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THE FUTURE POSITION OF THE EUROPEAN UNION IN FREE MARKETS FOR SUSTAINABLE FUEL ETHANOL: A NORMATIVE APPROACH FOR EVALUATING THE FEASIBILITY OF EU POLICY OBJECTIVES

MÉMOIRE

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Table of Content

List of Figures

List of Tables

Summary

Biofuels, and particularly ethanol, play an increasing role as alternative fuels in the road transport sector. Nevertheless they still depend on policy support in order to be competitive. Like many other countries, the European Union protects its market for agricultural products, like ethanol, from more competitive producers. Besides border protection, the EU ethanol sector benefits from other support measures over the whole value chain. This is, however, not in the interest of long-term market development as liberalized ethanol markets are assumed to be more beneficial in terms of economics and greenhouse gas-savings. Rising concerns regarding social and ecological sustainability add to the current structural problems. Hence free trade in sustainable ethanol is a more desirable image for the future. In the context of this master thesis, it will be discussed whether and to what extent EU policy objectives are in line with this desirable image of the future, i.e. how current policy strategies supporting ethanol can be aligned to free trade and how they can contribute to more sustainable development of ethanol markets. The research suggests that current EU policy objectives are strongly biased towards enhancing farm income and rural development; this policy objective is, however, not in compliance with free trade. Furthermore, sustainable development of ethanol markets requires the EU to adjust the notion of competitiveness as stipulated in its energy policy. Despite the range of available policy instruments, it is challenging for the EU to achieve its policy objectives in liberalized markets for sustainably produced ethanol. Therefore research suggests that EU cannot promote trade liberalization and sustainability without jeopardizing its current policy objectives.

Keywords: Biofuels, International trade, Renewable energy policy, Climate Protection.

Résumé

Biocarburants et éthanol en particulier jouent un rôle de plus en plus important en tant que carburants alternatifs. Néanmoins, ils dépendent du soutien gouvernemental afin d'avoir le même niveau de coûts que les carburants basés sur le pétrole. Comme plusieurs d'autres pays, l'U.E. protège son marché agro-alimentaire, et donc le marché interne d'éthanol contre les importations plus compétitives. Quant au bioéthanol, ce protectionnisme implique des mesures différentes au niveau de la production des matières premières et au niveau du produit final (tarifs douaniers et subventions). En conséquence, la situation actuelle est désavantageuse pour le développement d'un marché durable. En fait, une situation de marché libre est plus favorable au niveau économique ainsi qu'au niveau des gaz à effet de serre. C'est pourquoi le commerce libre d'éthanol durable est le scénario souhaitable pour l'avenir. Dans le cadre de ce mémoire, le but est d'examiner si les stratégies politiques de l'Union Européenne soutiennent le marché libre et la production durable d'éthanol. La recherche suggère que la politique de l'Union Européenne est partiale vers l'augmentation du revenu des fermiers et du développement rural. Ce but politique n'est pas en accord avec le commerce libre. De plus, le développement durable des marchés d'éthanol force l'U.E. d'adapter la notion "capacité concurrentielle" consignée dans la politique énergétique. Bien que l'U.E. possède des nombreux instruments d'intervention dans un tel scénario, il est un défi extraordinaire pour atteindre les buts politiques. La recherche suggère qu'il est impossible pour l'U.E. de promouvoir un marché libre et durable sans perturber l'atteinte des buts actuels de sa politique en faveur d'éthanol.

Mots clés: Biocarburants, Commerce international, Politique de promotion des énergies renouvelables, Protection du climat

Chapter I

Introduction and Research Objective

1.1. A primer on biofuels, trade and sustainability

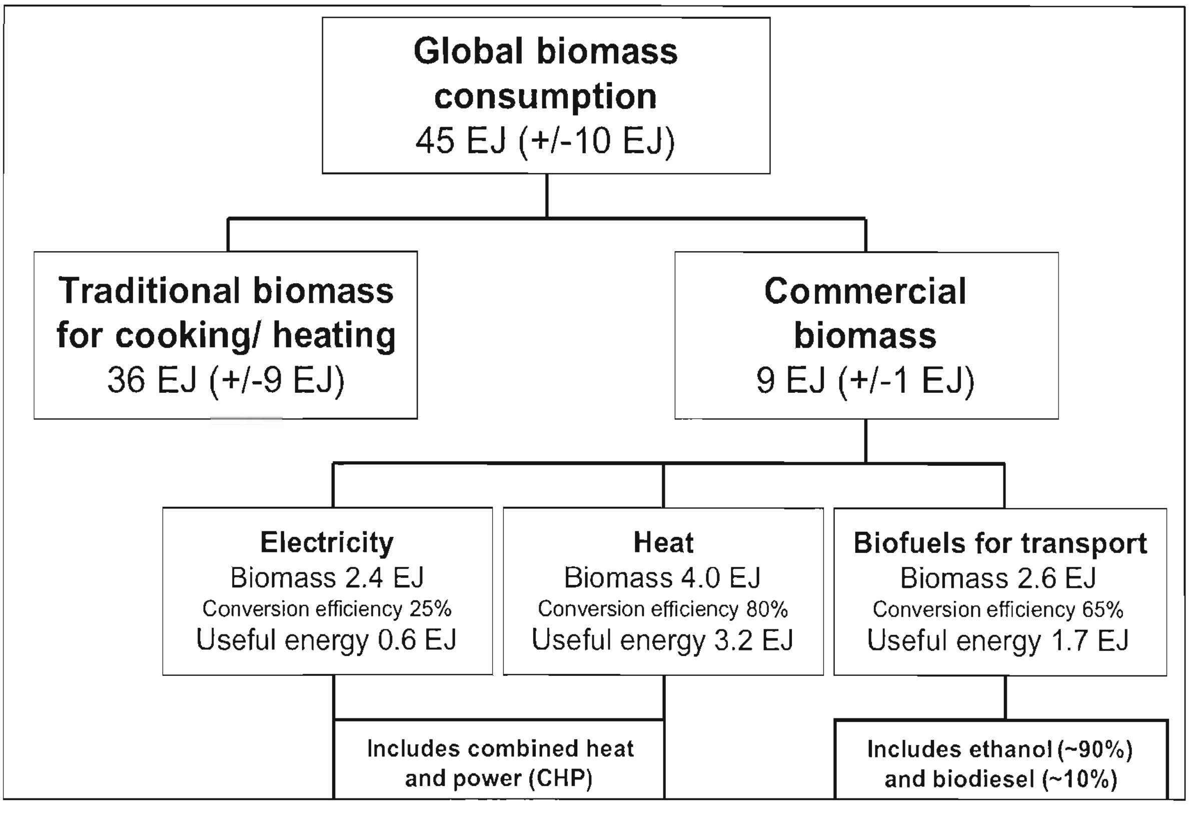
For the last two centuries fossil energy sources like crude oil, natural gas or coal have provided most countries around the world with cheap and abundant energy supply. This allowed exceptional economic growth and shaped production and consumption patterns worldwide. Burning fossil fuels, however, releases carbon dioxide and other heat-trapping gases into the atmosphere, leading to gradual global warming. The consequences are an increase in average global temperatures, decreasing agricultural production areas, higher sea levels that threaten coastal cities, and a disruption in national economies. The overall economic damage associated with a changing climate could amount to 20% of global GDP each year. Therefore it is impossible to separate future economic development from environmental issues (Stern, 2006).

In the future sustainable energy supply is imperative. Renewable energy from infinite natural resources, e.g. wind, solar energy, hydro power or biomass, is associated with significantly less emissions than conventional fuels. In the same way, the efficient use of energy is imperative for making future consumption and supply more sustainable. The causes of global warming can be described as "the biggest market failure ever seen" (Stern, 2006), because limited environmental resources have not been appropriately been paid for. Therefore, governments around the world have to intervene in order to create a market for emissions by pricing carbon dioxide and similar gases, or by setting emission caps. In more technical terms, government intervention is required to internalize externalities. In consequence, costs for fossil energy sources increase and the competitiveness of renewable energy as well as of energy efficiency technology rises.

It is important to note that other than environmental benefits are associated with the development of renewable energy sources. Hence there may be numerous other justifications for market intervention. Governments around the world expect significant economic benefits in the context of the transition towards a "greener economy", because it is necessary to develop new technologies for energy production and efficiency, and to implement them on a large scale. Furthermore the idea of using a country's natural resources to produce "green" and "home-made" energy is appealing and very popular in most societies. Against the background of depleting fossil energy sources and a high level of import dependency on vital energy commodities, particularly crude oil, there is an increasing pressure to find alternative energy sources.

Biomass is often perceived as a new, alternative energy source. It includes all non-fossil materials of biological origin like energy crops, agricultural and forestry wastes and by-products, manure or microbial biomass. However, it is the most ancient source of energy that plays a particular role in developing and least-developed countries. In 2007 the contribution of biomass to world primary energy demand was around 10%, or 470 exajoule (EJ). Around 80% of global biomass consumption (36 EJ) was devoted to traditional use, e.g. wood for heating and cooking. Dedicated crops grown for energy purposes, so-called commercial biomass, is used for electricity, heat and biofuels for transport. It accounted for 20% of global biomass consumption (9 EJ). This kind of biomass-based energy receives particular attention as technology can help to transform energy stored in the plant into substitutes for fossil fuels. Moreover commercial biomass is associated with value creation in the agricultural sector and in (biomass-) processing industries. Biofuels for transport have a special appeal because they displace fossil *transport* fuels, which are imported in most countries. Therefore policy makers see triple benefits in promoting this kind of energy technology: in addition to environmental benefits and lower import dependency, biofuels create additional outlets for farmers and, thus, support development in rural areas. This master thesis focuses on ethanol, which displaces gasoline in spark-ignition vehicles. In 2007 it accounted for 90% of global biofuel consumption. Biodiesel (for diesel engines) accounted for the remaining 10%.

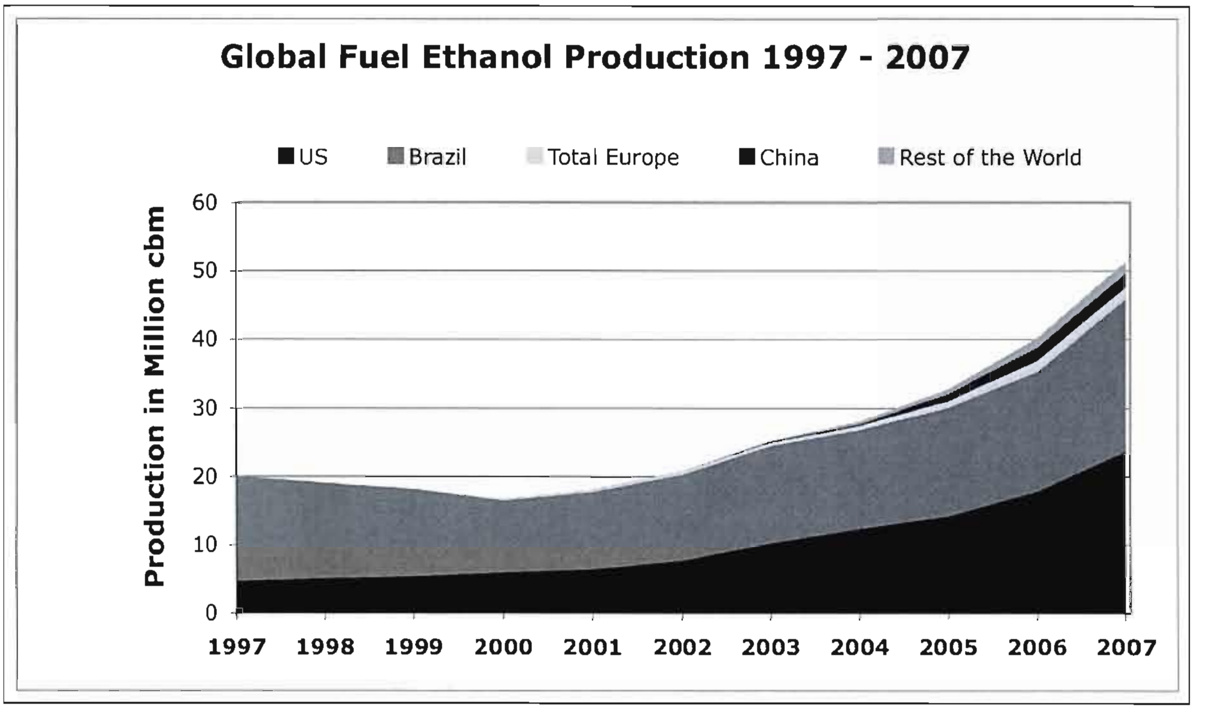
Figure 1.1: Global biomass consumption in 2007



Source: FAO (2008)

Based on the previous reasoning it is not surprising that the development of fuel ethanol in all countries is driven by government policies. However, environmental concerns do not always dominate policy making. In the United States, where promotion of ethanol started in 1978, the focus was on improving air quality by displacing lead and other more polluting gasoline additives with ethanol. In recent years, energy independence and security became a rising concern for policy makers so that today ambitious policies fostering ethanol production aim at increasing independency from major oil producing countries. Brazil launched its "Proálcool" programme to promote ethanol in 1975. The major objective was to reduce oil import bills, which were putting great constraints on the external trade balance, and to stabilize prices for agricultural products by creating additional outlets for farmers. Thanks to competitive input (sugarcane) and continuous process improvements, Brazilian ethanol is today competitive with gasoline. Despite numerous setbacks and market imbalances in the nineties, Proálcool has become the most important bioenergy programme in the world and a role model for other countries (Henniges, 2006; Goldemberg et al., 2004; Berg, 2004; Moreira/ Goldemberg, 1999).

Figure 1.2: Global fuel ethanol production from 1997 to 2007



Source: own illustration based on BP (2008)

As in the USA and Brazil, reducing oil dependency and diversifying energy sources are still principal motives for developing economies like China (the third largest producer of fuel ethanol in 2007), India or Thailand to foster production of fuel ethanol. However, environmental and rural development benefits become increasingly important, not only in these countries. The ratification of the Kyoto Protocol, for instance, is the main reason for Canada developing a domestic fuel ethanol industry. Countries in Central and South America (e.g. Colombia, Peru) seek to follow Brazil in establishing a domestic fuel ethanol sector, driven by the aim to foster development in rural and often poor areas, savings on foreign currency and improving access to commercial energy (Walter et al., 2008). Creating additional outlets for farmers and sugar refiners was the rationale behind policies in Australia, India or Thailand to launch production at the beginning of this decade (F.O. Licht, 2003; Berg, 2004). In the European Union, the fourth largest producer of ethanol, rural development, energy security, and environmental issues have an equal importance (Loppacher/ Kerr, 2005).

In many countries there is a long history of market intervention in favour of ethanol and biodiesel, which primarily aimed at the promotion of rural development and energy independence. On the one hand, policies are required to push the development ethanol and to bring costs down to the level of conventional fuels. On the other hand, governments seek to benefit from side effects associated with the development of new technologies. Analysis from the USA (Rubin et al., 2008) and the EU (Kutas et al., 2007) suggest that these motives still play an important role. Consequently, the problem is that ethanol and biodiesel policies are not exclusively designed to promote a sustainable, long-term solution to environmental problems. In order to achieve such a long-term solution, two major challenges have to be tackled: the issue of sustainability and the creation of a global market for biofuels.

In order to illustrate the need for global markets in sustainably produced ethanol, it is best to start with the current market structure. Policies to promote biofuels are implemented in markets, which *are* already subject to high government regulation. Markets for most agricultural commodities are already constrained by severe trade distortions like tariffs or national (export) subsidies. Often governments in industrialized countries limit trade for those commodities that domestic farmers produce less efficiently than foreign producers due to climatic conditions. Typical examples include sugar or cotton. Costs for ethanol, the world's most important biofuel, vary significantly from one region to the other due to differences in costs for feedstock, i.e. the agricultural input used in the production process. Ethanol made from sugarcane, for instance, is more competitive than ethanol produced from grain feedstocks. Consequently, policy makers have to translate trade distortions on the level of feedstocks into trade distortions on the level of bioenergy markets in order to avoid "leakage effects". Considering the initial argument that renewable energy, including energy from biomass, is a more desirable form of energy, an important - though rather rhetoric - question is whether it is desirable that future energy markets are subject to significant trade distortions. Loppacher and Kerr (2005) conclude:

> "[...] the isolation of industries in each country could significantly impede the development of this unconventional fuel. Significant welfare benefits could be achieved through increased integration, international standards and uniform rules for this industry. However, due to conflicting policy goals of some of the major players internationally, this is unlikely to happen. [...] a more efficient international trade regime will be necessary. Producers should begin pushing for reforms immediately as these can take years to achieve and will be easier to achieve before positions and special interests are entrenched."
> Loppacher/ Kerr (2005: 22-23)

Consequently inputs, production processes and products need to be standardized to ensure a fungible market and to seize environmental benefits.

The second major issue concerns the sustainability of biofuels. The United Nations define sustainability (or sustainable development) as:

> "[...] Development that meets the needs of the present without compromising the ability of future generations to meet their own needs."
>
> World Commission on Environment and Development (WCED, 1987: Chapter 2, 1)

Sustainable development is based on the concept of "needs", particularly on the essential needs of the world's poor, and on the concept of limited environmental capacity - due to technology and social organization - to meet present and future needs. The need to counteract global warming by switching to cleaner energy sources follows immediately from the notion of sustainability. In the same way it strictly limits the development of economic activity whenever such activities endanger natural systems like waters, soils and the living beings, that support life on earth. In addition to respecting available environmental resources, sustainable economic development takes into account that resources and income should be equally distributed so that all human beings can cover their essential needs. In this context trade plays a crucial role: currently, gains from trade are unequally distributed, and patterns of trade negatively affect economies and ecologies of those countries that are currently disadvantaged (WCED, 1987). Free trade has the potential to cover essential human needs in these countries through economic growth and higher income. Both factors help to overcome essential problems, like access to safe water, urban sanitation and the overuse of natural resources due to poverty (Kane, 1999). The development of a sound ethanol market cannot be regarded separately from sustainable development because the fuel can provide significant savings in GHG-emissions compared to gasoline and the fuel can lead to additional income in rural areas, particularly in those countries and areas that suffer most from current trade distortions. Furthermore, biofuel production can contribute to decrease the pressure petroleum imports exert on trade balances of many developing and least-developed countries. Despite these benefits, farmers have to respect sensitive ecosystems, i.e. important global resources, when expanding feedstock supply for biofuels. In the same vein, the expansion of energy crop area should not be at the expense of basic food crops, which cover the essential needs of many poor in the world (FAO, 2008a).

The current debate on sustainably produced ethanol vastly focuses on minimum social and environmental standards for the fuel. There are several inter-governmental initiatives that involve many stakeholders from all kinds of organizations (e.g. the Roundtable on Sustainable Biofuels). Moreover, various governments and other stakeholders are currently defining own standards based on their research and general perspective on the topic (e.g. various German Ministries, WWF, Greenpeace). The OECD, the United Nations and associated organizations are the only ones that regularly underline the importance of economic sustainability, notably the role of free trade.

The debate on whether biofuels could become globally traded goods is also at the heart of current negotiations in the framework of the Doha Development Round of the World Trade Organization (WTO). By now, industrialized countries reject to facilitate market access for biofuels, whereas developing and non-industrialized countries are strong proponents of biofuels and wish to add them to the list of "Environmental Goods", for which lower tariffs would apply (UNCTAD, 2006). Several authors have made valuable contributions to the discussion (Steenblik, 2005; Howse, 2007; Bruehwiler/ Hauser, 2008). However, as outlined earlier, industrialized countries must be willing to open their markets for agricultural goods in general. Otherwise facilitated market access for biofuels only would undermine the protection of other agricultural sectors, notably those for biofuel inputs.

As trade negotiations on biofuels reach a deadlock and discussions about sustainability gain in importance, it comes at no surprise that market and policy uncertainty determine the outlook for global ethanol production. Market outlooks from commodity analysts (e.g. F.O. Licht 2007) and industry experts (Walter et al., 2008; Walter et al., 2007) see the major producers, i.e. Brazil and the USA, in a dominant role. The development of ethanol industries in other countries greatly depends on future support on national level and on the outcome of multilateral negotiations on trade and sustainability. If other countries than Brazil and the US start to produce sustainable ethanol on a larger scale, the fuel can become a win-win solution. Although it is not a panacea to deal with all kinds of problems, it can contribute to solve some of the issues that the world needs to address urgently. In this context trade plays a crucial role in enlarging the share of biofuels on future transport energy demand (Walter et al., 2007).

For further analysis the future policies and actions of governments in industrialized countries play the most important role: their image of a future global market for bioenergy is crucial, because

- less developed countries tend to be less concerned about environmental issues as their focus is on economic growth to cover essential needs. Environmental concerns are especially high in industrialized countries, partly because these regions *have* already experienced significant economic growth in the past, which makes them more aware of ecological issues today (Fritsch et al., 2008).
- the need for alternative, low-carbon energy sources is important to counteract climate change. Industrialized countries are the main polluters and main users of fossil energy sources. Their economic strength and their power position enable them

to push the development of sustainability and of renewable energy sources in particular (Stern, 2006).

- they are the main countries that limit trade in agricultural products, and thus, in biofuels and feedstocks at the expense of less developed countries (Kojima et al., 2007; FAO, 2008a).

1.2. The Starting Point for Further Research

This master thesis focuses on the use of ethanol in one of the major producer regions: the European Union (EU). The EU seeks to displace 10% of all road transport fuels with either ethanol or biodiesel in 2020. The role of the EU is of particular interest because the community has significant measures in place to distort trade in agricultural goods, is a major polluter of the atmosphere, and has committed to sustainable development in its major guidelines. Since ethanol contributes to the achievement of policy objectives in various fields, such as energy, environment, and agriculture, the European Commission (EC) has defined seven policy axes for promoting the fuel: the so-called European Biofuels Strategy.

The goal of this master thesis is to assess the feasibility of EU policy objectives in relation to ethanol in a "free trade in sustainable biofuels" scenario in 2020, and - based on the findings - to propose an "Alternative Ethanol Strategy" for the EU. To reach the goal, four phases of analysis are required: (1) it is necessary to clearly define policy objectives in relation to ethanol (Chapter 5); (2) the current policy trade-offs have to be analyzed to reveal the relative feasibility of each objective under free trade (Chapter 6.1); (3) those sustainability issues that can be included in free markets have to be sketched out and remaining issues have to be addressed (Chapter 6.2); and finally (4) effective policy strategies have to be proposed to reach the objectives (Chapter 6.3).

The present research is based on existing literature and data. The rationale is to analyze the information in a framework that emphasizes the normative character of policy objectives, policy strategies and sustainability. It is important to note that policy making is by its very nature a normative process, i.e. a process driven by values (Robinson, 1990). In the same way, the notion of sustainability involves value judgements "with respect to which qualities of which resources should be sustained by which means, as well as for and by whom" (Sikor/ Norgaard, 1999). A normative perspective on bioenergy markets has not been taken yet by other researchers. Indeed, most scientists reject such a perspective on a subject because they search for "objective" results. At the same time, however, they neglect own value judgements when it comes to underlying assumptions for, and recommendations from their analysis (Robinson, 1988). In the present thesis a qualitative scenario approach will be applied that strictly ties future developments to policy objectives (backcasting). Based on fixed objectives, causal arguments that explore the limits of the future development will be used to evaluate the relative feasibility of each policy goal under the specific constraints, i.e. the sustainability and free trade criteria previously defined.

The outcome is not only interesting for researchers in the biofuels and bioenergy sector, but also for those interested in how far free trade and sustainability are compatible. The normative approach of this thesis allows to illustrate whether combining both issues, sustainable development and free trade, just leads to a *theoretic* concept that serves for discussions among scholars, or whether such a concept has the potential to promote today's policy objectives. In this context ethanol markets can be considered as an ideal case because trade liberalization and the implementation of sustainability issues prove to be a significant driver to future market development.

