructures. To avoid any confusion with processes used in the food industry sector, the term « hydro-treatment » is preferred to « hydrogenation ».

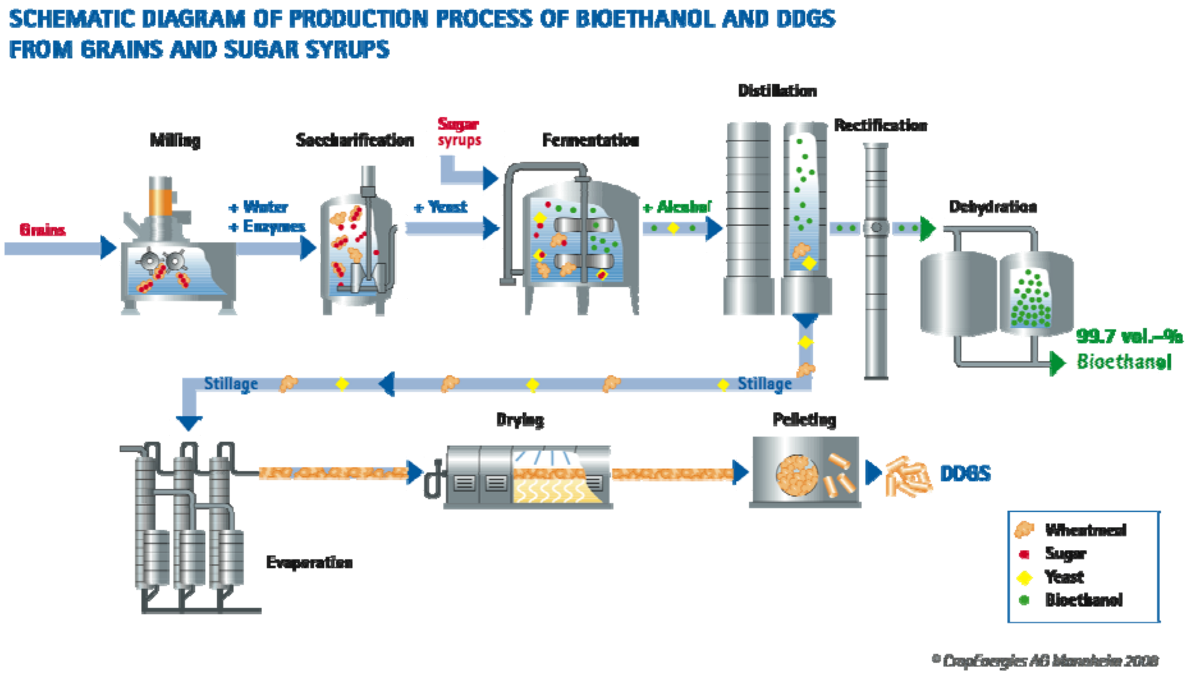
Biomass to liquid (BTL): Biomass to liquid (BTL) is a multi steps process to produce liquid biofuels from biomass. Contrary to currently used biodiesel pathways (FAME and hydro-treated vegetable oils and fats), the Biomass-to liquid process aims at using whole plants (biomass), including agricultural and forest residues.
The so-called “Fischer-Tropsch” technology, which is an integral part of the BTL process, is an advanced biofuel conversion technology that comprises gasification of biomass feedstocks, cleaning and conditioning of the produced synthesis gas, and subsequent synthesis to liquid (or gaseous) biofuels. Originally, this process was used for the production of liquid fuels from coal (CTL) and natural gas (GTL). The CTL, GTL and BTL production pathways are usually referred to as “XTL” fuels.

Biodiesel from animal fats and used cooking oils UCOs: Many European producers also use recovered vegetable oil and animal fats from food processing as it is a readily available waste product and produces a biodiesel with extremely beneficial greenhouse gas savings. Several of the biggest biodiesel producers in Europe are agricultural producers who add value to their oilseed products and processing capacities by converting oil to biodiesel, similarly many are involved in the oleo chemical industry as biodiesel production produces glycerine suitable for the cosmetics and pharmaceutical industries. Biodiesel production also results in increased availability of oilseed cake used for protein in animal feeds.