1.3. Research Questions

The following premises represent the vantage point for the research questions:

1. The European Union, as one of the most powerful economic regions, has considerable influence on the outcome of multilateral negotiations on climate change, sustainability principles and trade.
2. Societal values regarding environmental protection and multilateral co-operation in economic and environmental issues shape future energy markets. Depending on the interplay of these trends different scenarios for 2020 are possible. However, sustainable development, as defined earlier, should be the underlying principle for a desirable future scenario. The most direct interpretation of sustainability implies free markets, in which ecological resources are protected, environmental limitations respected, and in which the needs - particularly those of the poor - are sufficiently considered.
3. Policies on national and international level remain the major driver for the development of biofuel markets. The point of reference for policy objectives are explicit statements made in official EU documents. If no such references exist, implicit policy objectives for ethanol can be derived from the situation in markets for crude oil

and/ or gasoline. Policy objectives can be defined depending on whether the current state of affairs in these markets is perceived as desirable or not.

4. For the European Union, all policy objectives in relation to ethanol are equally important. If sustainability is the underlying principle of EU policy makers, then policy objectives and strategies should fit into this framework.
5. Policymakers define objectives and elaborate strategies to achieve these objectives. The goals policymakers are aiming for and the strategies they employ indicate their willingness to promote certain trends and to co-operate with others on major issues. When analyzing policy objectives and policy strategies separately, it is possible to identify different means to achieve a goal and thus, the feasibility of policy objectives under certain conditions. Analyzing the decision for or against certain strategies also reveals the implicit and explicit objectives of policymakers.
6. The inability to reach a balanced outcome of policy objectives through several iterations, e.g. scenarios or plausibility checks, e.g. trade-offs, can be said to represent strong prima facie evidence that the goals and constraints defined earlier present problems.

Based on these premises the following research questions guide through this thesis:

1. What *concrete* policy objectives in relation to ethanol does the European Union aim for?
2. What are the major trade-offs of the current Biofuels Strategy? And, against the background of sustainable free trade, what policy objectives are at risk on the short term and on the long term?
3. To what extent is it possible to include sustainability principles in free trade and what issues remain to be addressed?
4. What strategies are required to bring current EU policies regarding ethanol in compliance with a sustainable free trade? Or differently stated, what are essential policy strategies of an "Alternative EU Strategy for Ethanol"? Can the implied objectives of the Biofuels Strategy be reached in that case?

Chapter II

Economics and Sustainability of Global Ethanol Production

This chapter provides the background of global ethanol production. The first objective is to critically analyze economics and environmental benefits of ethanol based on a transparent methodology. The data will be the vantage point for further analysis within this master thesis. The second objective of this chapter is to show how sustainable development and biofuel production interrelate. In particular it will become obvious why trade and sustainable development are imperative for the future of a global ethanol market.

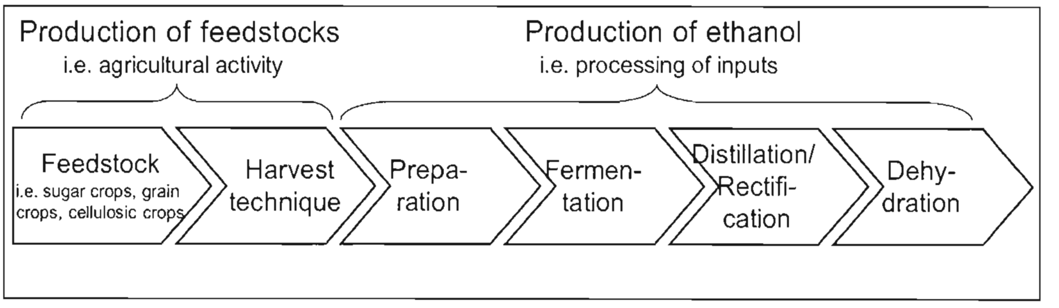
2.1. Definition of Ethanol

Ethanol is a clear and colourless liquid that can be used for chemical and pharmaceutical purposes, in beverages, and as a transport fuel (F.O. Lichts, 2003). It can be produced from a variety of feedstocks (biological or fossil) in very different production processes. This master thesis concentrates on ethanol as a transport fuel made from biological feedstocks.[1]

Since ancient times the production of ethanol has included two major steps: fermentation of sugar/ glucose and distillation of the fermented mash. In principle, all biological feedstocks that contain appreciable amounts of sugar, starch, or cellulose can be converted into ethanol (IEA, 2004). Depending on the feedstock, however, different preparation steps are required in order to convert the biological materials into glucose. The following fermentation and distillation processes are similar for all inputs. The process yields ethanol, which is a (chemically and economically) homogenous product (Henniges, 2006). The following figure summarizes the crucial production steps.

[1] Most authors use the terms "alcohol", "ethanol", "fuel ethanol", and "bioethanol" synonymously. Chemists refer to ethanol as "ethyl alcohol" (chemical formula C_2H_5OH) whereas some stakeholders call the fuel "agro-ethanol". In this master thesis the term "ethanol" will be used for describing transport fuel.

Figure 2.1: Steps in the production of ethanol



Source: own illustration based on IEA (2004).

Ethanol production entails various by-products that depend on the kind of feedstock and the energy concept of the production plant. These by-products are either marketed or re-used in the production process. The following section briefly explains the production of ethanol by feedstock.

2.2. The Production Process

2.2.1. Ethanol Production Based on Sugar Crops

Sugarcane and sugar beet are typical feedstocks for sugar-crop-based production processes. Cane-based ethanol production commences with crushing sugarcane stalks, which contain significant amounts of sugar. Process water is then required to extract the sugary juice from the bagasse (fibrous part of the stalks and leaves, “cane trash”). In order to clear the juice it needs to be heated at (150°C) and lime (or calcium and sulphate) is added The juice evaporates, thus concentrates, and results in sugar crystals. The residue is referred to as ‘A-molasses’. The process can be repeated twice, resulting in ‘B-’, and ‘C-molasses’. The sugar crystals are sold, while molasses represents the actual input of ethanol production. (F.O. Lichts, 2003).[2] Alternatively, the sugar cane juice can be used directly for ethanol production. By adding yeast, the mash (i.e. molasses and additional water) ferments at 34 - 36°C. In this phase, CO2, which has been absorbed by the plant during photosynthesis, is partly emitted. [3] After twelve hours, the mash shows a 7%-ethanol content, which increases during the distilla-

[2] B-molasses is the residue of the second, and C-molasses of the third process of crystallisation. Sugar producers conduct three crystallisations, depending on market economics (Ibid). Typical yields for cane molasses are 270 litres of ethanol/ ton (C-molasses, sugar content of 55%), 350 l/ t (B-molasses, 72%), 410 l/ t (A-molasses, 83%), 425 l/ t (sugar syrup) (F.O. Lichts, 2003: 14).

[3] The chemical reaction of sugars leads to 49% of CO2 and 51% of ethanol (theoretical maximum yield).

tion and rectification process[4] to 96% (hydrous ethanol). To produce 99.5% ethanol, which is water free or anhydrous, it needs to be treated with chemicals and steam. Ideally, molecular sieves reduce the need for steam in the dehydration process (Schmitz, 2005).

In Europe, the harvest of sugar-beet starts in September/ October and ends in November/ December. Once sugar beets arrive at the ethanol plant, they have to be cleaned, a process, which is not required for sugar cane (Schmitz, 2005). The following step includes slicing the beets and extracting the glucose. As with sugar cane, molasses or sugar beet juice[5] serves as input for the production of ethanol. If molasses is the main input, sugar crystals from previous process steps are marketed. The fermentation, distillation and dehydration steps are similar to those described above (IEA, 2004).

Although both processes seem similar, important differences exist in relation to the by-products. As mentioned above, it is not possible to use the cane trash in the fermentation and distillation process. However, the bagasse provides energy in the production process of cane ethanol (electricity and heat in a combined heat and power plant), which may even result in net energy gains (Schmitz, 2005). In contrast the remainder of the sugar beet preparation, which is sliced and glucose free cannot be used in any further production process. It has to be dried and marketed as animal feed. Finally, pulp, as a remainder of the distillation process, serves as fertilizer or animal feed (both production routes), or it dilutes the molasses before fermentation (sugar beet only; Schmitz, 2005).

2.2.2. Ethanol Production Based on Grain Crops

Other grains used for the grain to ethanol process are starchy plants, such as wheat, rye and corn. The use of other starchy feedstocks is possible, but not practised on a large-scale due to low competitiveness (potatoes), little experience (cassava) or better alternatives (corn is preferred to sweet sorghum). In comparison to sugar-based ethanol production, starchy feedstocks require an additional process step called "saccharification" to convert the starch into glucose. Saccharification starts with (wet- or dry-) milling of grains.[6] In the following process hot water is added and, under high pressure, the starch "explodes". Thus, its molecules become receptive for the enzymes added in the next step. These enzymes are α-

[4] Rectification is an advanced distillation process. A temperature of 78°C is required for the mash so that the ethanol content can evaporate.

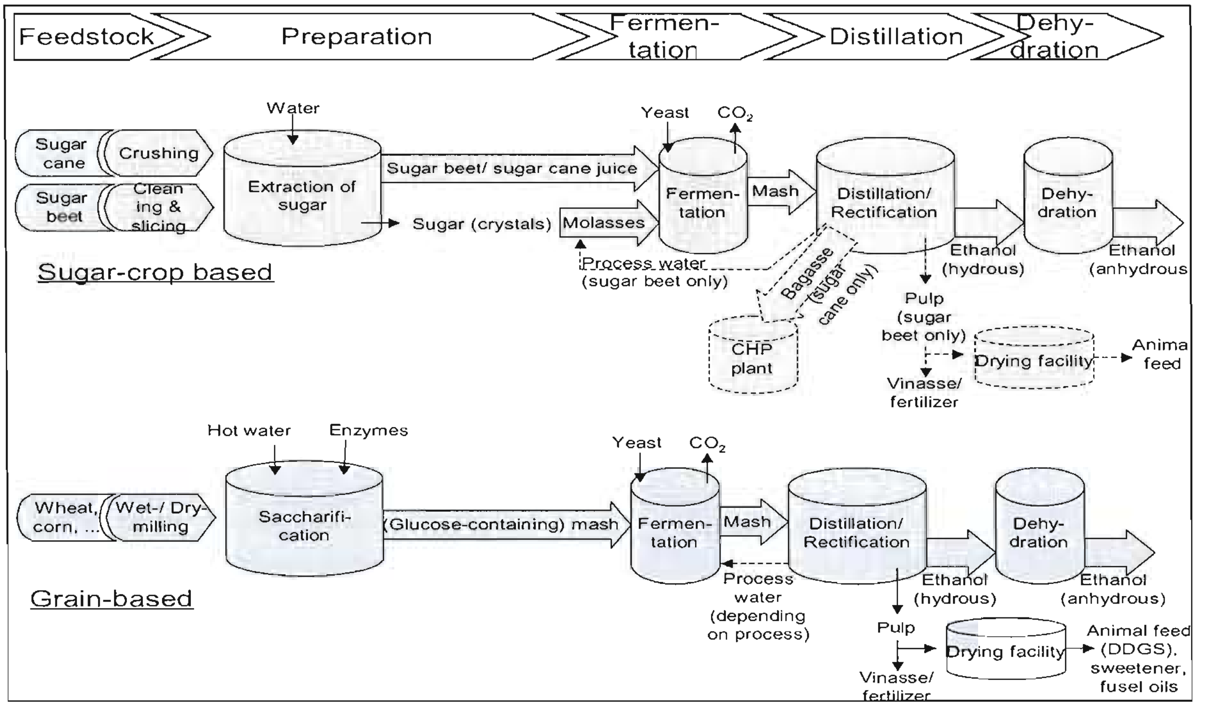
[5] Sugar beet juice consists of the glucose as extracted from the beets (20%) and the water (80%) from the previous process step.

[6] The process of dry milling is relatively simple but energy-intensive. Wet milling, by contrast, requires the grains to steep in water for 24 - 48 hours before milling starts. This process is less energy intensive but requires higher investments in milling equipment (F.O. Licht, 2003).

amylase, to reduce the viscosity of the mash (added at 80 - 90°C), and ampyloglucosidase (β-amylase), to produce glucose (added at 65°C). Thereafter, the mash contains sufficient amounts of glucose, which is fermented (F.O. Lichts, 2003; Schmitz, 2005). The fermentation, distillation and dehydration processes are similar to those described above.

Due to the variety of possible feedstocks, the production of ethanol based on grain crops yields numerous co-products. Virtually all distilleries market the pulp resulting from distillation as protein- and vitamin-rich animal feed. It is possible to sell the pulp directly to producers of fodder or as distiller's dried grains with solubles (DDGS) after drying. Moreover, ethanol production from grains may yield sweetener (corn-based production) and certain oils (F.O. Lichts, 2003; IEA, 2004). In contrast to sugar cane processing plants, grain-based ethanol plants do not produce sufficient electricity nor the heat required for the production of fuel.[7] Therefore, most distilleries procure the energy required from nearby cogeneration plants (Schmitz, 2005).[8] The following figure illustrates the conventional production process of ethanol.

Figure 2.2: Ethanol production based on grain and sugar crops



Source: own illustration based on IEA (2004)

[7] Once converted into biogas, the pulp could equally serve as process fuel. This, however, is only a theoretic concept and not suitable for large-scale ethanol production, since each litre of ethanol yields 10 litres of pulp. This would require enormous storage facilities for biomass and cause logistical problems (Schmitz, 2005; Henniges, 2006).

[8] Cogeneration plants (synonymously: combined heat and power (CHP) cycles) process fossil fuels (e.g. natural gas), biomass or municipal wastes to produce heat and electricity.

2.2.3. Ethanol Production Based on Cellulosic Biomass

In conventional crop-to-ethanol processes, only a small percentage of the crop (the starchy or sugary part) is converted into ethanol. Although cellulose, hemicellulose and lignin represent most plant matter, they are residues of conventional production processes.[9] Therefore, current research focuses on the use of cellulose and hemicellulose, which are polysaccharides that can be hydrolysed to sugars and be fermented to ethanol (Hamelinck et al., 2005a). Potential inputs to the production process include all sorts of agricultural wastes and energy crops, forest residues, municipal solid wastes (MSW) and wastes from pulp/ paper processes. These kinds of feedstock entail numerous advantages, as they are inexpensive and abundant (IEA, 2004).

The conversion of ligno-cellulosic materials starts with mechanical pre-treatment to size the biomass and to destroy its cell structure. After size reduction, lignin, which provides structural support (for the plant), hemicellulose (C-5 and C-6 sugars) and cellulose (C-6 sugars) are separated by chemical, physical or biological treatments. When adding water or steam, the free hemicellulose is hydrolyzed to sugars. Thereafter, hemicellulose is ready for fermentation and separated from the cellulose and lignin parts. The most common methods used to saccharify the cellulose are acid-hydrolysis (i.e. chemical treatment, at the expense of sugar-yield) or enzymatic hydrolysis (a relatively new and currently expensive method resulting in higher sugar yields). In the long term, the use of enzymes (notably cellulase) to hydrolyse cellulose should become viable, particularly if costs for enzymes decrease (e.g. by enzyme recovery and recycling). Advanced production processes merge the fermentation of hemi-cellulose (C-5 sugars), hydrolysis of cellulose and fermentation of the resulting C-6 sugars in one process step (simultaneous saccharification and fermentation: SSF; Hamelinck et al., 2005a).[10] According to Hamelinck et al. (2005a), the logical endpoint in the evolution of biomass conversion technology would be consolidated bio-processing (CBP). In CBP, a "micro-organisms community" produces ethanol and all required enzymes in a single reactor. Thus, there are no costs for enzyme production or purchase and investments could be significantly reduced.

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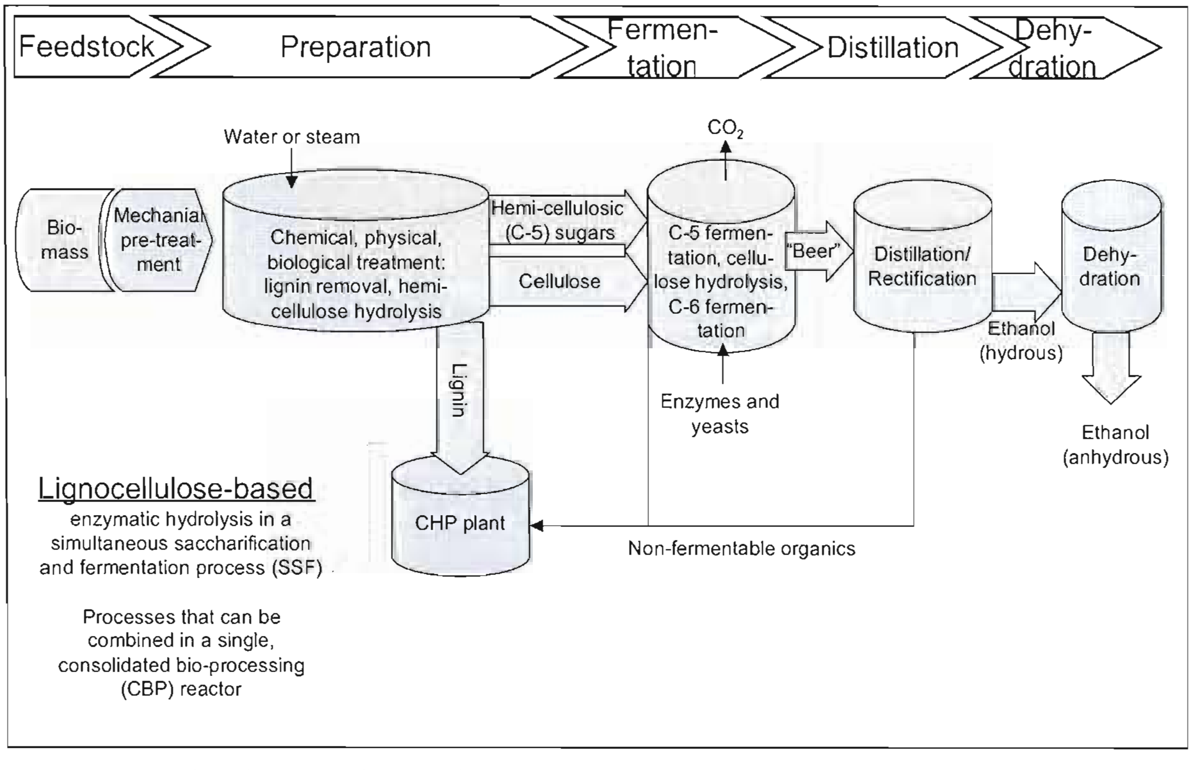
[9] Cellulose makes up 40 - 60% of the dry biomass, hemicellulose 20 - 40% and lignin 10 - 25%.

[10] Although dilute acid-hydrolysis of cellulose leads to very high sugar yields (90%), allows for handling diverse feedstocks and is a relatively rapid process, enzymatic hydrolysis is more promising. This is, because the use of enzymes will allow for merging numerous process steps into one, like in the case of SSF.

In contrast to the fermentation process described earlier, various yeasts and genetically modified microbes are required to ferment the mash under oxygen-free conditions and to attain sufficient ethanol content (F.O. Licht, 2003). Distillation, rectification and dehydration are proven processes from sugar- and grain-based ethanol production. They require no further research and development (R&D) efforts, whereas the biomass pre-treatment, the production of suitable enzymes and the co-fermentation of C5 and C6 sugars remain crucial R&D issues (Reith et al., 2002).

The remainder of the preparation phase is lignin, which is burnt to produce heat and electricity in a cogeneration process (Schmitz, 2005). In the same way, the pulp, as a residue of the distillation, may also be used for the production of energy.[11] Ethanol based on ligno-cellulosic feedstocks belongs to so-called second-generation biofuels that require no traditional energy crops as feedstock and therefore avoids land-use conflicts with the production of food- and feedstuffs as discussed later. The following figure summarizes the principle production processes for ethanol by feedstock.

Figure 2.3: Ethannol production based on ligno-cellulosic feedstock



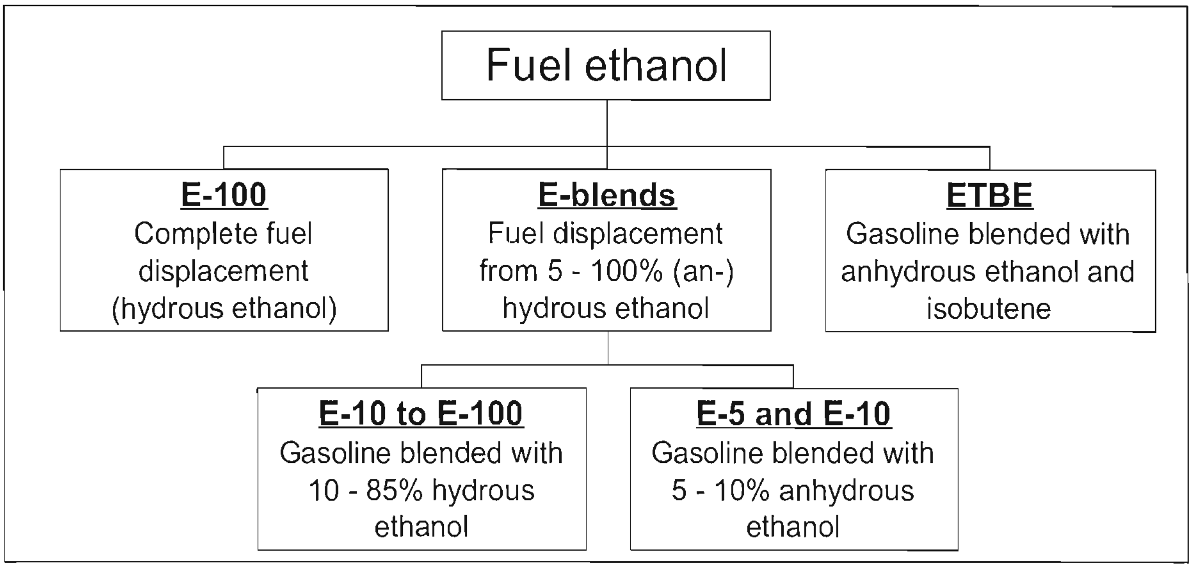
Source: based on Hamelinck/ Faaij (2006).

[11] Currently, only few ethanol plants process cellulosic materials on a commercial scale. One of the few companies producing ethanol this way is Iogen Corp. in Ottawa. The company currently produces 220,000cbm ethanol per year, mainly from straw (Schmitz, 2005)

2.3. The Use of Ethanol as Transport Fuel

There are three ways in which ethanol can be used as transport fuel. They can be summarized as follows.

Figure 2.4: The use of ethanol as transport fuel



Source: own illustration

- **E-100/ hydrous ethanol:** Ethanol can completely replace gasoline as a transport fuel. This kind of fuel is called *hydrous* ethanol because it contains about 96% ethanol and 4% water. After the distillation process it is not necessary to dehydrate the ethanol. From a technical point of view, the use of hydrous ethanol requires modifications to engines and distribution systems (Schmitz, 2003). The use of E-100 during the 1980s in Brazil was widely regarded as a success. However, in those days engines were not able to run on blends of gasoline and ethanol. Consequently, the use of E-100 proved to be problematic in the beginning of the 1990s, when irregular supply and relatively inflexible demand forced the Brazilian government to import significant amounts of synthetic ethanol (Schmitz, 2005).
- **Low ethanol-blends (anhydrous ethanol, E-5 and E-10):** Blends containing 90 - 95% gasoline and 5 - 10% *anhydrous* ethanol (E-5 or E-10) are relatively common in North America, Australia and many European countries. Besides

environmental issues, there is also a technical reason for using these blends of ethanol. Ethanol increases the amount of octane and oxygen in gasoline and therefore, ensures higher energy efficiency and better performance compared to the use of pure gasoline (Schmitz, 2003). Despite this advantage, major technical problems have to be mentioned. First, ethanol causes corrosion of some (older) engine components, e.g. inner tubes or seals.[12] Secondly, in higher blends, vapour pressure due to chemical reactions in the engine prevent the car from running smoothly. Finally, the affinity of ethanol for water might make the alcohol hydrate in some engines, leading to even higher vapour pressure and to a separation of ethanol and gasoline in the tank. Thus, the positive effect of higher oxygen content vanishes (Henniges, 2006).

- **High ethanol-blends (hydrous ethanol):** Recent developments in engine design facilitate the future use of higher ethanol blends, like E-85 or even E-100. Flexible-fuel vehicles (FFV) as developed by Volkswagen, FIAT, General Motors and Ford are capable of running on any blend with a *hydrous* ethanol content of between 25 to 100%. Thus, these engines overcome the technical problems mentioned above (Schmitz, 2005). In FFVs, sensor and control systems automatically recognize the combination of fuel in the tank and allow for real-time calibration (IEA, 2004). It is important to note that these vehicles do not require *anhydrous* ethanol. This renders the last step in the production process (dehydration) unnecessary.
- **ETBE (ethyl-tertiary-butyl ether):** Another way to overcome problems with direct (anhydrous) ethanol blends is the use of ETBE. Most ethanol in the EU is processed into ETBE. ETBE contains 47% anhydrous ethanol and 53% isobutene, a crude oil derivative. As an additive, ETBE improves octane and oxygen contents in the fuel. It can be blended with gasoline up to 15%. ETBE has virtually no affinity to water, which makes it easier to blend (in refineries) and to transport (in pipelines). ETBE is the gasoline additive preferred by the petroleum industry as it provides an additional outlet for isobutene and is easy to handle. From an environmental point of view, ETBE and ethanol show simi-

[12] Nearly all recent-model conventional gasoline vehicles produced for international sale are fully compatible with 10% ethanol blends (E-10). These vehicles require no modifications or engine adjustments to run on E10, and operating on it will not violate most manufacturers' warranties. However, older models are not fully compatible with ethanol blends like E-10 (IEA, 2004: 102). For this reason, the German environment minister recently abandoned plans to introduce E-10 on large scale in Germany.

lar CO2-emissions; however, it might have a carcinogenic effect (Schmitz, 2003; EC DGR, 2006).

The discussion about ethanol in the context of this master thesis focuses on ethanol blends. The following table summarizes the technical characteristics of ethanol that are worth mentioning. It is important to note that ethanol only contains two thirds of the heating value of gasoline (0.65). When using ethanol in high blends, e.g. as E85, the average difference in fuel economy is similar to the energy differences. In low blends ethanol shows a higher efficiency than heating values suggest, ranging from 0.7 to 0.8. The actual efficiency depends, however, not only on the blend but also on the vehicle (Roberts, 2008; Schmitz, 2005).

Table 2.1: Physical and chemical characteristics of ethanol

		Ethanol	Gasoline	ETBE
Density (15°C)	[kg/cbm]	790	750	742
Thermal value[13]	[MJ/kg] [MJ/l] [kWh/l]	26.80 21.17 5.88	43.50 32.63 9.06	36.39 27.00 7.50
Gasoline equivalent	[l]	0.647	1.00	0.83
CO2-eq. emissions	[kg/l]	Various	2.36	Various
Vapour pressure	[kPa]	16	60/90	28
Boiling point	[°C]	78	25 - 215	72
Oxygen content	[Vol-%]	35	0 - 2	16

Source: Henniges (2006).

2.4. Economics of Ethanol Production

2.4.1. Approach and Scheme of Evaluation

As in other industries, exact cost data for ethanol is too sensitive to be disclosed. Therefore, the comparison of costs in this thesis provides no results of empirical research, but summarizes the outcomes of various studies on ethanol costs. Data for these studies came from industry experts and plant managers (e.g. Tiffany/ Eidman, 2003; Solomon et al., 2007), or ethanol plant designers (e.g. Schmitz, 2003). Publications that only referred to economics found in other studies have not been considered (e.g. F.O. Lichts, 2003; IEA, 2004; VIEWLS, 2005). The same is true for studies that did not provide insight into crucial data or assump-

[13] Values in MJ refer to MJ lower heating value (LHV).

tions (e.g. Berg, 2004; VIEWLS, 2005; Sassner et al., 2008). Except for two cost summaries (Goldemberg, 1996, and Wooley et al., 1999), studies that have been published before the year 2000 were considered outdated. Although numerous cost studies for ethanol based on cellulosic biomass exist, none of them is based on actual data or previous experience. This is, because only one plant has been operating commercially since 2004 (Iogen Corp., Ottawa) and others are starting up production in 2007 and 2008 (Solomon et al., 2007). Hence, costs for second-generation ethanol are based on technical concepts (e.g. Hamelinck et al., 2005a) or on information from commercial ethanol plant developers (e.g. Aden et al., 2002).

Before a wide range of cost studies could be reviewed, an evaluation scheme had to be established to sort the information in a fashion common to all. There is no standardised method for analyzing the economic performance of biofuels and consequently, the scope and the goal of the study determine the evaluation scheme (VIEWLS, 2005). For an initial comparison of costs, a scheme as presented by the International Energy Agency (IEA, 2004: 72) was selected. It briefly summarizes the most important cost factors (feedstock costs, operating costs and capital costs), which allow for appreciating the competitiveness of ethanol production.[14] Moreover, data on the harvest of feedstocks gives an insight into the conditions of raw material production.[15]

The production of second-generation ethanol is based on lignin as process fuel. Instead of energy costs, expenses for enzymes play a decisive role in increasing the competitiveness of this technology (Reith et al. 2002). Therefore, the evaluation scheme has been altered respectively. Profits for ethanol plants are not included in the evaluation scheme. Nevertheless, high capital costs in some studies include dividend requirements of investors or risk premiums (e.g. Wooley et al., 1999; Reith et al., 2002; Tiffany/ Eidman, 2003).

Finally, it should be noted that an important cost factor has been neglected in the evaluation scheme. According to Elam (2000) and Henke/ Klepper (2006) blending and distributing ethanol causes additional expenses for materials and handling at oil refineries (e.g. investment in corrosion resistant storage facilities, blending facilities, water controls, quality controls etc.). The reason for not taking these costs into consideration in the evaluation scheme is that they would occur in either case, i.e. for domestic *and* imported ethanol. Once

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[14] Capital costs represent the annuity, based on total investment, interest rate (i) and economic lifetime of the plant (n): annuity factor (ANF) = $(1+i)^n*i / ((1+i)^n-1)$. As some authors conducted a more refined analysis of capital costs than others, the annuity ensures a better comparison of costs, which is less sensitive to underlying assumptions.

[15] For all studies, transport costs (from the farm to the distillery) are assumed to be included in operating expenses. Further costs for denaturing, i.e. making ethanol unfit for consumption, are often included, although most authors do not state them explicitly.

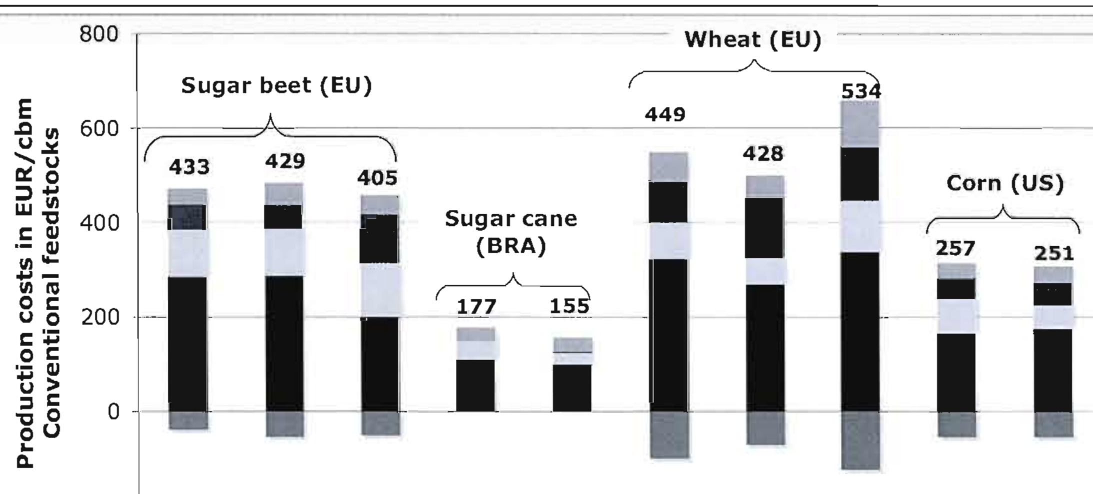
the costs in Europe are discussed for both domestic and imported ethanol, blending and distribution expenses become more important.

2.4.2. Economics of Ethanol Based on Sugar-Crops and Grain-Crops

2.4.2.1. Summary of Relevant Studies

The following table summarizes cost studies of first generation ethanol. It highlights the importance of raw material expenses for (net) ethanol production costs. Average expenses for feedstock make up 49% for sugar beet, 63% for sugarcane, 40% for wheat and 46% for corn (in percent of net production costs). Operating costs amount to 20% for sugarcane-based ethanol, and from 35 to 40% for other feedstocks (sugar beet and grain crops). The share of capital recovery for plants processing sugar cane and corn (10 to 12%) is lower than for those processing wheat and sugar beet (15 to 20%). For sugar beet and wheat, however, different plant concepts and economies of scale lead to a broad range of outcomes, which limits the significance of respective mean values.

Figure 2.5: Sample production costs (in EUR/ cbm) for 1st generation ethanol



	Sugar beet molasses	Sugar beet juice I	Sugar beet juice II	Sugar cane I	Sugar cane II	Wheat I	Wheat II	Wheat III	Corn I	Corn II
Capital costs	34	46	39	28	30	61	46	99	30	34
Energy costs	54	52	105	0	2	88	129	114	44	47
Other overheads	99	100	113	39	24	76	57	109	72	49
Co-product credit	-40	-55	-52	0	0	-100	-72	-125	-57	-56
Feedstock costs	285	286	200	110	99	324	268	338	166	176

Source: own illustration based on data from various studies.

2.4.2.2. The Role of Feedstocks

A competitive feedstock price is decisive for lowcost ethanol regardless of the production route. This is obvious since the price represents the costs (in the production of ethanol) for a certain amount of energy per unit of biomass.[16] The type of feedstock also determines:

- the simplicity of converting the input into ethanol (e.g. from a simple conversion of sugar-containing juice to advanced bio-chemical processes in cellulose conversion; measured as tons of biomass per cbm of ethanol),
- the kind of by-products, associated revenues and costs,
- further costs associated with handling the input (e.g. washing or sizing of feedstock, the amount of enzymes and yeasts required for fermentation, etc.), and
- the energy concept of the plant

(Henke/ Klepper, 2006; IEA, 2004).

Due to favorable climatic factors, ethanol production from sugarcane in Brazil is most cost effective (Johnson, 2002). Yields in the Centre-South region, where 85% of Brazil's sugarcane is grown, average 95 tons per hectare. Costs vary from 27 to 30 Brazilian Real (BRL) per ton, i.e. 9 to 10 EUR/t (Henniges, 2006). Although nearly 12 tons of feedstock is required to produce one cbm of ethanol, no other country shows a similar competitive position as the simple conversion of sugar cane keeps operating costs low. Moreover, cane trash (bagasse) provides process power and heat in the conversion process. Consequently, no energy costs are incurred and, depending on the plant design, excess electricity can even be fed into local grids (Schmitz, 2005; not considered by Henniges, 2006).

Ethanol from corn in the United States has similar net feedstock costs as in Brazil (110 to 120 EUR/ cbm ethanol). The key to the competitive production of corn is a high ethanol yield per ton of biomass (2.4 to 2.5 tons/ cbm), which balances relatively high feedstock costs (60 - 80 EUR/ t; IEA, 2004). However, economics strongly depend on credits for the co-product DDGS and thus, are exposed to forces in other markets (Henke/ Klepper, 2006).[17]

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[16] Market or guaranteed prices for feedstock takes profits for farmers into account

[17] Some analysts argue that an expansion of (corn- or wheat-based) ethanol production leads to an increase in DDGS supply. According to Tiffany/ Eidman (2003: 32; 37), revenues from DDGS are less important for the economics of corn-based ethanol in the US than factors like energy prices or scale effects. The authors find that only a massive oversupply of DDGS (and other feedstuff like soybean meal from biodiesel production) would significantly increase net feedstock costs and, thus, reduce profits. However, such a situation was deemed unlikely by the authors. On the other hand, it can be argued that ethanol production expands - in the long term - at the expense of dairy and beef cattle kept outdoors. Feeding these animals indoors would require high amounts of feedstuff, which could be provided by ethanol facilities. This would favour stable or higher prices for animal feed.
Both arguments underline the uncertainty associated with relatively narrow co-product markets. By contrast, additional electricity generated from plant residues in CHP-cycles of ethanol plants does not lead to an oversupply in power markets.

Revenues for DDGS, for instance, varied from 0.03 USD to 0.33 USD per litre between 1975 and 2003 (F.O. Licht, 2003). Both studies considered, valued the by-product moderately at (0.06 to 0.07 USD per litre), which leads to a decrease of gross feedstock costs by 30 to 35%. It should be noted that in times of high sugar prices and low corn prices, ethanol from corn could be as competitive as cane-ethanol from Brazil (Henniges, 2006).

In Europe, the wheat-to-ethanol route is more economical than the sugar beet-to-ethanol process due to lower (net-) feedstock costs (Schmitz, 2003) current studies, however, suggest that both production routes might also lead to similar net costs. Net feedstock costs range from 148 to 245 EUR/ cbm for sugar beet, and from 150 to 224 EUR/ cbm for wheat. As in the US, the economics of both production routes strongly depend on revenues from by-products. Selling co-products can reduce gross sugar beet prices by 15 to 25%, while gross wheat prices even decrease by 30 to 35%.[18]

2.4.2.3. Other Cost Items and Economies of Scale

The lowest operating costs are associated with sugarcane-to-ethanol production since the feedstock (molasses or sugarcane juice) is ready for fermentation. In annexe facilities, sugar and ethanol production share the initial production steps (pre-treatment), which reduces costs further (not considered by Goldemberg, 1996). Finally, costs for energy are zero since the bagasse provides process energy. In the US and Europe, operating costs are higher than in Brazil. This is due to high cost factors, particularly for labour in Europe, and additional expenses for enzymes and yeast to prepare starchy feedstocks (wheat and corn only). However, the main drawback for American and European ethanol producers is the relatively high cost for energy. The main corn, wheat or beet residues cannot be used for generating electricity and steam in large scale production processes, which further reduces the competitiveness of ethanol production in both regions.

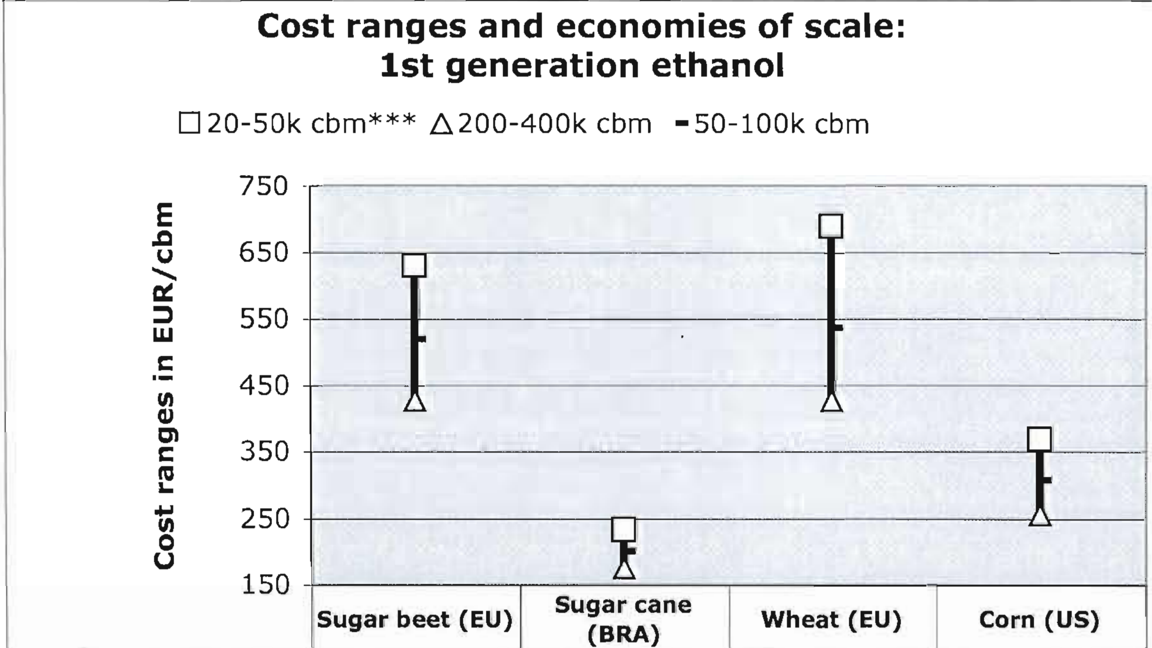
Economies of scale can be observed, for instance when comparing capital costs for wheat-to-ethanol plants (Schmitz, 2003; Henniges, 2006; Elam, 2000). However, differences in initial investments, assumed plant lifetimes, and assumed interest rates lead to annuities that cannot be directly compared.[19] Capital costs in Brazil are typically lower due to long de-

[18] DDGS, as protein rich animal feed, has a higher value than vinasse, the by-product from sugar beet-to-ethanol processes. Therefore, potential demand for vinasse, an animal feed and the by-product of sugar beet-to-ethanol processes is more limited, making potential revenues more volatile (Schmitz, 2003).

[19] In this context, it is interesting to analyze the capital recovery rates of an annexe facility in France (Monier/ Lannerée, 2000; JRC, 2002; USDA, 2006) and a wheat-to-ethanol plant in Sweden (Elam, 2000). Despite its lower capacity, the French plant has a much lower annuity due to the fact that it shares initial process steps

preciation periods in a relatively stable policy environment, low investment costs and high economies of scale (Henniges, 2006; Goldemberg, 1996). According to the studies considered, this seems to be the lowest possible level for capital recovery per cbm for all feedstocks. Schmitz (2003) and Henniges (2006) also investigated economies of scale for operating costs. Compared to large-scale ethanol plants (capacity of 200,000 to 400,000 cbm p.a.) operating costs for medium-sized plants (50,000 to 100,000 cbm p.a.) increase by approximately 20%. Cost uncertainties, bottlenecks or idle capacities could lead to further cost increases of 25% (Elam, 2000; Tiffany/ Eidman, 2003). Small-scale plants with capacities of 20,000 cbm to 50,0000 cbm p.a. show capital and operating costs that are 1.5 times higher than those of average plants (proxy, based on Schmitz, 2003; Henniges, 2006). The maximum plant size presented here (400,000 cbm p.a.) is the absolute limit for ethanol production in Europe, as otherwise transport costs for feedstock would offset scale effects (Henniges, 2006).

Figure 2.6: Cost estimates 1st generation ethanol



	Sugar beet (EU)	Sugar cane (BRA)	Wheat (EU)	Corn (US)
□20-50k cbm***	631	235	690	370
△200-400k cbm	429	177	428	257
-50-100k cbm	520	202	537	309

Source: own illustration based on data from various studies.

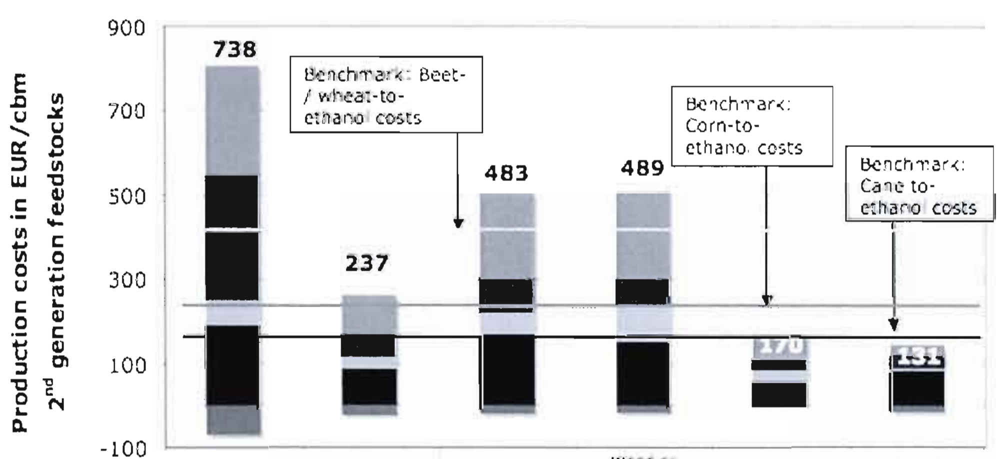
with the sugar refinery. Thus, the initial investment only amounts to one third of the investment required for a wheat-to-ethanol plant in Sweden.

2.4.3. Economics of Ethanol Based on Cellulosic Biomass

2.4.3.1. Summary of Relevant Studies

The following table summarizes cost studies of second-generation ethanol, i.e. based on cellulosic biomass. In contrast to first-generation ethanol plants, facilities processing ligno-cellulosic feedstock are in their development phase with economics being continuously improved. Consequently, the costs presented in the following figures are based on the "nth" plant, considering that initial plants will be smaller and more conservatively designed in order to minimize design risk and uncertainty (S&T^2 Consultants, 2000). According to the studies considered, average net feedstock costs amount to 29%, operating costs to 31% and capital costs to 41% of net ethanol cost (near term).[20] Compared to the production of sugar- or grain-based ethanol, the feedstock issue loses its significance, which shifts the focus to operating expenses and capital recovery.

Figure 2.7: Sample production costs for 2nd generation ethanol



	Wheat residue	Corn stover	(Hybrid) Poplar	Wood or switchgrass	Hardwood chips	Poplar
Capital costs	258	88	202	203	57	22
Enzyme/ chemical costs	300	56	80	65	28	35
Other operating costs	60	29	54	87	25	6
Co-product credit	-70	-25	-21	-18	0	15
Feedstock costs	190	88	168	152	60	83

Near term concepts (2010 - 2020) Long term concepts (2020 onward)

Source: own illustration based on data from various studies.

[20] The study from Reith et al. (2002) was not considered for calculating the cost structure as it includes extraordinary high (operating) costs for enzymes.

2.4.3.2. The Role of Feedstocks

Development of ligno-cellulosic ethanol is based on the rationale of cheap and abundant feedstocks. Net feedstock costs lie in a range of between 120 to 148 EUR/cbm and thus are lower than in the case of grain- or sugar beet-based ethanol. However, except for corn stover (i.e. residues from the corn plant), feedstock costs for second-generation ethanol are not expected to be under those of cane-processing facilities in the near term. Nevertheless, low feedstock costs are the main driver in making cellulosic ethanol as competitive as wheat- or sugar beet-based ethanol today. In the long term, feedstock costs for ligno-cellulosic ethanol are expected to decrease significantly and to fall below costs for sugarcane and corn (60 to 70 EUR/ cbm). Better conversion and feedstock efficiencies in the long-term stem from higher enzyme performance and from biotechnological progress. Genetically engineered feedstock is expected to contain more (hemi-) cellulose at the expense of the lignin content ($S\&T^2$ Consultants, 2000). A future option is, therefore, feedstock that only contains as much lignin as is required for energy purposes in the production process. Such a long-term plant concept, modelled by Wooley et al. (1999)[21], would not produce any excess electricity. By contrast, the consolidated bio-processing (CBP) concept from Hamelinck et al. (2005a) is purely based on higher enzyme performance while lignin is used in the CHP-plant for producing (excess) energy, like in all near-term concepts.[22]

2.4.3.3. Other Cost Items and Economies of Scale

While studies on near-term economics often consider optimum large-scale plants, the first concept (wheat residue I; Reith et al., 2002) provides an idea of the economics of an initial SSF-plant. The authors outline the need for significantly reducing costs of cellulase (for enzymatic cellulose conversion) and for recycling process water. All other concepts already anticipate optimized enzyme performance and costs that are up to 80% lower (90% in the long term). Other fixed and variable expenses are in line with those of large-scale first-generation ethanol plants.