Algae biodiesel for Jet Fuel: While algae biodiesel has the same characteristics as normal fuel, the production process can be also used to capture CO^2 from power stations and other industrial plant (synergy of coal and algae). Algae oil production per acre is extremely high and does not even require agricultural land as it can be grown in the open sea, open ponds or on industrial land in photo-bioreactors. Moreover algae biodiesel production can be combined with wastewater treatment and nutrient recycling, where polluted water (cleaned by algae) acts as a nutrient in their growth. But most importantly is that algae biodiesel jet fuel represents the best potential answer for the sustainability of the aviation industry.

Bioethanol production techniques[2]

Bioethanol, also known as alcohol, is a renewable fuel made by fermenting sugars mainly from cereals such as wheat, maize, triticale, rye, barley and from sugar cane or sugar beet. The typical production process implies a series of steps, as follows:



As for biodiesel, the production techniques of bioethanol evolved in time through sustained investment in research and development.

(2) new feedstock and conversion technology to handle it

Advanced generations of bioethanol fuel offer the prospect of sourcing energy from an even wider range of feedstock. These include non-food crops such as grasses; agricultural residues such as cereal straws and corn stover; industrial, municipal and commercial wastes and processing residues such as brewer's grain; and forest products and residues such as wood and logging residues. Those new pathways will provide even higher greenhouse gas savings. Compared with a conventional feedstock, production of ethanol from new feedstock requires different technological (pre-) treatment:

Biomass Enzymatic Hydrolysis. extensive processing to release the sugars in cellulose and hemicellulose that account for 30 to 50% and 20 to 35% of plant material, respectively. However, the composition of biomass is variable and more complex than starch-based grain feedstock. The right combination of the "enzymatic cocktail" will be able to attack the cellulose and hemicellulose fractions, releasing sugars for fermentation. Research is being carried out to bring down the substantial costs of enzymes and thus the overall production costs of advanced bioethanol.
A further challenge is efficient co-fermentation of both hexose (six carbon, C6) and pentose (five carbon, C5) sugars to ethanol. None of the yeasts or other microorganisms currently in commercial use can ferment C5 sugars. Research is proceeding to develop organisms that can effectively use both types of sugars in order to maximize ethanol yields per ton of biomass feedstock. Efficient conversion of both types of sugars to ethanol is needed to make the whole process economical.

Thermo chemical conversion of biomass. The biomass first undergoes a severe heat treatment. In the presence of a controlled amount of oxygen, a process called gasification takes place. The product gas from gasification is called synthesis gas or syngas. If the process is conducted in the

[2] Input from Dr. Gloria Gaupmann, European Bioethanol Industry Association eBIO

absence of oxygen, the process is called pyrolysis; under certain conditions, this process might yield predominantly a liquid product named bio-oil.
The syngas can be used in a catalytic process for the synthesis of a variety of products. In a Fischer-Tropsch (FT) process, the syngas will be used for the production of transportation fuels like diesel and gasoline, along with other chemicals. The syngas can be used as well for the synthesis of methanol, ethanol and other alcohols. These in turn can be used as transportation fuels or as chemical building blocks. The bio-oil can be burned for direct energy production in a combustion process or can be gasified to syngas. Another potential use is the extraction of chemicals.

This ***biorefinery*** concept, where biomass is processed into a wide spectrum of marketable products, resembles a petroleum refinery: The feedstock (conventional or advanced) enters the refinery and is, through several processes, converted into a variety of products such as transportation fuels, chemicals, plastics, energy, food and feed. The feedstock is used in the most efficient way thus enhancing economic, social and environmental sustainability.