Plants processing ligno-cellulosic feedstocks are more capital intensive than conventional ethanol facilities. Near-term concepts require high investments for feedstock pre-

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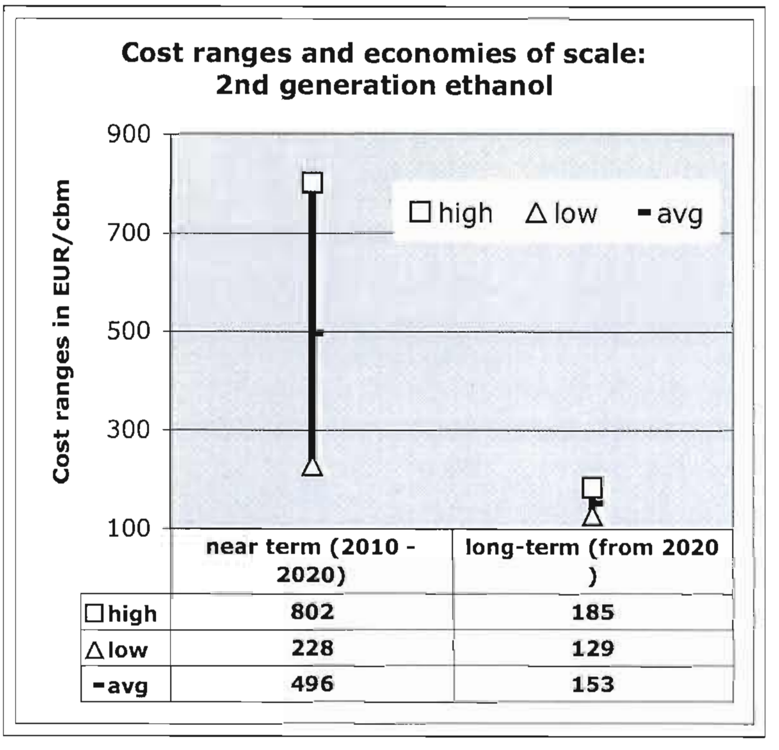
[21] Wooley investigates economics of a simultaneous saccharification and co-fermentation (SSCF) concept, which can be regarded as an intermediate stage in the development of CBP-plants.

[22] It is important to note that technology to process ligno-cellulosic biomass is also an attractive option for those producers that already have a favorable cost position today. Currently, Dedini, a Brazilian plant manufacturer, operates a pilot plant, which would be able to convert cellulosic parts of the bagasse into ethanol. This would increase ethanol yields per hectare by 83% (Schmitz, 2005).

treatment, SSF facilities, and energy utilities (Aden et al., 2002; Solomon et al., 2007). Currently 40% of net ethanol costs are attributed to capital recovery of which the majority accounts for interest payments. In the studies considered, high capital recovery rates are associated with high investment costs (210 to 290 MEUR) and relatively short periods of depreciation (15 years). Those concepts with favorable annuities depreciate over 15 to 20 years and benefit from high scale economies and/ or low investment costs (130 to 220 MEUR). Decreasing the total capital investment is crucial in the long term. Major cost reductions take place when progressing to co-fermentation technologies like SSCF and CBP because continuous development of (new) micro-organisms improves the performance per reactor and allows for the integration of even more functions within less reactors (Hamelinck et al., 2005a). Moreover, economies of scale play an important role in improving economics of cellulose-to-ethanol plants. Similar to conventional facilities, however, a trade-off exists between savings resulting from economies of scale and increased costs for the collection of feedstock (Aden et al., 2002). The best way to exploit scale economies is therefore the use of the cheapest and most abundant feedstock (e.g. municipal solid waste, MSW) that allows for minimizing the collection distances and costs as plant scales increase. Bearing these arguments in mind it can be doubted whether 2nd generation ethanol plants based on hybrid poplar, i.e. a relatively bulky feedstock, can take advantage of extraordinary economies of scale (compare Hamelinck et al., 2005a: plant capacity of ~1.3M cbm p.a.).

The following graph summarizes cost ranges for short and long-term cellulose-to-ethanol concepts based on the literature review. The size of near-term plants is smaller than for long-term concepts (150,000 to 260,000 cbm p.a. versus 320,000 to approx. 1,300,000 cbm p.a.). No uncertainties were assumed for operating costs whereas the total capital investment (TCI) varies between -10% and +25% (Aden et al., 2002).

Figure 2.8: Cost estimates 2nd generation ethanol



	near term (2010 - 2020)	long-term (from 2020)
□high	802	185
△low	228	129
-avg	496	153

Source: own illustration based on data from various studies.

2.5. The Link Between Agricultural, Biofuel, and Energy Markets

Markets for energy products are much larger than markets for agricultural commodities. Thus price movements in energy markets influence agricultural markets in two major ways. On the one hand agricultural inputs such as fertilizers, pesticides and of course diesel are highly energy intensive, which causes an upward pressure on costs as energy prices rise. On the other hand, rising fossil fuel prices increase the competitiveness of biofuels. Sugar or grain crops, as the determining input factors in ethanol production, become competitive at so-called parity prices. Once crude oil prices rise beyond this parity price, feedstock prices might follow (FAO, 2008; Abbassian, 2008).

The following equations define the parity price by setting up the relation between fossil fuel and feedstock prices. The parity price equals the maximum price for feedstock ($P_{f,max}$) that biofuel processors are willing to pay. In reality the price for feedstock is lower than suggested by the following formulas. This is because further costs and profits on processor and distributor level are included. For the sake of simplicity, however, these items will be neglected at this stage. Assuming fixed operating costs on processor's level (C_{nf}), and fixed revenues from co-products, the maximum feedstock price ($P_{f,max}$) depending on the biofuel price (P_{EtOH})[23] in cbm of output is:

$$(2.1) \quad P_{f,max}\ (P_{EtOH})\ [EUR/\ cbm] = P_{EtOH} - C_{nf} + P_{co}$$

Dividing equation (2.1) by the average conversion factor of ethanol plants ($Con_{f/EtOH}$ in ton/ cbm) gives the feedstock price in EUR/ ton.

$$(2.2) \quad P_{f,max}\ (P_{EtOH})\ [EUR/\ ton] = (P_{EtOH} - C_{nf} + P_{co})\ /\ Con_{f/EtOH}$$

As one litre ethanol replaces only 0.65 of gasoline the price of ethanol trades at a discount that takes different heating values into account. Therefore it is possible to replace P_{EtOH} in equation (2.2) by the gasoline price (P_{gas}) adjusted by the fuel efficiency factor (FE) of 0.65. The maximum feedstock price depending on the adjusted price for gasoline is:

$$(2.3)\ P_{f,\,max}\ (P_{gas})\ [EUR/\ ton] = (P_{gas}*FE - C_{nf} + P_{co}) * Con_{f/EtOH}$$

As the gasoline price depends on the crude oil price in EUR/ bbl (P_{oil}), the following relation can be established between prices for ethanol feedstock and petroleum (as computed by a linear regression analysis):

$$(2.4)\ P_{f,\,max}\ (P_{oil})\ [EUR/\ ton] = ((71.2 + 5.9*\ P_{oil})*FE - C_{nf} + P_{co}) * Con_{f/EtOH}$$

Whether crude oil prices have a direct effect on feedstock prices depends on the relationship between gasoline and ethanol in a country, i.e. whether ethanol is a substitute for gasoline or a complementary product. In low blending ratios, e.g. E-5 or E-10, *anhydrous* ethanol is used. This is the case in North America or Europe, where the vehicle fleet is simply not designed to run on higher blending ratios. In these markets ethanol acts as a complement to gasoline. Currently Brazil is the only market in which flexible fuel vehicles (FFV) play an important role. As already outlined earlier, it is possible to vary the ratio of *hydrous* ethanol

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[23] Prices for fuel ethanol are difficult to obtain. Only 5 - 10% of ethanol in the USA is traded on illiquid spot markets, while 90 - 95% is sold under long-term contracts (6 to 12 months). These contracts are private agreements between ethanol producers or marketers and petroleum companies. According to industry observers, roughly 90 to 95% of ethanol is sold under these long-term contracts. Many of these contracts are "fixed price" and only some them are "pegged" to a gasoline benchmark (RFA, 2008b). In this master thesis, the assumption is that the price for ethanol is tied to gasoline prices.

and gasoline in these vehicles and, thus, *hydrous* ethanol can act as a substitute for gasoline. The relationship between gasoline and ethanol is crucial when analyzing how markets for biofuel feedstock and crude oil interrelate. Tokgoz and Elobeid (2006) research the interrelation of price movements in gasoline, corn and raw sugar markets in the US and Brazil by simulating external shocks, i.e. short-term price increases of 20% in each market separately.[24] Such an increase in crude oil markets leads to lower consumption of gasoline. Therefore, demand for *anhydrous* ethanol in the US falls with gasoline consumption. In Brazil, higher gasoline prices lead to slightly higher ethanol consumption. However, production in the South American country decreases due to the lack of demand from the US.

If an increasing share of vehicles in the US are FFV, then ethanol will become a substitute for gasoline in both countries. In this case a 20% increase in gasoline prices leads to rising demand for ethanol and, thus, to an ethanol price on world markets that is 35% above the baseline scenario. In the US, consumption increases by 17% despite the strong price reaction. In Brazil, however, higher prices for ethanol as well as for gasoline lead to lower consumption of both fuels. This suggests that the demand for road transport fuels in the US is less flexible to price movements than in Brazil. Higher ethanol prices also increase production in Brazil (+13%) and in the US (+4%). As domestic consumption declines and US demand for ethanol increases, Brazilian producers export significantly more ethanol than in the baseline scenario (+86%) (Togkoz/ Elobeid, 2006).

Depending on whether ethanol is a complement to, or a substitute for gasoline in the US, a 20% rise in gasoline prices has different implications for feedstock markets. If the share of FFV in the US is low, ethanol is a complement for gasoline. Substitutional effects are very limited and, thus, higher energy prices lead to lower consumption, production and demand for corn and sugarcane. The price for raw sugar decrease slightly due to higher supply from Brazil, whereas higher energy costs drive the price for corn. Togkoz and Elobeid also introduce price shocks in markets for corn and raw sugar. As markets for energy, e.g. crude oil, are larger than agricultural markets, there is no impact of rising feedstock prices on gasoline markets. In Brazil, ethanol and sugar prices tend to move together and, thus, a 20% price increase in global raw sugar markets leads to a subsequent rise in ethanol prices (+6%) as more sugarcane is diverted to sugar production at the expense of ethanol supply. A 20% price shock in US corn markets reduces production of corn ethanol in the US. As demand for ethanol in the

[24] The authors use 10 year projections from various institutions to compute a baseline scenario for prices in feedstock, crude oil and associated markets. Price shocks of 20% are then introduced separately for gasoline, raw sugar and corn in each year. The results provided in the study are averages for the 10 year period and represent a comparison to the baseline scenario. Detailed information is provided in the annex of the study from Tokgoz and Elobeid (2006).

US decreases not as much as domestic production falls, there is a strong increase in imports (+57%) and higher prices on the world market for ethanol (+7%). The study from Togkoz and Elobeid provides a good idea of how markets in crude oil and ethanol feedstocks interrelate. It can be concluded that equation (2.4), setting up a simple relationship between both markets, is only valid if ethanol acts as a substitute for gasoline. However, the relationship is an important concept for further discussion and is indeed important if markets for bioenergy and energy integrate further in the future. The following tables summarize the results from the previously discussed study.[25]

[25] The baseline scenario from 2005 to 2015 is as follows (expressed as averages): Prices for gasoline (+5%), corn US (+38%), raw sugar (+27%), ethanol (+5%). USA: consumption (+137%), production (+135%), imports (+204%). Brazil: consumption (anhydrous +5%; hydrous +54%), production (+48%), exports (+114%).

Table 2.2: Impact of higher gasoline prices on ethanol markets

	SCENARIO	*20% PRICE INCREASE: GASOLINE*		*20% PRICE INCREASE: GASOLINE (FFV IN US)*	
		Price effect	*Reason*	*Price effect*	*Reason*
World	**Gasoline Price**	+20.0%	External shock	+20.0%	External shock
World	**Corn Price (US)**	+0.6%	Energy costs, outweighing lower demand for corn	+1.5%	Higher demand for corn ethanol.
World	**Raw Sugar Price**	-0.2%	Lower demand for ethanol; more sugar cane is diverted to sugar markets	+3.9%	Higher demand for ethanol decreases raw sugar supply.
USA	**Ethanol Price**	-1.9%	Fall in ethanol demand in the US	+34.9%	Higher demand for ethanol.
USA	**Ethanol Consumption**	-1.5%	Ethanol partly substitutes gasoline, but total demand for transport fuels decreases stronger.	+17.4%	Ethanol is a substitute for gasoline as oil prices increase; consequently, demand leads to higher domestic production and a strong increase in imports as sugarcane-based ethanol is more competitive.
USA	**Ethanol Production**	-0.7%	Price decrease of ethanol.	+3.9%	
USA	**Imports**	-16.7%	Lower demand.	+278.1%	
Brazil	**Consumption anhydrous ethanol (common vehicles)**	-5.2%	Lower consumption due to complementary relation with gasoline.	-8.7%	Anhydrous ethanol is a complementary product for gasoline: as gasoline consumption decreases, demand for anhydrous ethanol falls. Owners of FFVs substitute hydrous ethanol for gasoline, but demand decreases due generally higher energy prices.
Brazil	**Consumption hydrous ethanol (for FFV)**	+2.6%	Higher consumption due to substitutional relation	-2.7%	
Brazil	**Ethanol Production**	-0.7%	Lower demand for fuels, incl. blends	+12.6%	Production of ethanol more profitable than production of raw sugar.
Brazil	**Exports**	-5.3%	Lower demand in the US	+86.8%	Higher demand for ethanol as a gasoline substitute.

Source: own illustration based Togkoz/ Elobeid (2006).

Table 2.3: Impact of higher feedstock prices on ethanol markets

	SCENARIO	*20% PRICE INCREASE: RAW SUGAR*		*20% PRICE INCREASE: CORN*	
		Price effect	*Reason*	*Price effect*	*Reason*
World	**Gasoline Price**	0.0%	Market too large to be affected.	0.0%	Market too large to be affected.
World	**Corn Price (US)**	+0.2%	Higher demand due to tighter ethanol market.	+20.0%	External shock
World	**Raw Sugar Price**	+20.0%	External shock	+0.6%	Higher demand for ethanol.
USA	**Ethanol Price**	+6.1%	Lower production in Brazil	+6.6%	Response to higher US imports.
USA	**Ethanol Consumption**	-0.5%	Higher price for ethanol.	-0.6%	Higher price for ethanol.
USA	**Ethanol Production**	+1.0%	Tighter markets due to lower imports.	-3.7%	Net margins decline
USA	**Imports**	-24.9%	Lower demand due to higher world prices.	+56.6%	Reduction in production exceeds the reduction in consumption.
Brazil	**Consumption anhydrous ethanol**	-0.6%	Higher prices for ethanol have a more direct effect on demand for hydrous ethanol than on demand for anhydrous ethanol; Higher prices have a stronger effect on the demand for hydrous ethanol.	-0.6%	Higher ethanol prices: hydrous ethanol is blended in higher ratios than anhydrous ethanol. Higher prices have a stronger effect on the demand for hydrous ethanol (elasticity of demand with respect to the price is higher) .
Brazil	**Consumption hydrous ethanol**	-0.9%		-1.0%	
Brazil	**Ethanol Production**	-2.6%	Sale of sugar on world markets relatively more attractive.	+2.4%	Higher production and exports due to higher prices on the world market.
Brazil	**Exports**	-10.0%	Lower production in favour of raw sugar.	+17.4%	

Source: own illustration based Togkoz/ Elobeid (2006).

2.6. Issues of Social Sustainability

From January 2002 to June 2008 international food trade commodity prices rose by over 130%, and by 56% from January 2007 to June 2008. Prices for fats and oilseeds as well as for grains were the most prominent drivers of this development, showing increases of ~200% (oilseeds), ~300% (maize), and ~130% (wheat). Moreover, export limiting policies in some countries and speculative activities exacerbated these price hikes. The extent to which biofuels have contributed to the development is difficult to assess. Studies providing estimates on the contribution of biofuel production to the overall surge in prices are difficult to compare as authors applied different methodologies, based their analyses on different prices (e.g. export, import, wholesale, retail) and took different periods into consideration (Mitchell, 2008). The following table summarizes major estimates.

Figure 2.9: Estimated impact of biofuel production on price increases of food commodities

Source (Year)	**Methodology and Limits**	**Feedstock**	**Contribution of ethanol demand to price increase**
International Monetary Fund, IMF (2008) *	N.A.	Maize	70%
Collins (2008)*	Simulation model; period from 2006-08.	Maize	60%
Rosegrant et al. (2008)*; results similar to those found by the World Bank, (van der Mensbrugge, 2006)*	General equilibrium model; long-term impacts on weighted cereal prices from 2000 to 2007; no short-term price dynamics.	Maize Wheat	47% (39% in real terms) 26% (22% in real terms)
Prakash, FAO (2007)**	General equilibrium model measuring the influence of oil prices on grain prices from 1978-2007	Maize Wheat	15%: influence of crude oil price; 12%: industrial use (proxy for ethanol); 16%: influence of crude oil price
OECD (2008a)	General equilibrium model; 2005 to 2007	Coarse grains	50%

Source: own illustration based on Mitchell (2008); * cited by Mitchell (2008); ** cited by Abbassian (2008).

Apart from the (long-term) analysis by the FAO, all short-term studies attribute ~50 to 75% of recent price increases in grains to the rising demand for biofuel production. Other factors such as increased production and transport costs, growing demand from feed and food sectors, recent harvests (influencing stocks) or the decline in the USD fx-rate are deemed equally or less significant.

The market reactions that have led to the development can be described as follows. Farmers are indifferent regarding the end use of the crop they grow - i.e. food, feed, or feedstock purposes - as long as the sale of the crop provides sufficient income. Therefore, "food" and "fuel" are substitutes under the current state of liquid biofuel production. However, current incentives are directed towards - first generation - biofuels based on feedstock from food crops (Rubin et al., 2008). In this context additional demand from biofuel markets has two effects. First, owing to limited resources, farmers cannot adjust their land-use fast enough to cope with demand from both markets. Hence, diverting more crops to fuel markets leads to fewer supply for food markets. In addition, supply shortfalls due to bad weather and low yields in major exporting countries have reduced grain stocks in 2006 and 2007 so that supply shortages had a more direct effect on prices. Secondly farmers have faced relatively inelastic demand from feedstock markets as governments have increased their blending mandates in recent years. Indeed the usual reaction to rising gasoline prices would have been lower consumption and, thus, lower demand for biofuels and associated inputs (at least in the US and Europe, where ethanol is mainly produced from grains and where the fuel acts as a complement to gasoline; see study from Togkoz/ Elobeid). So despite lower consumption of gasoline in the US and Europe in recent years, the rising share of biofuels in transport fuels due to mandates has created increasing demand for feedstocks. The consequence was repercussions on other food markets, notably the market for cereals (UN Energy, 2007; FAO, 2008b; OECD, 2008a).

The price development in many foodstuffs and the contribution of biofuels has raised doubts about the social sustainability of large-scale biofuel production as high prices for basic commodities prevented low-income households in many poor countries from buying sufficient food, i.e. from covering their essential needs. The fact that the flexibility in prices for all grains is lower than respective flexibility for individual grains indicates that consumers are able to adjust their demand according to respective market prices. However, the general increase in grain prices, as seen in recent years, suggests that consumers *have* already made use of substitution possibilities. The consequence for low-income households is to reduce their grain consumption (Searchinger et al., 2008). Whether consumers are actually affected by these price increases depends on their ability to change consumption patterns and dietary habits.[26] If consumers spend a significant share of their income on foodstuffs, as in many developing countries, least developed and low-income food deficit countries (LIFDC), the surge in prices is a serious problem (Kerckow, 2007). On the other hand, bioenergy offers significant opportunities for pro-poor rural development and income generation through employment in respective sectors.

If bioenergy markets should be socially sustainable, the risks, i.e. food security issues, have to be eliminated and the chances, i.e. the creation of income generation opportunities, have to be seized (FAO, 2008b). According to the FAO, "food security exists when all people at all times have physical, social and economic access to sufficient amounts of safe and nutritious food that meets their dietary needs and food preferences [...]." (Abbassian, 2008: 17). Food security has four major dimensions: (1) availability, (2) access, (3) stability, and (4) utilization; for further analyses, availability, access, and stability have the highest importance.[27]

- *Food availability:* Currently 1% of the world's arable land is devoted to biofuel production (14 million hectares). The share could rise to 2.5 to 3.8% by 2030 and to 20% by 2050. This growth is only sustainable if productive land, water or other resources are not diverted away from that required for food production. Consequently, the notion of *competition* between food and fuel is inseparably linked to food availability.
- *Access to food* is crucial, but it is not ensured for low-income consumers when prices surge, particularly in low-income countries. 75% of the world's poor currently live, and will still be living in rural areas in 2040. As they vastly depend on income from agriculture, growth in this sector is important for increasing their revenues. Bioenergy represents a potential growth factor for agriculture and, thus, could ensure access to food. Therefore, higher *income* improves access to food.

  In this context the economic incentives, i.e. the importance of economies of scale in ethanol production, are somewhat against socially sustainable development. Comparative advantage in ethanol production can be further increased by mechanization and a decrease in workforce. As plantations that rely on manual tillage and harvest are under increased (cost) pressure, socio-economic

[26] An OECD analysis on rising food prices underlines the link between high agriculture commodity prices and the impact on close substitutes, such as fish (OECD, 2008a).

[27] Utilization refers to peoples' ability to absorb nutrients contained in food. As it is closely linked to issues like health and nutrition, utilization is less directly linked to bioenergy than the other aspects.

conditions in large-scale plantations can be precarious. In order to ensure income in rural areas, independent smallholding and joint initiatives on farm level are of particular importance.

- *Stability* means that access to food has to be ensured at any time. But the more energy and agricultural markets integrate, the more price volatility from energy markets will be transmitted to the agricultural sector. However, increased price volatility may be more detrimental to food security than long-term price trends because the poor are usually less able to adjust to rapid price changes. The use of food crops for biofuels establishes a floor price for respective commodities, but hardly limits upward pressure from petroleum markets because energy markets drive agricultural markets.[28] In the extreme case of a low-income country that imports food *and* energy, high prices for energy put pressure on farmers to divert or even exploit resources in favour of bioenergy production, thus exacerbating the problem of food supply. As long as a rise in food prices in the long term is associated with a rise in rural incomes, the actual problem is price *volatility*.

(FAO, 2008a; Abbassian, 2008; UN Energy, 2007).

Technology is, and will be available in the future to convert (non-) food crops into biofuels. The major opportunity lies in the generation of higher income for rural communities in less developed countries. Land-use competition should support income, i.e. by making the crops more valuable on markets, and not put the availability of food at risk. Finally, measures have to be implemented to keep price volatility under control, thus ensuring continuous access to food.

2.7. Issues of Environmental Sustainability

2.7.1. Environmental Performance of Ethanol

2.7.1.1. Approach and Scheme of Evaluation

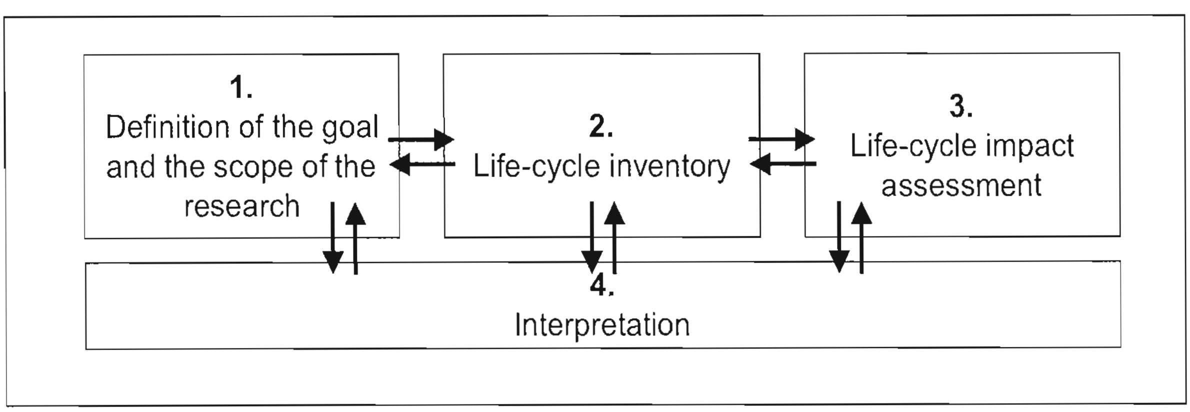
Biomass-based ethanol is CO2-neutral because emissions from using the fuel have been absorbed earlier by photosynthesis. The production and conversion of feedstocks, how-

[28] The "floor price effect" can be explained as follows: farmers facing low prices for their products due to oversupply can divert crops from food to fuel production; thus, they limit supply on food markets and provide (relatively) cheap input for the biofuel industry. Reallocation occurs as prices on food markets rise. The upward pressure on agricultural commodity prices ceases if overall demand for energy falls due to high prices.

ever, requires fossil energy and, thus, is associated with carbon-intensive inputs. Therefore, the main question is how much GHG-emissions can be saved by displacing gasoline with ethanol. In the past, studies on energy- and carbon balances for ethanol led to very different results, even for the same type of feedstock (e.g. Pimentel/ Patzek, 2005; Graboski, 2002). This is, because calculations of fossil energy and carbon balances are highly sensitive to assumptions about feedstock production, conversion technologies and system boundaries (Schmitz, 2005; Farrell et al., 2006). Consequently, a sound methodological approach is required for summarizing results from literature.

For analyzing the environmental impact of biofuels, many authors refer to the life-cycle analysis (LCA), either implicitly or explicitly (e.g. Schmitz, 2005; Sheehan et al., 2004; Shapouri/ McAloon, 2004). LCA is a standardized tool to understand key energy and environmental aspects of ethanol production. It allows for identifying all steps necessary or caused by the fuel's existence (Sheehan et al., 2004). According to the International Organization for Standards (ISO, 2006), a LCA consists of four steps: (1) determining the goal and scope of the study, (2) establishing a life-cycle inventory, (3) appreciating the impact (in terms of energy consumption and/ or environmental impact), and (4) interpreting the results.

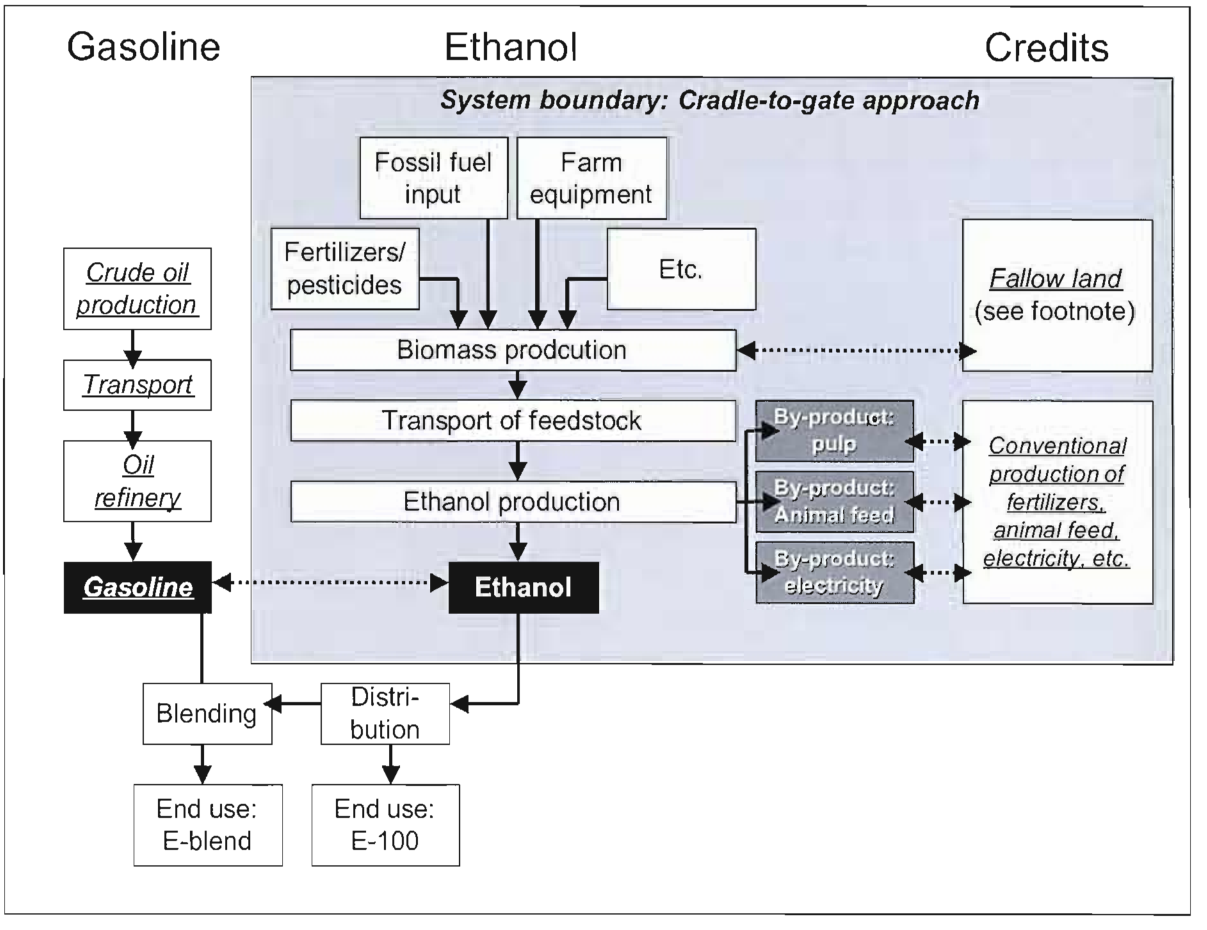
Figure 2.10: Conceptual framework of life-cycle analyses (Schmitz, 2005)



Source: illustration based on Schmitz (2005).

Carbon dioxide balances presented in this master thesis are not based on field research, but refer to data found in literature. Only those studies applying a life-cycle approach and expressing (intermediate) results in terms of mega joule per litre (MJ/l or GJ/ cbm) and CO2-eq. emission per litre (gCO2-eq./ l or kgCO2-eq/ cbm) were considered. The CO2 balances include all primary and secondary fossil energy inputs and related emissions, from the production of feedstocks to the provision of the fuel at the factory gate ("cradle-to-gate" approach). The energetic value from co-product substitutes diminishes gross fossil fuel consumption, resulting in net fossil energy consumption[29]. The following figure illustrates the kind of data considered by the "cradle-to-gate"-approach.

Figure 2.11: Comparison of life cycles for ethanol and gasoline



Source: own illustration based on Reinhardt/ Helms (2007).

In this master thesis the environmental performance of ethanol is based on the most detailed inventory found in the literature of (Farrell et al., 2006). All other life-cycle studies considered were adjusted accordingly. The actual energy required to grow feedstock and to convert it into ethanol varies depending on the feedstock and energy intensity of production. The environmental impact associated with energy use is based on the 100-year global warming potential (GWP) as published by the United Nations (IPCC, 2002; cited by Schmitz, 2005).

[29] Fallow land represents a "credit" in energy and emission balances because land, if not used for growing energy crops, has to be maintained to assure a certain soil quality. This approach is straightforward, but only pursued by Schmitz (2005). No data was available on energy and emission balances of fallow land in other countries. Therefore, the decision was to adjust the studies from Schmitz (2005) and to ignore the credits for fallow land in this study.

GHG-emissions and possible reductions are decisive in the evaluation of the environmental performance of ethanol. This implies a comparison of ethanol with gasoline. Considering the lower heating value of ethanol, the combustion of 0.65 litre gasoline is associated with 1.53 kgCO2-eq and further life cycle emissions of 0.33 kgCO2-eq (compare Shapouri/ McAloon, 2004, Ecoinvent, 2003). Therefore, the baseline for gasoline is 1.86 kgCO2-eq per litre ethanol.[30] For a positive environmental contribution of ethanol life-cycle emissions should not exceed this benchmark (Farrell et al., 2006). Equation (2.5) defines the GHG associated with ethanol, while equation (2.6) formalizes the environmental restriction that overall emissions from ethanol should not exceed those from using gasoline.

$$(2.5) \quad GHG_{EtOH}\,[kgCO_{2\text{-eq.}}/\,L_{EtOH}] = GHG_{Gross} - GHG_{co}$$

where:

$GHG_{EtOH}\,[kgCO2_{\text{-eq.}}/\,L_{EtOH}]$ = The GHG-emissions associated with the combustion of one litre ethanol;

GHG_{Gross} = GHG-emissions associated with primary and secondary input energy;

GHG_{co} = GHG-emissions displaced by substituting other products with co-products from ethanol production (displacement method according to ISO, 2006).

$$(2.6) \quad GHG_{EtOH}\,[kgCO2_{\text{-eq.}}] \leq GHG_{gas}\,[kgCO2_{\text{-eq.}}]$$

For interpreting the energetic performance of ethanol the net energy value (NEV), i.e. the difference between output and input energy, is a robust metric. Energy gains only occur if the energy contained in ethanol and its by-products exceeds the energy required in farming and conversion processes. Savvy energy concepts of ethanol plants regularly result in significant energy gains (Schmitz, 2005). The more energy is saved within the conversion process, the more favorable is the energy balance and, thus, the GHG-savings. As a proxy for sustain-

[30] Test-drives show that ethanol-blended gasoline performs better than the heating value of ethanol might suggest. Macedo et al. (2008), for instance, assume that 1 litre ethanol equals 0.75 litre gasoline in engines dedicated for hydrous ethanol. For E25 the authors assume that 1 litre anhydrous ethanol displaces 0.8 litre gasoline. Comparing gasoline and ethanol based on heating value is therefore a conservative approach to evaluate the energetic and environmental performance of the biofuel.

ability, GHG-savings are more important and, therefore, energy balances will not be discussed further within this thesis.

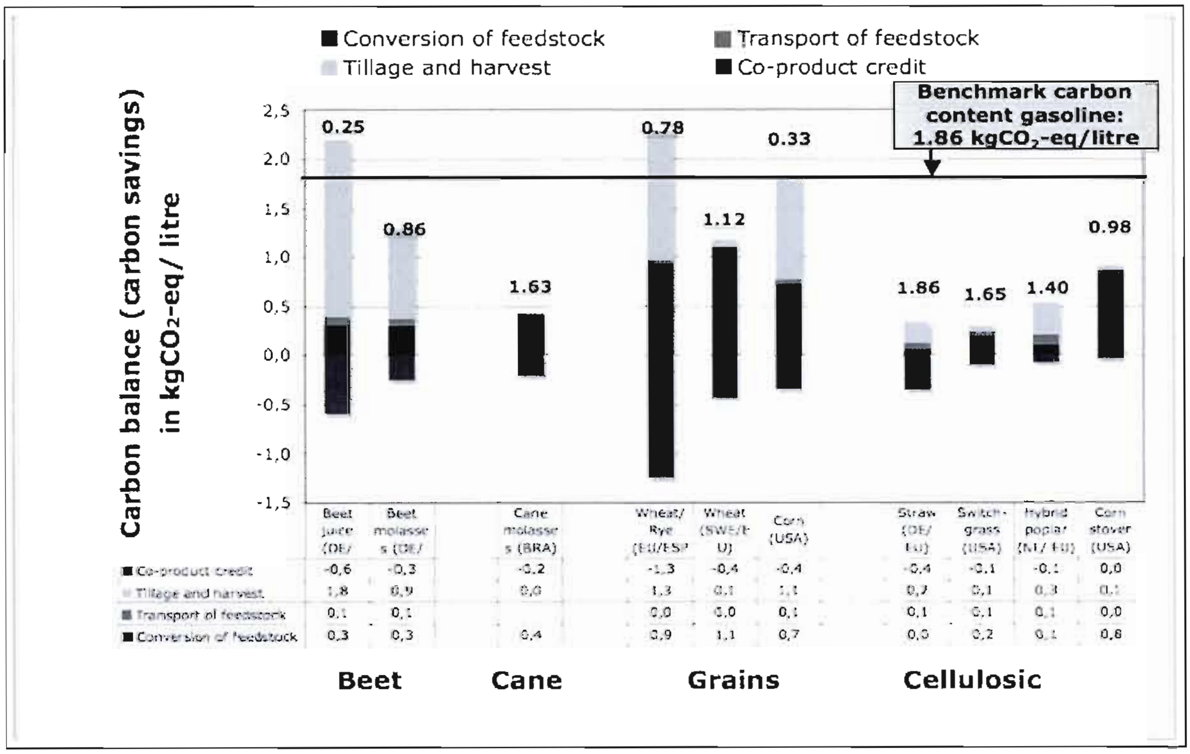
2.7.1.2. The Environmental Performance of Ethanol

In terms of the CO2-eq emissions avoided cane-based ethanol outperforms other sugar- and grain crops. Per litre ethanol from sugarcane, 1.63 kgCO2-eq can be avoided (net emissions: 0.2 kgCO2-eq/ litre). The environmental performance of ethanol from sugar beet or grain-crops depends on the source of process energy, whereas special conversion technologies or economies of scale are less important (Schmitz, 2005). When being powered by lignite (brown coal), the conversion of sugar beet juice to ethanol only leads to emission savings of 0.25 kgCO2-eq per litre. The conversion of corn-to-ethanol shows a similar result (0.33 kgCO2-eq/ l). Efficient process design and energy use (sugar beet molasses: 0.86 kgCO2-eq/ l; wheat: 1.12 kgCO2-eq/ l) or high CO2-eq savings through co-product credits (wheat/ rye: 0.78 kgCO2-eq/ l) are the main reasons for improved emission balances (Schmitz, 2005).

The production of ethanol from cellulosic feedstocks requires much less fossil energy input and is comparable to ethanol from Brazil. Hence, ethanol from straw, switchgrass and hybrid poplar avoid GHG-emissions from 1.40 to 1.86 kgCO2-eq/ l. Low energy requirements in feedstock production and conversion as well as high co-product credits are decisive for these favorable GHG-balances. The study from Sheehan et al. (2004) on corn stover is an exception for two reasons. First, the authors allocate most energy requirements in the production of corn, to corn stover.[31] Secondly, the conversion plant generates the lowest co-product credit of all facilities considered. Thus, corn stover is associated the least energy gains and emission savings (0.98 kgCO2-eq/ l) of all cellulose-to-ethanol plants. Emission balances for the most advanced, but long-term production processes, SSCF and CBP, were not available.

[31] This is obvious when comparing energy consumed in feedstock production in the corn-to-ethanol process with that consumed in the production of corn stover.

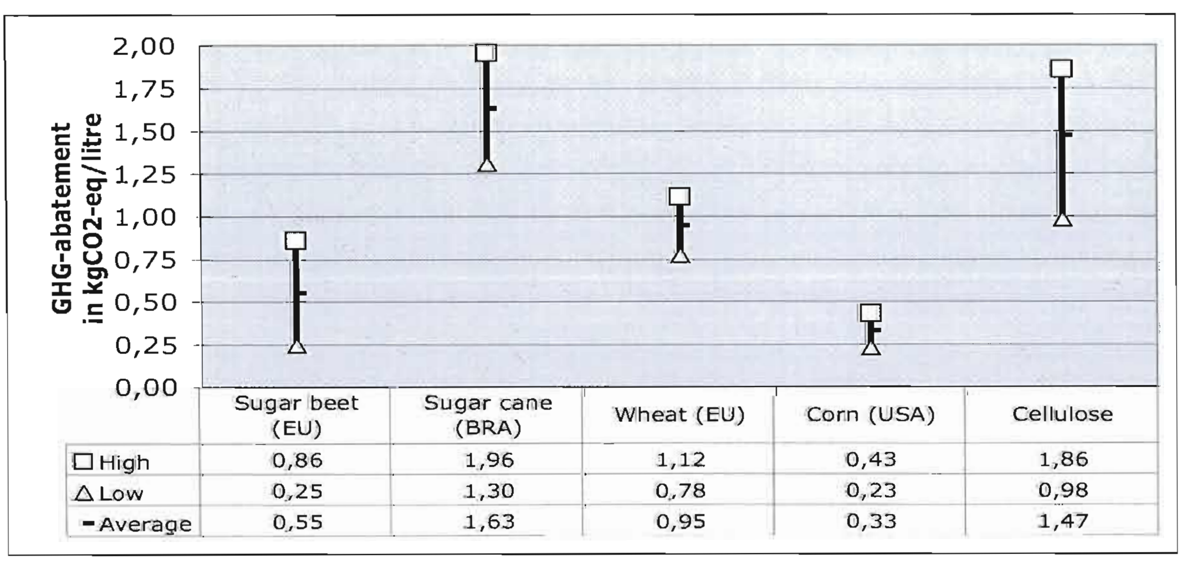
Figure 2.12: Carbon balances for ethanol in CO_2-eq per litre



Source: own illustration based on data from various studies.

For further analyzing GHG-savings the following ranges and mean values apply. GHG-savings for ethanol from cane and corn are assumed to vary by 20% and 30% respectively around their mean values.

Figure 2.13: GHG-abatement in kgCO2-eq per litre from various feedstocks



Source: own illustration based on data from various studies.

2.7.2. Impact of Land-Use Changes on the Environmental Performance

The GHG-balances presented above do not consider changes in land-use for growing feedstocks. They are based on the assumption that either no GHG emits when formerly unused land is used for cultivation or that land has always been dedicated to feedstock production. However, the need for addressing this issue is obvious when considering that land use changes, particularly deforestation, accounts for 15 to 25% of global CO2-emissions (UN Energy, 2007) and that increasing demand for biomass-based fuels puts pressure on all sorts of available land.

Because existing land uses already provide benefits by sequestering and storing carbon in soils, it is crucial to compare these carbon benefits to potential GHG-savings from the production of biofuel feedstocks (Searchinger et al., 2008). Recent research reveals that the net carbon benefit is negative when converting rainforests (tropical or peatland) in Southeast Asia or Brazil, cerrado areas (wooded or grassland) in Brazil, and grassland or abandoned cropland in the US to grow biofuel feedstocks. The following figure illustrates the results from Fargione et al. (2008) for ethanol feedstocks.[32] At the same time it shows that previous publications underestimated the environmental impact of land conversion on GHG balances (BMELV, 2007).

Figure 2.14: GHG-abatement costs in EUR/ tCO2-eq

Biofuel	Sugarcane ethanol	Corn ethanol		Prairie biomass ethanol (ligno-cellulosic)		Wheat ethanol	Sugarbeet ethanol
Former ecosystem	Cerrado wooded (native ecosystem)	Central grass-land (native ecosystem)	Abandoned cropland (degraded)	Abandoned cropland (degraded)	Marginal cropland (degraded)	N.A.	N.A.
Location	Brazil			US		Europe	
Carbon debt in ton CO2-eq/ha							
Fargione et al. (2008)	165	134	69	6	0	-	-
Bundesregierung (2007)*	27	1		-	-	1	2
Calculation of "biofuel debt" (Fargione et al., 2008)							
Debt allocated to biofuel (considering by-products)	100	83	83	100	100	-	-
Annual repayment (ton CO2-eq/ha)	9,8	1,2	1,2	4,3	7,8	-	-
Time to repqy biofuel carbon debt (years)	17	93	48	1	0	-	-

* Original estimates expressed as carbon debt in CO2-eq/ GJ fuel; converted into tonCO2-eq./ha based on data from Henniges (2006)

Source: own illustration.

[32] The analysis account for the amount of CO2 released through combustion and decomposition of plants. Converting native habitats to cropland releases CO2 as a result of burning or microbial decomposition of organic carbon. Soils and plant biomass are the two largest biologically active stores of terrestrial carbon, containing approximately 2.7 times more carbon than the atmosphere (Fargione et al., 2008).

High carbon debts for native ecosystems, e.g. forests, are easy to comprehend. High carbon debts for abandoned, i.e. degraded cropland in the US are however less obvious. But cropland that has retired from annual production has already lost significant portions of its carbon stores.[33] Planting these areas with perennial grasses instead leads to a gradual recovery of carbon stores. Reactivating this land e.g. 15 years later to produce corn for ethanol creates a "carbon debt" that takes 48 years to "repay". Until the carbon debt is repaid, ethanol made from feedstock grown on the above mentioned, converted areas causes greater environmental harm than the gasoline it replaces (Fargione et al., 2008).

But not only changes in soil carbon stores are crucial when evaluating environmental sustainability. One of the greatest risks is the potential impact on virgin land or land with high conservation value, and thus the associated effects on habitat and biodiversity as well as on water and air quality (UN Energy, 2007). Moreover, agricultural biodiversity is also at risk if large-scale mono-cropping practices dominate feedstock production.

At this stage it is important to recall the concept of "limitations", embodied in the definition of sustainability. In order to be sustainable, feedstock production should be produced with little reduction in soil carbon. Fargione et al. (2008) suggest growing native perennial feedstock on abandoned or marginal cropland for 2nd generation ethanol. This provides ideal GHG benefits and offers wildlife benefits. The results also highlight the value of ethanol produced from waste products like municipal waste, crop waste and grasses from reserve lands (Fargione et al., 2008; Searchinger et al., 2008). The United Nations outline that "dedicated energy crops that are appropriate to the regions where they are planted - such as native perennial trees and grasses - can minimise the need for chemical input [...], while also reducing the need for water and providing habitat for birds and other wildlife" (UN Energy, 2007). Compared to annual agricultural crops, as used for common biofuels, perennial grasses and short-rotation forestry, used for 2nd generation biofuels, provide advantages in terms of biodiversity.

Certification schemes for biofuels can provide a framework to ensure GHG-benefits as discussed earlier, sustainable land-use changes and the preservation of ecologically valuable land. However, these schemes are only effective when covering all biomass (regardless of the end-use) on a global scale. Moreover, in the light of an increased importance on biofuels in global energy markets, a timely implementation is crucial to avoid the unsustainable expansion of feedstock production (Schmitz, 2008). It is important to note that any certification scheme should be designed in a non-discriminatory manner to respect the rules of global

[33] Ploughing the respective area leads to an immediate release of soil carbon.

trade. The downside of current certification schemes is their lack of accountability for indirect land-use changes. Such indirect effects occur whenever crops for bioenergy replace food crops, which are then cultivated on land with high preservation value. Indirect land-use changes are notoriously difficult to attribute and to measure. Therefore, current research is focused on a common methodology that considers indirect land use changes (FAO, 2008b).