New utilizations:
Bioethanol in Fuel Cells: Electrochemical fuel cells convert the chemical energy of bioethanol directly into electrical energy to provide a clean and highly efficient energy source. Besides the fact that it comes from renewable resources, highly purified bioethanol can solve the major problem of membrane contamination and catalyst deactivation within the fuel cell, which limits its life expectancy.

E-Diesel: The bioethanol-diesel blend, better known as E-diesel, contains up to 15% bioethanol, diesel fuels, and additives. Compared with regular petrol-diesel fuel, E-diesel can significantly reduce particulate matter and toxic emissions, and improve cold flow properties. Research is underway to make E-diesel commercially available

Bringing down the learning curves and decreasing production costs is a common goal for the research in new technologies in both biodiesel and bioethanol industries. However this can only be done under a favourable policy mix that provides investors with the necessary return on investment security.

2. Standardization of sustainably grown biomass for biofuels

Since the production of biofuels in general is so strongly related to agricultural activities, the European production in particular follows the EU Common Agricultural Policy that governs all environmental standards of agricultural production.

Therefore the sustainability of European biodiesel and bioethanol is guaranteed by the Cross-compliance rules followed by the European Farmers and by all social and economical standards of developed economies.

As a result the European Production of biofuels does not contribute to deforestation or land degradation due to existing management practices and stringent national environmental legislation in the European Member States. Additionally, agricultural potential in new member states is finally becoming productive under the Common Agricultural Policy and European or private investment.

A need for standardization of sustainable production of biomass

Although biomass production in Europe rightfully claims the highest sustainability practices in the social, environmental and economical areas, a level playing field must be created at a planetary scale.
Secondly, it is senseless to standardize practices only in one sector of agriculture, where in fact the major sustainability concerns are omnipresent.
Thirdly, major risks are present or foreseeable in the future from a sustainability perspective. These risks can be found in different locations and present local/regional specificities.

Finally, it is important to consider the different legislations, the different regulatory frameworks but also the numerous voluntary initiatives that govern the biomass applications, especially for the biofuels end use.

Against this background, clear universal rules have to be defined for sustainable practices. At the same time the rules have to be applied for all biomass production horizontally, regardless of the final use. If this key point is disregarded, then the whole purpose of sustainability standards is lost. If only a small part of the production of biomass is being done in line with the sustainable practices and the rest is done through deforestation, biodiversity losses and in poor social conditions, then sustainability is nothing more than a market failure.

In this context, **one optimal approach is to harmonize the minimum binding requirements in the field of biomass for energy and to horizontally apply these requirements to all the biomass production regardless of the end use.** This approach should base itself therefore on the requirements already in place at EU level and in USA, Brazil, Malaysia, Indonesia, Argentina, etc.

Biomass stakeholders are ready for this step and are calling for harmonization of the binding rules in a meta-standard concept that will guide their sustainability and certification requirements (either present or future ones).

Overview on the Biomass Sustainability Standardization initiatives

There are today more than 25 international, national, regional, binding or voluntary initiatives and their number follows an ascending trend.

Although the purpose of this report is not to benchmark against the existing sustainability initiatives for biomass, an overview of what has been done is more than required within our scope of work.
The Certification initiatives will be laid down in the third part of this Chapter.

The existing initiatives in the field of sustainability of biomass for biofuels can be classified as from the beginning into the following main categories:

A. Main international initiatives, European initiatives
B. Member states initiatives, world national/regional initiatives
C. Minor international initiatives, regional initiatives, local approaches

A. This first category includes projects like:

- the Roundtable on Sustainable Biofuels,
- the Global Bio-energy Partnership Taskforce on Biofuels Sustainability,
- the CEN TC 383 on Sustainable Produced Biomass for Energy Applications,
- the Roundtable on Sustainable Palm Oil,
- the Roundtable on Responsible Soy,
- the MEO Institute International Sustainability Carbon Certification,
- ISO TC 28 /SC 7 Sustainability criteria for Liquid Biofuels
- International Energy Agency Taskforce 40 on Biofuels Sustainability
- United Nations Environment Programme Biofuels LCAs studies