2.8. Issues of Economic Sustainability

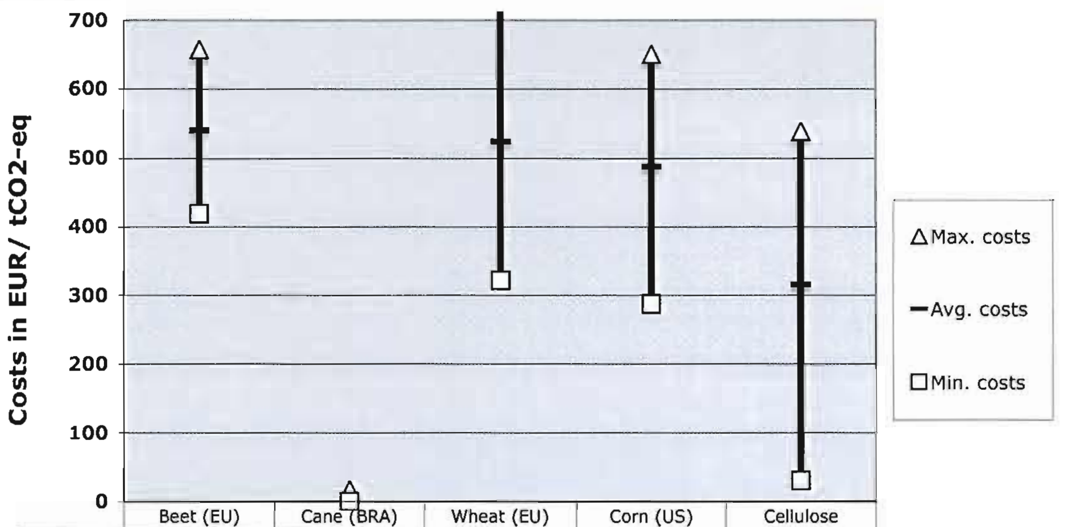
2.8.1. CO_2 Abatement Costs of Ethanol

This subchapter merges the findings from the previous chapters. In Chapter 2.4, the economics of ethanol production were analyzed, while this chapter cast a light on the energy and environmental performance of biofuel. If costs and GHG-abatement per litre are known, it is possible to set up a relation between both figures. In this way, costs for GHG-abatement ($C_{GHG\text{-}red}$) from the use of ethanol can be computed. The following equation establishes the relation between both figures. It is important to note that costs for abating CO2-eq. emissions by using ethanol depend on the net price of gasoline that ethanol substitutes:

$$(2.9) \quad C_{GHG\text{-}red}\,(P_{gas})\,[\text{EUR/ kgCO2-eq}] = (P_{EtOH} / FE - P_{gas}) / (GHG_{gas} - GHG_{EtOH})$$

The formula implies that costs for GHG-abatement only occur if ethanol is more expensive than gasoline on an energy basis. There are no costs for GHG-abatement if the energy provided by ethanol is cheaper than the energy provided by gasoline. In this case ethanol's environmental benefit is free. The following figure presents GHG-abatement costs based on the results from previous chapters, indicating the relation between production cost ranges and average CO2-eq emissions. The price for gasoline is fixed at 0.30 EUR per litre, which was equivalent to 50 USD per barrel crude oil in the past.

Figure 2.15: GHG-abatement costs in EUR/ tCO2-eq



	Beet (EU)	Cane (BRA)	Wheat (EU)	Corn (US)	Cellulose
Max. costs	658	18	975	651	539
Avg. costs	539	0	523	488	316
Min. costs	419	0	322	287	31

Source: own illustration based on data from various studies.

CO2-eq emissions can be avoided by the use of cane-based ethanol from Brazil. At crude oil prices of 50 USD even the most expensive way to produce ethanol in Brazil is just slightly cheaper than gasoline. By using ethanol from Brazil GHG-abatement costs are, indeed, negative. Although sugar beets are regarded as the best option environmentally for producing ethanol in Europe (IEA, 2004), a sample from the literature review suggests that wheat can show similar environmental performance and, thus, similar abatement costs. Extraordinarily high abatement costs are due to polluting primary energy inputs or poor energy concepts in the conversion process (e.g. wheat, max. costs). At crude oil prices of 50 USD/brl, ethanol from sugar beet processed in small scale plants with poor energy concepts can have CO2-abatement costs as high as 2,500 EUR/tCO2-eq. The corn-to-ethanol route shows lower abatement costs, which is mainly due to lower overall production costs. However, in the light of high corn prices GHG-abatement costs near or even below zero are rather unlikely.

Using current and future concepts of ligno-cellulosic ethanol is a promising alternative, but plants that are not optimized are likely to have higher abatement costs than the average sugar beet or wheat processing facilities in Europe (cellulose, max. costs). Current data suggests that GHG-abatement costs will not be below those in Brazil. Considering the prospects the cellulosic-to-ethanol route is the only opportunity for European or American ethanol manufacturers to improve their competitive position vis-à-vis Brazilian producers to 2020

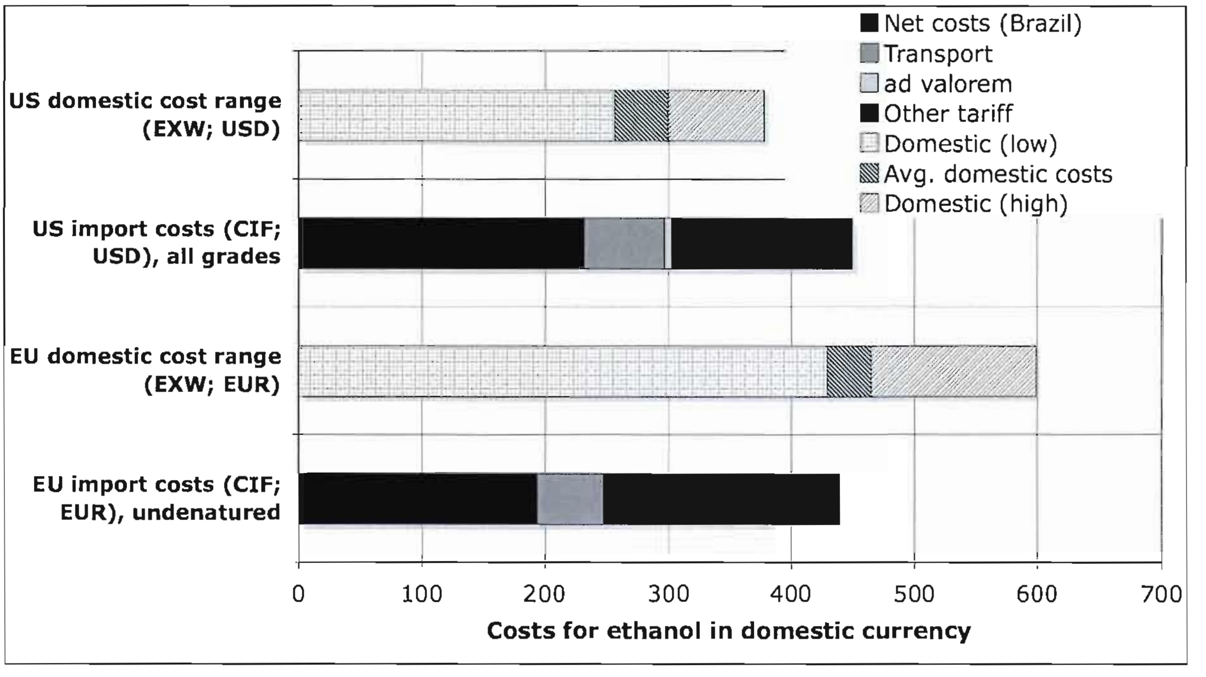
Beyond 2020 cheap and abundant feedstocks processed in large-scale plants may be able to compete with current Brazilian conditions (see long-term concepts, i.e. SSCF or CBP, presented by Wooley, 1999, and Hamelinck et al., 2005a). Finally, it is important to note that the price for energy, e.g. crude oil, has a significant impact on GHG-abatement costs. In this context volatile energy or feedstock prices are a good reason for policy makers or companies to build on other low-carbon technologies if the aim is to reduce emissions at lowest costs. Hence, investments in energy efficiency or other renewable energy projects, e.g. wind or hydro power, are more appealing than the promotion of biofuels.

2.8.2. *Trade Distortions in Ethanol Markets and the Consequences*

The early development of biofuel markets is shaped by existing trade distortions, including high internal subsidies and tariff quotas. While sugarcane-based ethanol is competitive with gasoline in Brazil, particularly farmers and processors in the EU and the US depend on government support. As already outlined in the introduction, the major problem is that ethanol is made from agricultural commodities and, thus, is affected by traditionally high market barriers. Another particular problem of ethanol is that, historically, most of the trade has been for alcoholic beverages and industrial applications. Small distilleries, which have dominated supply for these industries, have enjoyed extraordinary market protection, especially in Europe (OECD, 2008b). Consequently, trade volumes are low: only 10% of the ethanol produced in the world, or 5.5 million cbm, is traded internationally. Global ethanol exports are dominated by Brazil. Major trade flows from the South American country go to India, Japan, the EU and, indirectly, to the US. The USA have a special agreement with several countries in the Caribbean. This agreement, the Caribbean Basin Initiative (CBI) allows countries like Costa Rica or Jamaica to export ethanol duty-free to the US, even if the production of the fuel has occurs in another country (e.g. Brazil). However, market access for these countries is limited to 7% of US ethanol demand (Walter et al., 2007).

The USA and the EU have import duties in place that prevent more competitive producers, particularly Brazil, to export more ethanol to their markets. For ethanol imports into the US, an *ad valorem* of 2.5% applies in addition to a “secondary ethanol tariff” of 14.27 USD/hl. The EU has tariffs in place that amount to 10.2 EUR/hl for undrinkable (denatured) ethanol and to 19.2 EUR/hl for drinkable (undenatured) ethanol (OECD, 2008b). Based on the economics of ethanol production presented earlier, the following net import prices apply for Brazilian ethanol.

Figure 2.16: Average costs for ethanol (domestic and imported)



Source: Compare cost data (average) Chapter 2.4 and OECD (2008b); EUR/USD exchange rate: 1.20; information about transport costs from Hamelinck et al. (2005b); arrows indicate ranges.

It is obvious that import tariffs in the US have a prohibitive character as ethanol from corn even from small US plants is competitive with ethanol from Brazil after accounting for import duties and other charges. In the EU, the situation is different as tariffs merely compensate for cost differences.

Tariffs are indeed problematic from an economic perspective *and* from the point of view of sustainable development. First, tariffs prevent other, potentially more competitive producers in less developed countries to enter markets of industrialized countries. Consequently, those countries that are particularly in need of economic development cannot seize the economic and social opportunities from developing domestic biofuel industries. Furthermore, tariffs limit market liquidity for a certain good. In the case of conventional biofuels, however, restricted markets can cause adverse impacts on food supply if the EU and the US continue to reallocate corn and grains to ethanol production, which would hardly be viable without protective measures (Walter et al., 2007; OECD, 2008b). Secondly, in the framework of GHG-abatement, tariffs provide a wrong picture of the actual price for saving CO2 in the transport sector. Comparing the domestic price for ethanol - including import duties - with other technologies available to save GHG-emissions might be extremely misleading. Finally, virtually all authors giving policy recommendations find that tariffs are a significant barrier to the market development and may lead to risky supply shortages and high costs of supply (Walter et al., 2007; Loppacher/ Kerr, 2005; OECD (2008b); UN Energy, 2007). If the EU and China alone maintain their targets for ethanol, both countries will face significant shortages from 2020 onwards; moreover, constantly growing demand from Japan that has no domestic ethanol production will put further pressure on world ethanol markets. For the US, information about production potential is ambiguous; however, if food, feed, fibre and fuel production should to be maintained on a sustainable basis, only significant imports or large-scale production from cellulosic materials could balance the lack of supply. Projecting given market structures until 2030, Walter et al. (2007) conclude that Brazil will maintain its dominant position in ethanol markets, covering the lack of supply from all other countries mentioned above. Moreover, the authors highlight the role of those countries that are currently not as involved in ethanol production and trade as they could be. As demand for transport fuels will grow in other regions as well, more sugarcane growing countries should launch ethanol production and, thus, contribute to satisfy estimated demand.

Further trade liberalization is imperative for biofuel markets as well as for agricultural markets in general. Although being important, extensive studies on trade liberalization in agricultural markets are seldom. This is because complex and interdisciplinary models are required to capture the whole effect of such a multilateral accord. Furthermore, evolving markets for bioenergy and the rising importance of sustainability issues would have to be incorporated in such models. Studies from the Organization for Economic Co-operation and Development (OECD) and the UN's Food and Agriculture Organization (FAO) are regularly providing macro-economic models of agricultural markets. A recent analysis from the OECD on biofuel support policies has revealed potential implications of market liberalization for ethanol (OECD, 2008b). It is, however, important to note that market liberalization for biofuels alone would undermine other protective policies in industrial countries. Therefore, the impact of trade liberalization in other goods has to be considered as well; in the case of ethanol, for instance, liberalization of sugar markets would play a predominant role. The following tables outline the possible impact of market liberalization for biofuels, including the elimination of the most significant policy instruments (tariffs, blending mandates and excise tax reductions) on biofuel production, consumption, feedstock prices and total crop area.

Table 2.4: Impact of free trade on production and consumption (EU and US; 2013-17 avg.)

	EU Ethanol...		EU crop area	US Ethanol...		US crop area
	Consumption	Production		Consumption	Production	
No tariffs	+5%	-45% | -50%	-0.4%	+5% | +10%	0% | -5%	-0.3%
No mandates	-25% | -30%	-15%	-0.5%	0%	0%	-0.1%
No tax support	-15%	-15%	-0.5%	-15%| -20%	-10%| -15%	-0.3%
Total effect	-35 | -40%	-75 | -80%	-1.4%	-10%	-15%| -20%	-0.7%

Source: Approximate effect based on OECD (2008b). Note: Only trade liberalization in biofuels assumed; the decrease in EU crop area is due to lower feedstock production for ethanol *and* biodiesel.

The negative impact of free trade on consumption and production of ethanol is lower in the US than in the EU. The results also reflect different economics of production, indicating that the removal of support mechanisms for ethanol in the US is less detrimental than in the EU. After eliminating their tariffs, both regions will import significantly more ethanol than before, mainly from Brazil. Despite lower production in the US, global ethanol markets will keep on growing, though at a much lower rate than before. As already outlined by Walter et al. (2007), Brazil will be the dominant player in global ethanol markets in that case. However, other regions can also benefit from tariff reduction. The analysis from the OECD projects a production increase of 15%, mainly in Asia and Africa, though the initial level of production in these regions is rather low.

Table 2.5: Impact of free trade on domestic production

	Change in % to projected baseline					
	Brazil	USA	China	EU	India	Other
Supply	+10% | +15%	-2% | -3%	+5% | +10%	-45% | -50%	Approx. neutral	+15%
Demand	-25% | -30%	-15%	-0.5%	0%	Approx. neutral	Approx. neutral

Source: OECD (2008b); approximate values assuming no removal of tax and consumption incentives. Analysis does not consider removal of ethanol support polices in China; changes are driven by price changes for ethanol. No full consideration of Brazilian ethanol support programs.

2.9. Conclusion: The Need for Trade

The previous chapters have highlighted the most important features of ethanol markets. Significant disparities in feedstock costs lead to very different economics of production. From a technical perspective, it is important that the glucose in sugary and starchy plants can be extracted and converted easily to ethanol. Ethanol from sugarcane shows the lowest production costs as handling of the plant and extracting the glucose is relatively easy. Grown in tropical regions, sugarcane provides significantly more energy and at lower cost than other feedstocks (e.g. corn in the US and wheat or sugar beet in the EU). Compared with ethanol made from other feedstocks, sugarcane-based ethanol provides the highest GHG-savings because the feedstock production is less energy intensive and the whole plant can be used for energy generation in the conversion process. In more temperate climates, ethanol from cellulosic biomass is the only option for large-scale production at low costs. Once technology matures, GHG-savings can be as high as for sugarcane.

Depending on how market policies are designed, ethanol production can be associated with significant risks or opportunities for sustainable development. From an environmental perspective, expanding feedstock production should not be at the expense of areas with high conservation value (e.g. rainforests) or grassland with high level of carbon storage. From the point of view of socially sustainable development, an increase in ethanol production based on corn or wheat should not lead to shortages and price hikes of those grains that are important for the poor. However, if environmental standards are respected, ethanol production can significantly support social and economic development, particularly in poor countries.

Currently, however, industrialized countries like the US or the EU have trade distorting policies in place that prevent less developed countries from seizing the benefits of biofuel production. Hence the development of global ethanol markets is significantly hampered. "The USA and EU will have a central role on future fuel ethanol trade. The priorities of its energy and environment policies can constrain or deploy ethanol production in developing countries. Without clear possibilities of trade, investments on building or enlarging the capacity of production of fuel ethanol will not occur. For the majority of the countries with good potential to produce ethanol their domestic markets are very small in comparison with potential trade volumes. Without specific investments for exports, surplus amounts of ethanol will just allow trade on the margin." (Walter et al., 2007: 52-53).

Chapter III

The Research Model

This chapter is devoted to the underlying trade theory, namely the Heckscher-Ohlin model. As the previous chapter suggests evaluating the production and use of ethanol from an economic *and* environmental perspective, the Heckscher-Ohlin model is discussed from the classic perspective of cost efficiency and from the perspective of environmental economics in the context of the Kyoto Protocol. This joint perspective represents the theoretic foundation according to which European policies in relation to ethanol will be evaluated.

3.1. The Classic Theory of Trade

3.1.1. The Heckscher-Ohlin Model

According to the simplest trade models, countries will export goods that its labour force produces relatively efficiently, whereas it imports those goods that domestic workers produce relatively inefficiently. In the absence of trade, i.e. in a situation of autarky, the country would not use its labour force in the most efficient way, because if the economy requires all goods, it is forced to employ workers in inefficient industries. Trade allows a country to *completely* specialize in those sectors in which the labour force is most efficient, because it can trade the excess production for goods it produces relatively inefficiently. Gains from trade occur, as indirect "production", i.e. imports, requires less labour than direct production of the imported good. Thus a country is able to consume more goods at lower cost. This principle is known as the model of comparative advantage, first stipulated by David Ricardo in 1817, and it is one of the most basic models in international trade (Krugman/ Obstfeld, 2008; Hill, 2005).

As the Ricardian model is solely based on differences in labour productivity, Eli Heckscher and Bertil Ohlin extended the *"two-goods, two-countries, one factor of production"*-model. The standard Heckscher-Ohlin (H-O) model includes:

- *two* factors of production, e.g. labour and land, represented by their factor prices wages (w) and rents (r);

- two countries that are differently endowed with production factors, e.g. one has a relatively abundant labour force (country 1) while the other one has extensive land resources (country 2);
- two goods, e.g. the labour-intensive good 1 and the land-intensive good 2, represented by their prices P_1 and P_2.[34] In contrast to the Ricardian model, however, commodities are regarded as "bundles of factors", meaning that *both* input factors are required in the production process (Leamer, 1995).

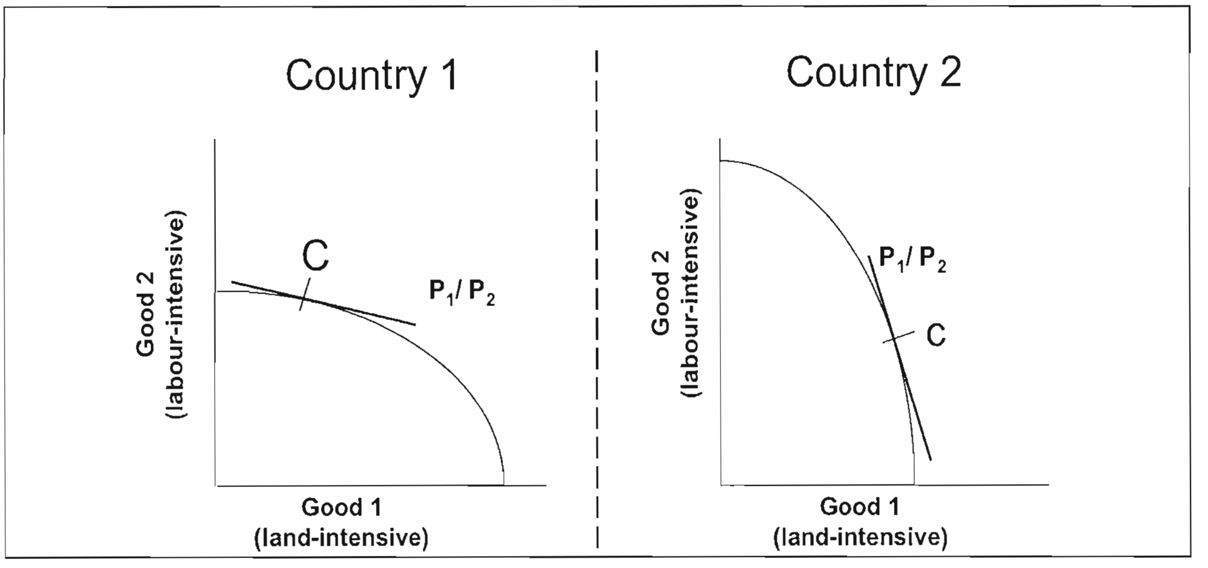
The H-O theory argues that, rather than differences in labour productivity, the relative abundance of input factors determines trade patterns. According to this reasoning, a country will focus on the production and export of those goods that intensively use the abundance of domestic factors of production. For the same reason, imports embody factors of production that are scarce in the importing country (Krugman/ Obstfeld, 2008; Hill, 2005). Therefore free trade acts as a perfect substitute for production factor mobility (Samuelson, 1948).

Unlike the Ricardian model, the H-O theorem considers that it is - *to a certain extent* - possible to use alternative input combinations in the production process of a certain good. In this context, an important assumption of the H-O theorem is that both countries employ exactly the same technology with constant returns on scale. Another assumption is that both economies must *completely* employ their production factors. This fact limits the economies concentration on the production of one good, because the more it employs the principal input factor, the higher the opportunity will be to produce the marginal unit of this good.[35] Furthermore, as the H-O model regards a competitive economy, the ratio of the marginal productivities of input factors (w/r) is always equal to the relative price (P_1/P_2), i.e. the price for the labour-intensive good compared to the price for the land-intensive good (Krugman/ Obstfeld, 2008; Samuelson, 1948). The following figure illustrates the production possibility curve of each country, indicating respective factor endowments and the relative prices, given that both countries are not involved in trade at all (C and c).

[34] A land-intensive good includes land as the major, but not the only production factor. In the same way, labour-intensive production requires more labour than land.

[35] Increasing opportunity costs are the consequence of numerous interactions: first, the higher the demand for land-intensive goods, the stronger the increase in rents; facing increasing rents, producers substitute to a certain extent land for labour, which is the relatively less expensive input factor; the higher use of labour increases wages and, in combination with high rents, leads to an increase in marginal costs for the second, i.e. labour-intensive good. Hence consumers would have to spend more on the land-intensive, *and* on the labour-intensive good, which stresses their limited income. Therefore the cost for consuming a marginal unit of the land-intensive good increases disproportionally; not only becomes this good is more expensive, but also it requires consumers to decrease the consumption of the second good, which has become more expensive as well.