B. The member states initiatives, world national/regional initiatives are:

- Germany: IFEU for the Biofuels Sustainability Ordinance BSO
- United Kingdom: Renewable Transport Fuel Ordinance RTFO
- The Netherlands: Cramer Criteria NTA 8080
- Belgium: Green Certificates System (Wallonia and Brussels regions)
- Switzerland: Environmental Law
- USA State of Massachusetts: Environmental State Law
- USA State of California: Low Carbon Fuel Standard LCFS

C. The minor international initiatives, regional initiatives, local approaches.

In this category we can include only the following initiative of the IPCC National GHG Inventory Programme. The other minor initiatives are relevant in the field of certification and we will refer to them in the next part of this chapter.

A standardization approach on the sustainable biomass production

A sustainability standard in the field of biomass for energy applications or other end-uses should follow the generic structure:

> 1. *Principles (1..n)*
>   a. *Criteria (i..m)*
>   i. *Indicators and verifiers (1..p)*

Each principle therefore includes one or several criteria while each criterion is covered by one or several indicators. The indicators are translated into verifiers which will form the actual "check-list" that auditors will use when going to the individual plant to perform the conformity assessment with the standard.

The **principles** are the overarching ideas or concepts that the standard tries to aim at. They can take the following form:

"Biofuel production shall follow all applicable laws of the country in which they occur, and shall endeavour to follow all international treaties relevant to biofuels' production to which the relevant country is a party." (Roundtable on Sustainable Biofuels - Version Zero, Principle One)

The **criteria** are therefore the particular aspects that one operator has to follow in order to apply the principle, for example:

"Producers and processors shall reduce GHG emissions from biofuel production over time." (Roundtable on Sustainable Biofuels - Version Zero, Principle Three, Criterion One)

Finally, **indicators** are the concrete verifiable and quantifiable aspects[3] that are used in the evaluation procedure. One such indicator could be for a plantation to have minimum GHG emissions of "X%" in "Y" year, per "Z" surface, for "T" crop.

A meta-standard approach

Aligned with the above systematic framework, a **meta-standard** for the sustainable production of biomass can be easily envisaged. A meta-standard is an umbrella for already existing standards. Its purpose would be to benchmark against other standards and its scope would cover all the legally binding sustainability provisions worldwide. Several concerned industries called for this meta-standard approach, among them the biofuels industry, the oil crushers, the farmers, the oil industry, etc. The benefits of such a move forward will clearly rest on the level of the burden that stakeholders will have to incur. Industries will face high costs and duplication of work if there is an atomicity of sustainability standards. On the contrary, one sustainability meta-standard will prevent stakeholders of spending high resources for the compliance with the standard. The economical decision will therefore be in favour of a meta-standard vision.

Voluntary standards

The **voluntary standards** that aim for higher sustainability requirements forecast different market responses. A voluntary standard is created when stakeholders foresee a comparative advantage if they differentiate themselves on sustainability grounds. Non governmental organizations (NGOs) call

[3] "Steps towards the development of a certification system for sustainable bio-energy trade", Levandowski and Faaij, Biomass and Bioenergy 30, 2005, p.83-106

for higher and stricter sustainability criteria in order to minimize/ cast all risks. NGOs favour therefore voluntary schemes that bring them the highest certainty for the protection of the field they are active in (e.g. biodiversity preservation, animal rights, human rights, etc.).

A combination of the two factors (on one hand the comparative advantage and on the other hand the NGOs urgency for progress) leads to the surging of voluntary sustainability standards for the biomass production.

Also, voluntary standards can be included under the umbrella of a meta-standard, however if the levels of strictness are too different, the meta-standard will restrict itself to comprise the minimum set of criteria and only the standards that are aiming towards that.