Figure 3.1: Factor endowments and relative prices in two countries prior to trade



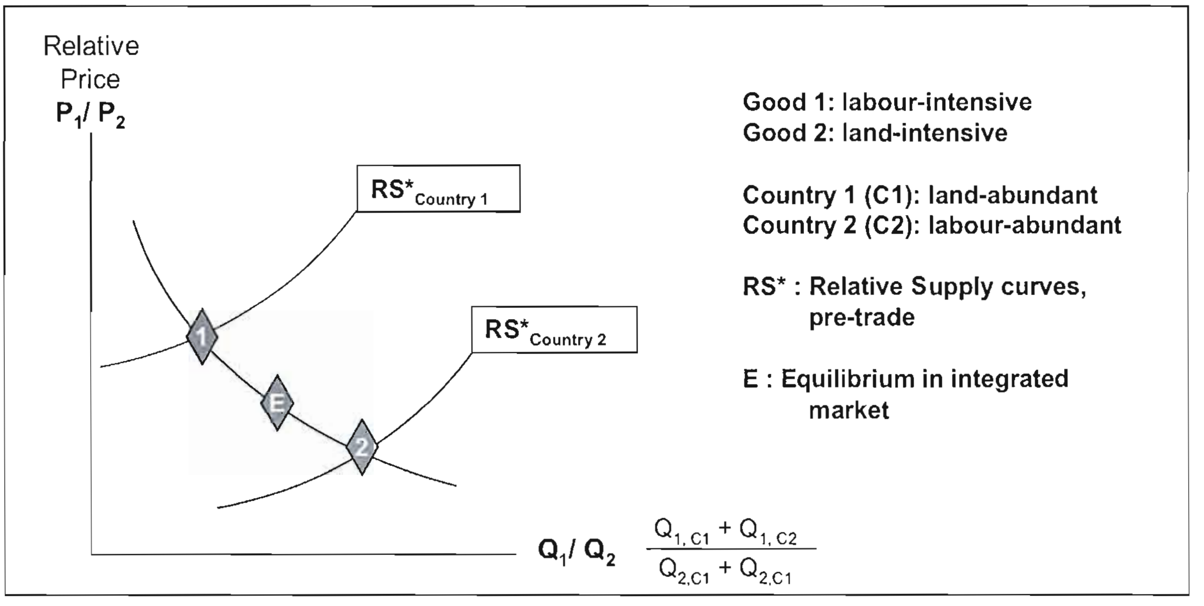
Source: own illustration based on Samuelson, 1948.

In the absence of trade, both countries make intensive use of their scarce factors of production because consumers attribute a higher value to the good that uses the scarce production factor more intensively.[36] Due to oversupply, the good embodying the abundant production factor is relatively cheaper. As in the Ricardian model prior to trade, prices ensure an optimal allocation of production factors, although the economy is "forced" to make relatively inefficient use of them. As the relative price (P_1/P_2) reflects the marginal productivities of input factors, i.e. the cost ratio (w/r), income of workers and landowners is directly affected. Therefore, in the pre-trade situation, income from scarce production factors is relatively higher than income from abundant input factors (Krugman/ Obstfeld, 2008).

When the two countries trade, there can no longer be two different price ratios. As the following figure indicates, the relative prices converge. High prices for the labour-intensive good in land-abundant "country 1" declines as labour-abundant "country 2" supplies more labour-intensive goods. "Country 1", however, will expand production of the land-intensive goods in the light of relatively high prices in "country 2". Trade allows both countries to *partially specialize* in the production of those goods that intensively use factors with which they are abundantly endowed (Samuelson, 1948).

[36] Technology allows for substituting - to a certain extent - land for labour in labour-intensive industries and vice versa. Consequently both countries adjust their input ratio to make relatively high use of the abundant factor of production when producing the good that mainly requires the scarce input factor.

Figure 3.2: Supply and demand in the integrated market



Source: own illustration based on Krugman/ Obstfeld, 2008.

As indicated by the single demand curve, an important assumption of the H-O model is that consumers in both countries have the same tastes and preferences. At the same time the demand curve represents the relative price and thus, the ratio of wages and rents. As "country 1" moves from its initial, pre-trade position (1) to the equilibrium of the integrated market (E), rents in the land abundant economy increase and wages decline. In labour-abundant "country 2", the opposite happens: when moving from the initial position (2) to the new equilibrium (E), landowners are paid lower rents while workers benefit from rising wages. Hence, "owners of a country's abundant factors gain from trade, but owners of a country's scarce factor lose" (Krugman/ Obstfeld, 2008: 68). The adjustment or equality of wages and rents is the consequence of free commodity trade, which acts - as already mentioned - as a perfect substitute for production factor mobility and compensates for the uneven geographic distribution of productive resources. Therefore the equilibrium (E) illustrated above represents the optimal productivity in the integrated market (Samuelson, 1948; Leamer, 1995).

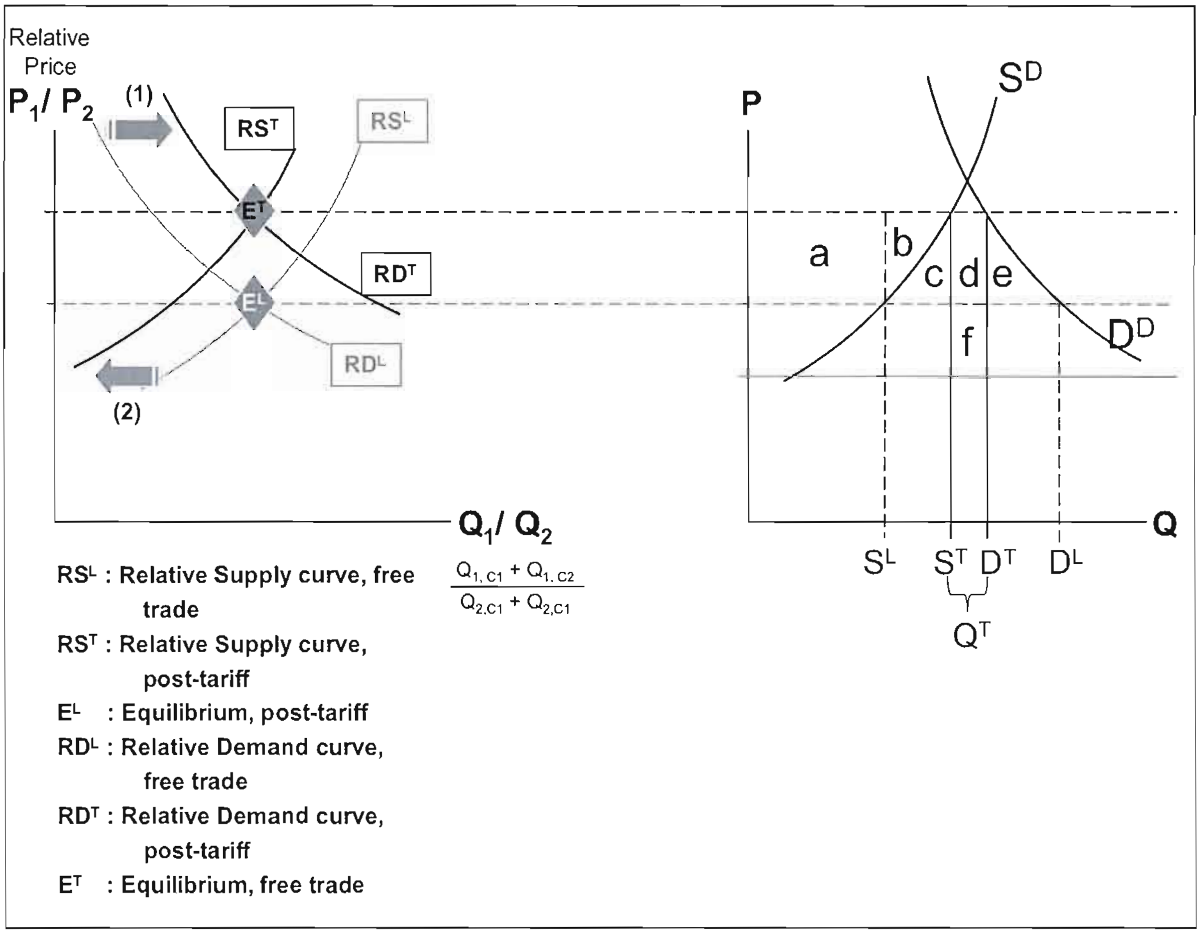
3.1.2. Trade Distorting Measures: Import Tariffs and (Export) Subsidies

According to the Ricardian and the H-O model, both countries gain from trade. However, the H-O model shows that incomes for owners of domestically scarce production factors will decrease. The fact that some groups lose (income) from free trade gives rise to trade distortions. Tariffs on more competitive foreign products are not only a measure to keep domestic market prices higher than world market prices; at the same time they represent a potential source of government revenue. (Krugman/ Obstfeld, 2008). There are several consequences of a tariff that is imposed on a relatively uncompetitive product, e.g. a labour-intensive good in a land-abundant "country 1":

- First, the tariff increases the domestic price of the labour-intensive good. Due to the relatively high *internal* price, the economy shifts production factors away from the competitive, land-abundant product towards the relatively uncompetitive good.
- Consequently, wages for workers rise while rents for landowners remain stable; i.e. the relative price changes in favour of the labour force.
- On the *internal* market, the higher price of the labour-intensive product shifts relative demand towards the relatively competitive, land-intensive product.
- Lower domestic production and higher domestic demand for the relatively competitive, land-abundant product reduces *external* supply, i.e. supply on the world market. The country's terms of trade improve as the price on the world market rises.
- All this happens at the expense of the country that exports the (labour-intensive) good for which the tariff applies. As world demand and prices *decline* for this product, the country shifts its production factors away from the productive (labour-intensive) industry to make more use of its relatively unproductive input factor (land). Consequently, incomes for workers decline and rents for landowners rise in the other country (Krugman/ Obstfeld, 2008).

The left graph of the following figure illustrates the effects of a tariff on relative prices and, thus, on income distribution in both countries.

Figure 3.3: Effects of a tariff in the standard trade model



Source: Krugman/ Obstfeld (2008).

The right graph shows the figures, the implications for income distribution and economic welfare in the country that imposed the tariff. Consumers lose due to higher prices (a+b+c+d+e). Protected by the tariff, producers receive additional profits (a) and marginal producers benefit from an enlarged market (b). Both effects *and* increase in government revenue (d) balance a part of the consumer losses. Whether a tariff has a positive or negative effect on *domestic* welfare depends on efficiency losses (c+e)[37], on the one hand, and gains in terms of trade (f), on the other hand. By imposing a tariff, a country can only improve its terms of trade if their own (import) market is large enough to impact world demand sufficiently and, thus, to depress export prices of other countries. If this is not the case, efficiency losses outweigh *domestic* gains from protection. Small economies find themselves in this position due to their minor domestic markets and therefore, tariffs are usually not beneficial to their economic welfare (Krugman/ Obstfeld, 2008).

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[37] Tariffs create efficiency losses on the domestic market because they distort incentives for efficient production and consumption (Krugman/ Obstfeld, 2008).

Export subsidies have the opposite effect on a country's terms of trade. An export subsidy for land-intensive products in a land-abundant country, for instance, aims at raising the income for landowners, i.e. for those already in a competitive position. Consequently, the relative price for the subsidized good rises, causing a shift of production factors towards the industry that has been subsidized. At the same time the higher relative price for the land-intensive good leads consumers to substitute the supported good for the relatively cheaper - and partly imported - product. The country's terms of trade worsen as increasing supply and decreasing demand depress world market prices. Moreover, costs for export subsidies clearly exceed associated benefits. The gains from export subsidies, from which landowners benefit in this example, represent consumer losses and government expenditures. As increased supply lowers world market prices, further government subsidies are required to keep prices for exports above current and eventually past world market levels (Krugman/ Obstfeld, 2008).

3.1.3. The H-O Theorem: Empirical Evidence

The H-O theorem has been subject to extensive empirical testing. In the classic test of the H-O theorem, Leontief (1953) analyzes the capital and labour intensity of US-trade and finds that, despite high capital endowments, the country is a net-importer of capital-intensive goods. Baldwin (1971) confirms Leontief's finding, although he points out that US exports are more *skilled*-labour intensive than US imports. Recent literature is based on Jaroslav Vanek's extension of the H-O model (H-O-V-model), in which trade flows are scrutinized according to a country's factor endowments in relation to world endowments (Vanek, 1968).[38] Based on the H-O-V-model, Bowen et al. (1987) analyze trade data in a multi-factor, multi-commodity and multi-country framework. The authors find that in contrast to the common H-O understanding "net factor exports [...] do not reliably reveal factor abundance" (Bowen et al., 1987: 805). Further tests suggest, "technological differences and measurement errors are [...] significant reasons for the poor performance" (Bowen et al., 1987: 804). Davis and Weinstein (2000) investigate the role of technology by examining input-output matrices. Their result confirms that countries improve their factor endowment by using different techniques. Indeed, technology enables countries to use their resources efficiently and hence, to overcome the lack of *effective* factor supply (Krugman/ Obstfeld, 2008). Moreover, Davis and

[38] The extension of the H-O-model, known as the Heckscher-Ohlin-Vanek (H-O-V)-model, is common in multi-factor, multi-product, and multi-country analyses. The rationale is to identify trade patterns by relating the country's factor endowments to world endowments (Vanek, 1968). The H-O-V-theory

Weinstein (2000) identify a consumer bias towards locally produced goods as one potential source of "measurement errors", mentioned by Bowen et al. (1987).

In the original H-O model effects like consumption biases, natural or political barriers to trade and, most importantly, technological differences are simply "assumed away", even though all these circumstances have strong effects on trade patterns and on factor price equalization. From an empirical perspective it is difficult to explain and to account for deviations from H-O-/ V-models. Therefore, recent research has focussed on countries that have radically different factor endowments. North-South trade is the primary case of endowment driven trade as resources of the North and the South[39] differ too much to be offset by technologies or other factors (Debaere, 2003; Krugman/ Obstfeld, 2008). Debaere (2003), for instance, applies an H-O-V-model, which focuses on differences in North-South endowments of capital, land, skilled, and unskilled labour. The author supports the H-O hypothesis that a country's commodity trade reflects abundant domestic resources along with those which are scarce. For 272 country pairs the H-O model predicts factor content of trade flows between the North and the South for skilled vs. unskilled labour in 77% of the cases, for capital vs. labour in 84% of the cases, and for unskilled labour vs. capital in 86% of the cases. The results, which are insensitive towards technological differences, are not too surprising because "The South" is expected to have abundant unskilled labour resources, whereas goods from "The North" should be capital and skilled labour intensive. The results from Romalis (2004), who applies an extended H-O-model, are similar. Researching the capital and labour intensity of trade flows into the US, the author finds that countries with low levels of human capital export goods that embody minimal skilled labour with the reverse being true for countries with abundant skilled labour. The same effect can be observed for capital abundance, though it is weaker (Romalis, 2004).

Empirical works trying to explain interregional and international trade based on the H-O-model leads to mixed results. In the original model, production factors are relatively similar and interchangeable to a certain extent; factor price equalization is the logical consequence of this setting. Much of the empirical work suggests, however, that factor abundance alone is insufficient to explain trade flows and that it is required to account for differences in technology. Extremely different production factors cannot be substituted for one another and hence, factor price equalization fails. In this setting the H-O-model gains in significance when ex-

[39] There is a standard definition neither for "the North", nor for "the South". In the sample of "The North", Romalis (2004) includes the EU-15, excluding Portugal and Greece, Iceland, Norway, Switzerland, Israel, Hong Kong, Taiwan, Singapore, Japan, Australia, New Zealand, and Canada; "The South" includes all other countries, except for small island economies that are not considered. The research by Debaere (2003) is based on a more limited sample.

plaining the factor content of (bilateral) trade. Regardless of empirical findings, the H-O-model proves to be especially useful when analyzing the effect of foreign trade on the distribution of income (Krugman/ Obstfeld, 2008).[40]

3.2. International Trade and GHG-Abatement

3.2.1. The Creation of Carbon Markets and Implications for Trade

Human activity, notably the combustion of fossil energy, adds to the concentration of heat-trapping gases (greenhouse-gases, GHG) in the atmosphere, leading to climate change (IPCC, 2007). Indeed public goods like the atmosphere are often included in economic activities without paying for the associated damage or "service". Hence it is crucial to include these side effects, i.e. externalities, in product prices to reflect the "real" cost of an activity (Siebert, 2008). When markets fail to include these costs, there is a need for an authority to directly administer, i.e. limit these side effects, or to fix a price for them. When limiting the externalities, the administration body issues licenses or rights to companies. As total supply of licenses in relation to total demand determines the price, companies in need of licenses face uncertain costs. Alternatively, fixed prices appeal to companies while leaving the authority with an uncertain outcome (Fritsch et al., 2008). In the context of the United Nations Framework Convention on Climate Change (FCCC), the Kyoto Protocol establishes a market for GHG-emissions by requiring signatory states to limit emissions to certain levels. By capping emissions in industrialized countries, the Protocol aims at controlling the setting at an international "price" for greenhouse-gases (Grubb, 2003).[41] The following figure briefly summarizes basic information about the Kyoto Protocol.

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[40] Phrases in italics refer to the titles of the original publications from Bertil Ohlin and Eli F. Heckscher respectively.

[41] The apparent objective of the Protocol is to create a market by creating demand that would not exist if the atmosphere remains a global public good. Carbon taxes represent another approach to include externalities in production costs, and, if properly designed, they provide the same GHG-benefits as the emission cap (Siebert, 2008). Carbon taxes are not discussed here, because they play no predominant role in the context of the Kyoto Protocol instruments.

Figure 3.4: Basic information about the Kyoto Protocol

Signatory States:

- All countries except for very few non-industrialized countries;
- Except for the United States, all industrialized countries, so-called Annex B countries, have ratified the Kyoto Protocol;
- Countries having ratified the Protocol have committed to GHG-reductions.

Coming into force:

- February 16th 2005; commitment period is from 2008 to 2012.

Emission reductions:

- Only industrialized countries commit to strict GHG-ceilings (assigned amount units - AAU - in official terminology);
- In the first commitment period from 2008 to 2012, most countries must on average have reduced their emissions compared to 1990;
- Committed to GHG-reductions: most EU member states and Switzerland (-8%), the USA (once having ratified the protocol: -7%), Canada, Japan, Poland and Hungary (each -6%).
- Countries having to stabilize emissions: Russia, the Ukraine and New Zealand;
- Higher pollution levels for: Australia (+8%), Norway (+1%) and Iceland (+10%);
- Compared to 1990, reduction commitments are -5.2% on average.

Developing countries:

- Developing countries to be included in post-Kyoto regimes;
- Particular focus on China and India due to their rapid growth in recent years.

Source: own illustration based on Grubb (2003), UNFCCC (1998), UNFCCC (2008).

The economic rationale behind the Kyoto Protocol is to encourage signatory states to engage in emissions trading in order to keep the overall costs for GHG-abatement low (cap and trade). The Protocol includes a range of trade instruments to encourage those countries with low marginal abatement costs (MAC) to save GHG-emissions in addition to their actual commitments. Such an incentive exists long as "the cost of the latest action to save emissions" (MAC) is lower than the market price for emission permits (Criqui et al., 1999). Consequently, signatory states will trade until marginal abatement costs are equal in all countries. This is possible because GHG-emissions are homogenous and, therefore, it does not matter where they are abated (Siebert, 2008). The following figure outlines the principles of emission trading under the Kyoto regime.

Figure 3.5: International flexibility mechanisms under the Kyoto Protocol

Trading of national emissions quotas (Assigned Amount Units):

- Governments - and, depending on national regulation, private firms from the most polluting sectors - participate in trading assigned amount units (AAU; emission rights in more general terms);
- AAUs are created if a signatory state (or a company in this state) reduces more emissions than required.

Joint Implementation (project mechanisms between Annex B countries):

- Joint Implementation (JI) projects: cross-border investments between market actors in Annex B countries aiming at emission reductions in one country;
- Emission Reduction Units (ERUs) represent the generated emission savings, also referred to as carbon credits;
- ERUs are split between both parties;
- Condition: JI-projects must be additional to other domestic carbon saving efforts;
- JI projects require the approval from the governments in the participating states.

Clean Development Mechanisms (project mechanisms between Annex B and non-industrialized countries):

- Clean Development Mechanism (CDMs): project mechanism enabling emission savings from projects in developing countries;
- Certified Emission Reductions (CER) represent the generated emission savings, i.e. carbon credits; CERs are completely transferred to the Annex B country and fully count towards the emission reduction target;
- Conditions for certification: voluntary participation of each party, real measurable long-term benefits in terms of GHG-savings, and emission reductions in addition to what would occur in the absence of the certified project activity.

Note:

In theory, different units defined under the Kyoto Protocol, e.g. AAUs, ERUs and CERs, are completely exchangeable and only indicate that different means have been used to achieve carbon savings.

Source: own illustration based on Kolstad/ Toman (2005), Grubb (2003), UNFCCC (1998).

Kolstad and Toman (2005) name three structural factors why a country has low MAC or why it is more "carbon competitive" than the other (Delgado, 2007). All three arguments can be related to the Heckscher-Ohlin theorem:

- Countries have different endowments of low-carbon energy resources (e.g. resources like wind, biomass, or natural gas) and high-carbon energy resources (e.g. crude oil). According to classic Heckscher-Ohlin-reasoning, countries well endowed with *low*-carbon energy resources are in a favorable position to provide carbon credits to economies using carbon-intensive energies (Criqui et al., 1999). This perspective differs not too much from that presented in the previous chapter. However, it relies heavily on two major assumptions in the H-O model: (1) low-carbon energy - as a factor of production - cannot be traded among countries; and (2) technology is the same everywhere (e.g. neglecting the technological capacity of some countries to use nuclear energy).

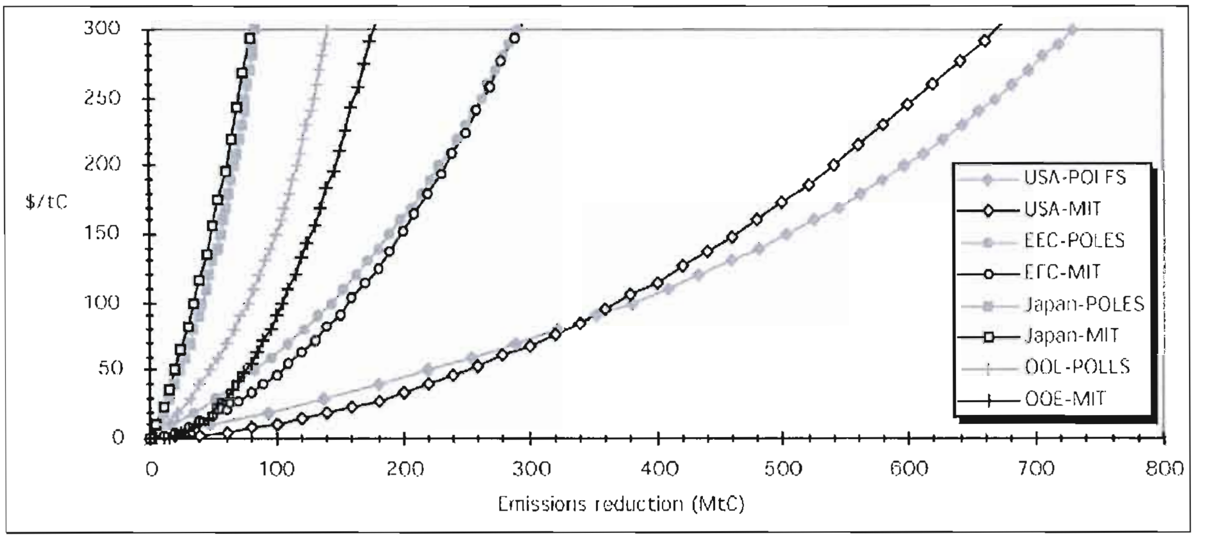
- Another factor is the structure of the economy, which determines energy demand (e.g. a service- or high-tech-oriented economy demands less energy than one focusing on heavy industries). According to the perspective of environmental economics emissions represent an input in the production process as they indicate the externalities caused by the production. In the absence of environmental regulation a country well endowed with environmental resources, i.e. resources capable of absorbing pollutants from the industry, exports "dirty" commodities. In the same way a country with few environmental resources exports "clean" goods (Rauscher, 2005).[42] Environmental policies capping emissions reduce in consequence the production possibilities and the competitiveness of the "dirty" sectors. Moreover, economies depending on these sectors are less carbon competitive and have to "import" carbon credits. Such an emission cap is less severe for economies that focus on "clean commodities" and that are potentially in a position to "export" carbon credits (Siebert, 2008).
- In some countries saving *further* emissions may be associated with considerable marginal costs. This is true if the most important sectors of an economy are low-carbon industries (e.g. service sector), if significant efforts to save emission in carbon-intensive industries have already been made, and/ or if the endowment with natural resources is not suitable for producing (more) renewable energy at competitive prices (Kolstad/ Toman, 2005; Delgado, 2007). In Japan, for example, saving (further) emissions turns out to be difficult and therefore the country faces the highest MAC (Criqui et al., 1999).