Conclusions

Finally, the market players will determine the relevance of different standards. They will decide upon their individual needs (imports/exports into/from different countries, marketing purposes, costs etc.). The market will therefore incline the balance towards a meta-standard that follows the legislation pathway or towards a more stringent voluntary standard.

In the field of biofuels in Europe, players face an obligation to market the product and the legislation has already set very high sustainability principles. As a result, there is no clear reason why players should set the sustainability threshold even higher. They already face the highest possible challenges compared to any other field of activity and they embrace these challenges courageously.

Ultimately, it is key to remember that costs are the main drivers for all economic activities which will include now more and more corporate and social responsibility (CSR), and sustainability aspects. In a cost and CSR-driven economy, the role for voluntary higher standards will remain clearly mitigated.

3. Certification

The next pillar of Sustainability is the practical implementation of the standard or of the principles and criteria that are aimed for. This step requires a tracking method and a labelling process and it is known as the **certification** of the product under assessment. Certification is the practice that implies third party assessment of the management procedures with respect to a certain standard.[4]

A good or service that is required to comply with a certain standard has to pass through the certification procedure. Here, the product will be translated from the pool of unidentified goods/ services into the smaller category of labelled goods. The product will be recognizable and its compliance with the standard in question will be indubitable.

Certification is the final step in the chain. However in order to fully develop the certification phase, one should discuss the previous segment, which is the traceability or the chain of custody.

Chain of Custody

The chain of custody is the course taken by the raw material (biomass) from the cultivation place (forest, agricultural land, etc.) to the final consumer[5]. This path includes therefore all successive steps from cultivation, crushing, manufacturing, transport, distribution[6].

A method for traceability is applied in order to keep record of the transformations occurring at each step. There are three main methods for traceability[7], generically called:

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[4] "Overview in recent developments in sustainable biomass certification" , IEA Bioenergy Task 40, 2006, p. 3;
[5] for biofuels we consider that the final consumer is the oil company that purchases biodiesel/bioethanol/biobuthanol, etc. for the blending purpose;
[6] FSC AC 2003;
[7] Idem, p.3

- track and trace - strict tracing and labelling at every step
- book and claim – full decoupling of the physical and the logical flow (e.g. green certificates for electricity)
- mass balance – a mix between the two methodologies above

Considering the particularities of biomass for energy applications, the optimal traceability method is considered to be "Mass Balance"[8]. This method takes account of the difficulty to trace the molecule of biofuels or of any other bundled products. In the same time it keeps sufficient restrictiveness to ensure with accuracy that the product is meeting a certain standard.

Certification initiatives

So far, certification exercises have been completed and implemented with success in the following fields: agricultural (crops, vegetables, fruits, etc.), forestry or electricity[9]. Also in the biomass sector, several international global or local initiatives have been created for the certification of the bio-energy or biofuels. The certification initiatives can be classified as follows:

A. Main international sustainability initiatives that include also certification
- Roundtable on Sustainable Palm Oil RSPO
- Forest Stewardship Council FSC
- Round Table on Sustainable Soy RTRS
- Better Sugar Cane Initiative BSI
- Roundtable on Sustainable Biofuels RSB[10]
- EUGENE – focus on the end part of the chain

The members in this category are identical with the ones mentioned in the sustainability initiatives subchapter. The participant experts set the scope of the sustainability initiatives to include certification. By inserting certification, the scheme becomes ready for implementation and the overall relevance of the initiative increases considerably.

B. Member States sustainability initiatives, world regional/ local initiatives that also include the certification step
- UK: Renewable Fuel Transport Obligation RTFO
- Belgium: Green Certificates System
- Netherlands: Cramer Criteria NTA 8080 – certification system for wood biomass
- USA: State of California: Low Carbon Fuel Standard LCFS

Similarly to category "A", the initiatives in category "B" included the certification phase for ensuring market implementation.

C. Pure certification initiatives, private, voluntary initiatives
- BiofuelsGO – focus on the second half of the chain
- SWAN Nordic Ecolabel
- SEKAB Certificates for Sustainable Brazilian Ethanol
- ENERS Labelling of Sustainable Biofuels
- Electrabel Certification of wood-pellets

The state of the art of sustainability research for biomass for energy is showing a complex framework in which voluntary and mandatory schemes co-exist. Also this framework has to be considered only as a picture in time. New initiatives and/ or certification schemes are announced regularly while the process of developing knowledge in this field will be a long-lasting one.

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[8] This is the method chosen by the European Commission for the traceability method for biofuels in the Renewable Energy Directive, voted in the European Parliament on December 17th 2008.

[9] Agriculture: EUREGAP , SAN Sustainable Agricultural Network, Fairtrade; Forestry: FSC Forest Stewardship Council; Electricity: EUGENE, Milieukeur, Ok-power, Green Power, Austrian Ecolabel;

[10] RSB aims at certifying biofuels and their standard will be ready for implementation in 2010

However, while analyzing the features of existing sustainability initiatives and the prospects for the future ones, it is important to consider all limitations in implementation, the drawbacks and the risks involved.

Risks and limitations in development and implementation of certification schemes

The application of certification schemes requires careful consideration of all factors involved. Early in the conception and the development stage, it is crucial to develop or to follow sound sustainability principles and criteria.

The parallel certification work is often criticised by stakeholders for lacking substance at the core or at the margin.

The main critiques or limitations brought forward so far are the following:

- ***scope inconsistencies***: the sustainability principles, criteria and indicators are not adequate; all stakeholders not involved in the sustainability process;
- ***implementation inconsistencies***: the monitoring and verification system are not adequate or even they are not practical for on-site auditing
- ***market failures***: the proliferation of labels and certificates undermined the substance of sustainability initiatives; final consumers are not making informed choices.
- ***costs barriers***: overburdening small producers leads to a market exit; the implementation of any scheme adds a cost to the overall production; when an individual operator is bound to comply with multiple schemes, he will be unable to cover costs[11].
- ***trade limitations:*** a sustainability and or certification system should not limit trade; however it should follow the legislation in force at national and international level.

Adequate measures to tackle each limitation or risk have been taken by numerous actors. Cramer *et. al* (2006)[12] and Zarrilli (2006)[13] are laying down the instruments to overcome the trade-related constraints and critiques. Also Ortiz (2006) is carefully considering the representation of interests of all stakeholders in the sustainability standard development process. Finally WWI (2006)[14] is proposing measures to tackle the consumer uncertainty and lack of information.

Conclusions

This chapter laid down the fundamentals of bio-energy in a sustainability context, starting with setting the stage with a classification of transport biofuels technologies. The main sustainability initiatives have been presented in a structured way, while the certification process and labelling schemes have been also described.

Defining the sustainability criteria for biomass for energy applications is a complex process which has crucial market implications. In the end, if not designed correctly, sustainability and certification schemes will undoubtedly trigger significant market disruptions. This is finally what all stakeholders are committed to avoid in any environmental-related field that is ruled by the "precautionary principle".

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11 "Biofuels for transportation - global potential and implications for sustainable agriculture and energy in the 21st century". Washington D.C., Worldwatch Institute, commissioned by German Federal Ministry of Food, Agriculture and Consumer Protection (BMELV) in cooperation with the Agency for Technical Cooperation (GTZ) and the Agency of Renewable Resources (FNR), WWI, 2006

12 "Criteria for sustainable biomass production", Netherlands, Projectgroep Duurzame Productie van Biomassa, Cramer et al., 2006;

13 "he emerging biofuels market: regulatory, trade and development implications", Geneva, United Nations Conference on Trade and Development (UNCTAD), Zarrilli, 2006

14 WWI, 2006