The mix between both, the carbon intensity of domestic energy production and industry determines MAC of individual countries. In a competitive market the price for emission

[42] The empirical evidence for this interpretation of the H-O-theorem is mixed. According to Rauscher (2005) there is no clear-cut empirical (econometrically backed) evidence that environmental policy has led to a change in trade patterns". Porter and van der Linde (1995) even reverse the H-O-thesis by claiming that "stricter environmental regulation is not only good for the environment but also for competitiveness", which may be underlined by the first-mover argument. Basic economic wisdom, however, suggests that companies should have the incentive to be early movers and/ or technology leaders by themselves, requiring no policy intervention at all. The discussion gives indeed rise to further empirical research (Rauscher, 2005).

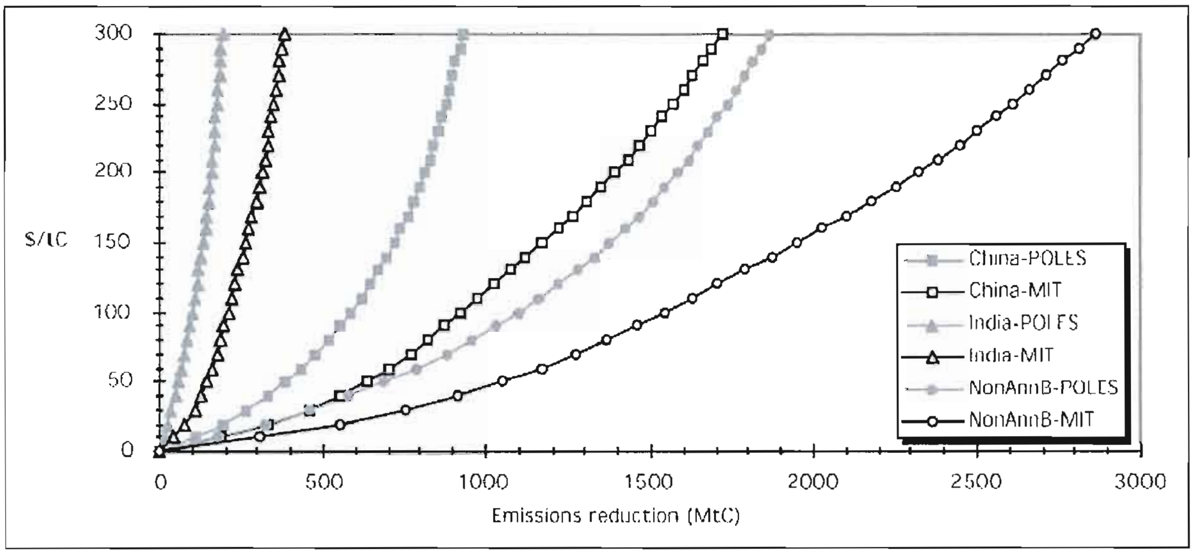
allowances indicates whether carbon credits are "imported" or "exported", or in other words, where emissions can be saved at lowest cost (Kolstad/ Toman, 2005). In numerous studies authors have modelled MAC for individual countries in order to identify their carbon competitiveness. It is important to note that industrialized countries, Annex B countries in Kyoto terminology, are facing much higher abatement costs than developing or least developed countries due to their carbon intensive economic structure. But even among Annex B countries there are significant variations in abatement costs. For a given amount, the US can abate much more emissions than other OECD countries, notably Japan. Among non-Annex B countries, India has significantly higher GHG-abatement costs than China. Other developing and least developed countries could provide the highest GHG-savings for a given amount (Criqui et al., 1999).

Figure 3.6: Comparison of MAC for OECD countries



Source: Criqui et al., 1999: 589.

Figure 3.7: Comparison of MAC for non-Annex B countries



Source: Criqui et al., 1999: 590.

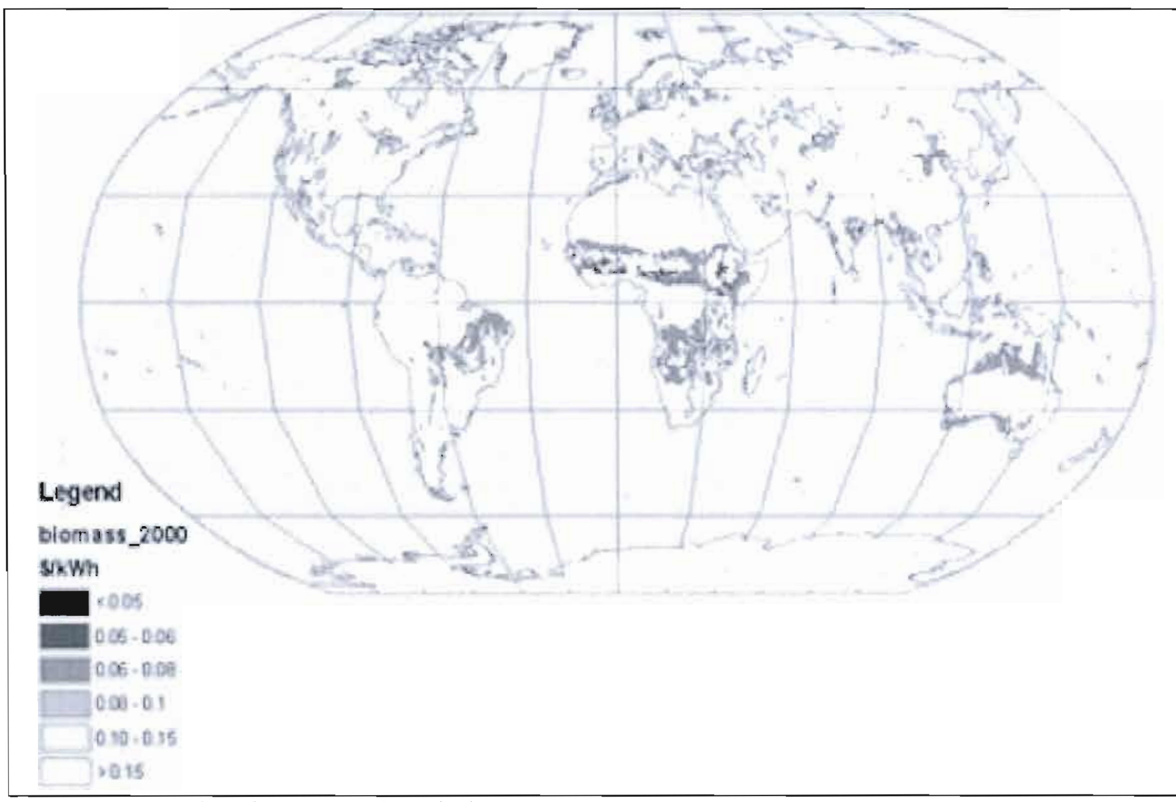
Previous explanations strongly suggest a common global market for carbon credits. However, the design of the tradable permit scheme under the Kyoto Protocol and the fact that political interests work against perfect fungibility of emission credits make the market imperfect and price equalization for carbon credits impossible. Grubb (2003) provides a detailed discussion on this subject. Nevertheless, when regarding GHG-emissions as an input factor of economic activity, the notion of *one global price* for greenhouse gases is appealing.

3.2.2. Renewable Energy Resources and the Heckscher-Ohlin Theorem

A country's endowment with renewable energy resources, i.e. wind, solar energy or biomass (WSB), can be taken as given. In this context the notion of resource endowment, which is the major criterion by which to evaluate trade flows according to the H-O-model, refers to the abundance of area *and* to the abundance of favorable climatic factors, e.g. solar radiation, annual rainfall etc.. Both factors determine the cost for bioenergy production: land-use and land-cover on the one hand (area) and meteorological data (climatic factors) on the other hand are combined to assess a country's potential to provide renewable energy from WSB.

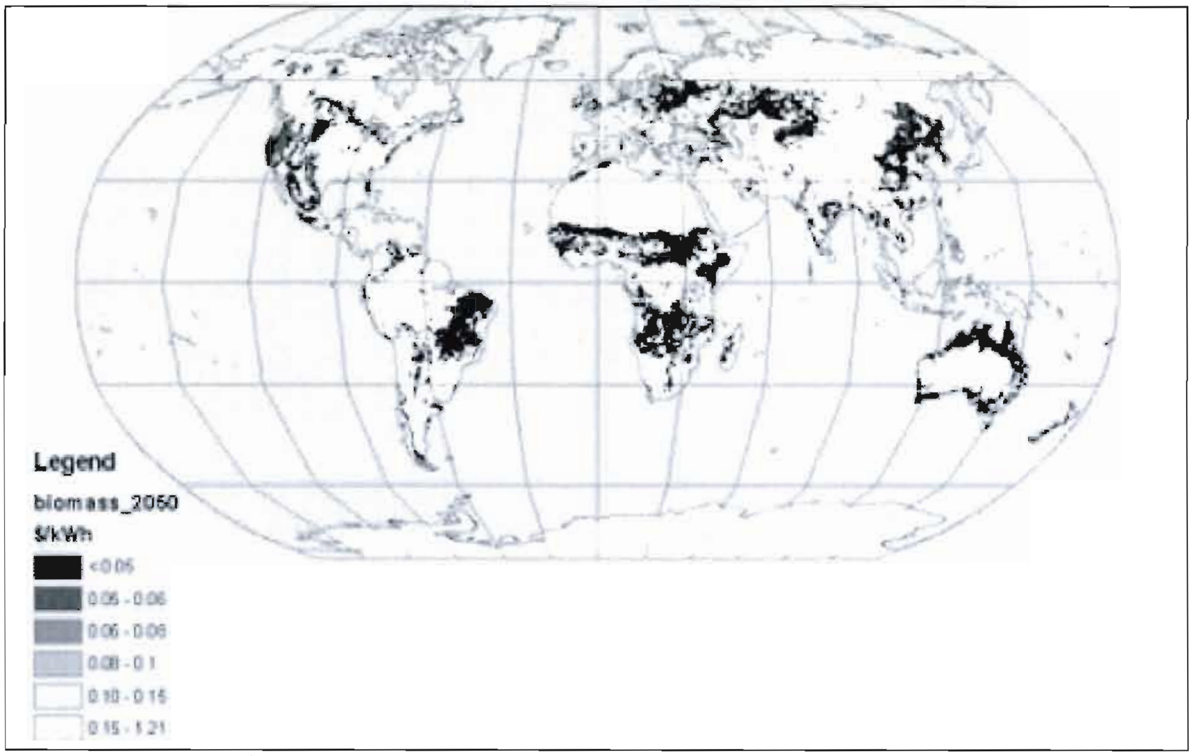
In this context the geographical potential is the energy flux theoretically extractable in areas suitable and available for production. Incompatible land cover (e.g. oceans or mountains) or land use (e.g. cities) is excluded. The technical potential represents the geographical potential after accounting for conversion losses, which occur when transforming primary energy carriers (e.g. sugarcane) into secondary energy carriers (e.g. ethanol). The economic potential represents the technical potential that can be produced up to an estimated production cost. At this stage it is possible to derive a country's endowment with competitive renewable energy sources and, hence, to assess whether or not renewable resources represent an abundant factor (de Vries et al., 2007; Hoogwijk et al., 2005). In an extensive study, de Vries et al. (2007) investigated the global economic potential for wind, solar-photovoltaic and biomass (WSB) using long-run supply cost curves. Based on production cost estimates, the authors calculated the competitiveness for each renewable energy source globally. Although no country-specific information is provided, the study provides *inter alia* a good idea about the regional competitiveness of biomass-based energy (conventional and second-generation transport fuels based on woody biomass, maize and sugarcane, as well as electricity from woody biomass).

Figure 3.8: Estimated global production cost and production potential in 2000.



Source: de Vries et al. (2007: 2601).

Figure 3.9: Estimated global production cost and production potential in 2050.



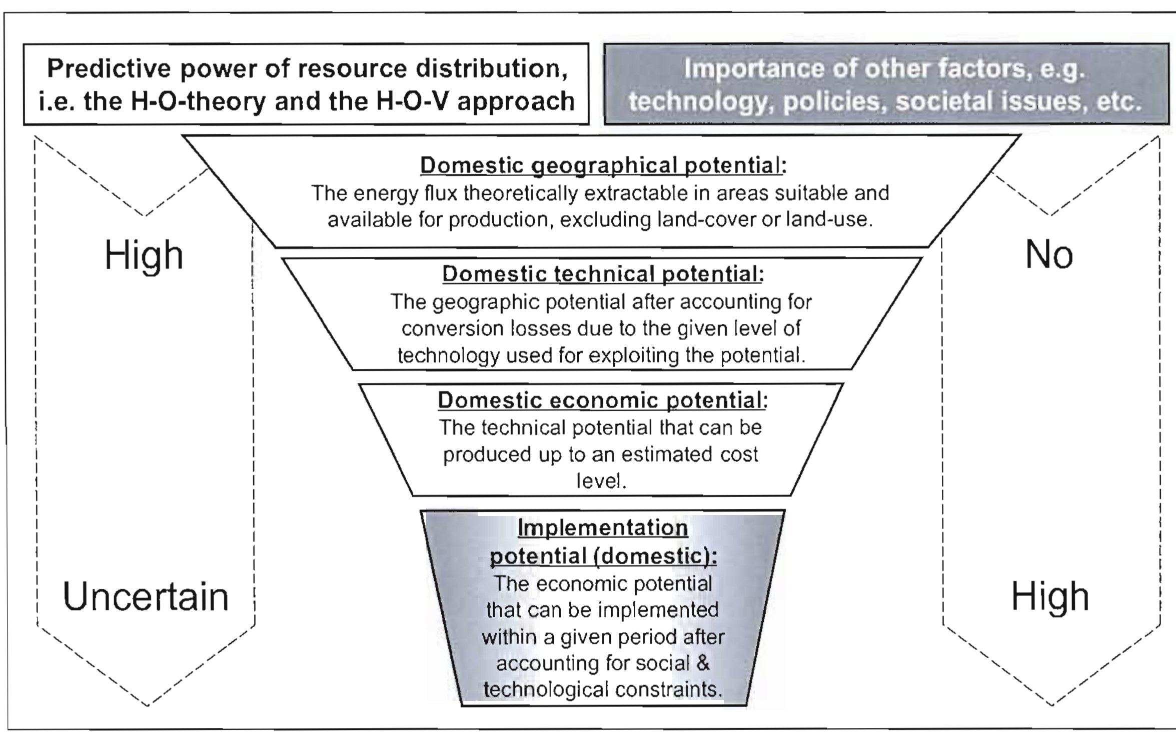
Source: de Vries et al. (2007: 2601).

The highest low-cost potential for biomass-based energy can be found in Central and South America, particularly in Brazil, in Sub-Saharan Africa and South-East Asia. Furthermore, the USA, countries of the Former Soviet Republic (FSR), and Australia can be expected to become low-cost bioenergy producers. However, according to the models from de Vries et al. (2007), options for low-cost *biofuel* production remain limited to tropical regions. In other countries, 2nd generation fuels and electricity from biomass are more relevant.[43] The figures above also show how progress in conversion technology drives down costs for biomass-based energy. Thanks to this development, costs for bioenergy in the FSR and South East Asia come down significantly and expand production possibilities. It is, however, worth to note that the production potential and costs in some regions can only be realized if perfect dispersion of technology is given. At this stage it is important to recall that assuming identical technology everywhere is not only crucial for defining the economic potential, but also for identifying opportunities for international trade according to the H-O-theorem (de Vries et al., 2007; Krugman/ Obstfeld, 2008). Regarding the dispersion of resources for low-cost bioenergy, Figure 3.8 strongly suggests North-South trade. Thanks to technological progress, however, low-cost resources will be distributed more equally in the middle of the 21st century (compare Figure 3.9).

[43] The authors use other graphs to illustrate this fact; it is not possible to see cost differences in the figures above.

Referring to the previous figures, particularly in less developed countries in Sub-Saharan Africa and Central Asia dispersion of technology has to be ensured for realizing the economic potential (Heinimö et al., 2007). But also country-specific factors such as incentive schemes and institutional barriers, alternative options to produce energy, availability of knowledge and, finally, the cost of integrating renewable energy resources into the larger energy system influence the extent to which a country develops its renewable energy potential (Hoogwijk et al., 2005). Hoogwijk et al. (2005) define the maximum economic potential that can be implemented within a certain timeframe as implementation potential. This potential, which will actually be realized, strongly depends on policies and preferences in society, perceived urgency of issues such as climate change or import dependence (de Vries et al., 2007). The following figure relates the concept of the H-O-theorem to the definitions of renewable energy potential as outlined by Hoogwijk et al. (2005).

Figure 3.10: The H-O-theory in the context of different resource definitions



Source: own illustration.

Policies potentially limit the predictive power of the H-O-model. However, they are imperative for sustainable trade in biomass-based energy commodities. Free trade is a precondition for sustainable economic development and, thus, for tapping yet unused bioenergy resources. In addition policies are required to ensure an adequate management of resources:

this includes facilitating the development of bioenergy, limiting overuse of resources, protecting biodiversity and setting social standards.

3.3. Conclusions: Theoretic Implications for this Research

The present research is based on the very basic ideas of the Heckscher-Ohlin (H-O) theory of trade, according to which a country's relative factor endowments determine the competitive position of a country vis-à-vis another country. Nevertheless there are other important factors, like technology, productivity or consumer preferences that determine the direction of trade flows. For this reason, empirical evidence for the Heckscher-Ohlin model is mixed. However, if factor endowments of two countries or regions, like industrialized (the "North") and less developed countries ("the South"), are significantly different, trade flows can be predicted very well by approaches based on the H-O-model.

In the context of environmental economics, the H-O model can be used to explain why countries are more "carbon competitive", i.e. why one country can save emissions at lower costs than the other one. The competitiveness depends on the carbon intensity of the economy and/ or on the possibility to use renewable resources. The latter factor is important for further analyses within this master thesis because conventional ethanol production crucially depends on cheap and abundant feedstock. Sugarcane and other low-cost inputs for the production of bioenergy are abundant in tropical climate zones, i.e. "the South". This suggests trade because energy from biomass is less abundant and more expensive in "the North". Whether, and to what extent "the North" and "the South" can, and will make use of their potential mainly depends on the dispersion of technology and on adequate policies.

Chapter IV

Methodology and Research Model

4.1. The Research Methodology

4.1.1. Definition of Scenario

In order to find a profound answer to the research question a future-oriented method is required. Scenarios are the most basic, though contested, concept in futures studies (Börjeson et al., 2006).[44] Van Notten et al. (2003) define scenarios in a very general manner as "descriptions of possible futures that reflect different perspectives on the past, the present and the future." Alternatively, the European Commission (EC) defines scenarios as "[...] a tool that describes pictures of the future world within a specific framework and under specified assumptions" (Banister et al., 2000a). In either case the term "scenario" implies the projection of a future situation as well as the possible development that might lead to the future (Schoemaker, 1993).

For the purpose of this thesis, the definition of the EC provides a better idea of scenarios. It gives a hint at different philosophical views and approaches that exist in scenario analyses (..."future world within a specific framework"...) and considers the fact that "specified assumptions" are crucial for all scenario studies (Dreborg, 1996; Robinson, 1990). Based on this definition the following subchapters will investigate the relation of philosophical perspectives and scenario approaches and thereafter, the relation of scenario approaches and associated assumptions. Both chapters provide the methodological background for understanding the research model.

4.1.2. Philosophical Perspectives and Associated Scenario Approaches

The use of scenarios in various scholarly fields such as business management, economics, social science and environmental studies is widely accepted. Hence, the scenario method is a normal science according to Kuhn (1970). This is, because questions related to methods and techniques for data gathering and analysis, instead of fundamental philosophical

[44] According to the etymological origin of the term, "scenario" refers to a "sketch of the plot of a play" and stems from the Late Latin word *scenarius*, "of stage scenes". In contrast to this ancient definition, the term has many meanings today, ranging from theatre scripts to loose or statistical projections of the future (Schoemaker, 1993).

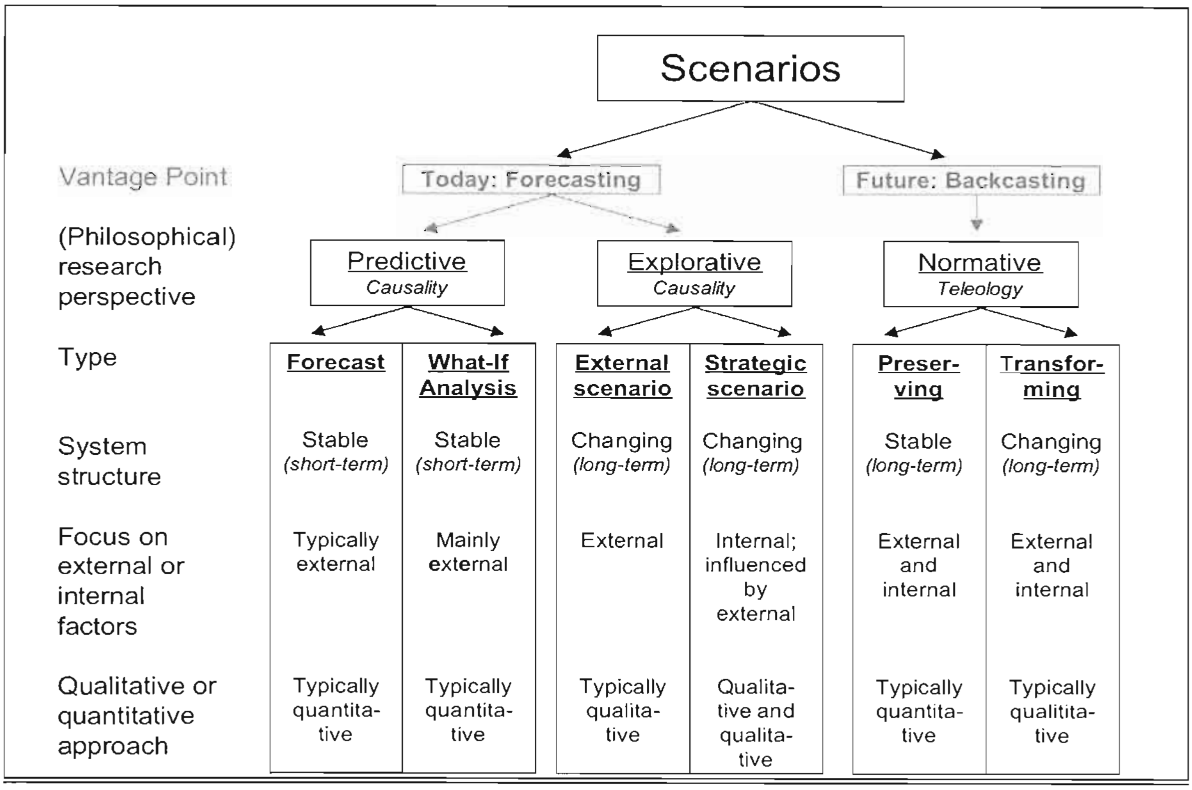
issues, dominate scientific debates (Dreborg, 1996). In scenario studies, three philosophical worldviews evolved. Traditional forecasting tends to be Leibnizian, focusing on a single, most *probable* future. In terms of inquiring systems, scenarios are Hegelian as they explore different, i.e. *possible* futures (Schoemaker, 1993). Both concepts are based on causality whereas the third scenario approach refers to teleology (purposefulness). According to the principle of teleology, the desires and beliefs of actors involved can explain the future in retrospect but cannot be fully predicted. This kind of scenario reflects a desirable, i.e. *normative* future (Dreborg, 1996).

The researcher's perspective determines whether the scenario approach is predictive, explorative or normative. In scenario analyses - like in futures studies in general - a research question can therefore be posed in three principal ways: *What will happen?*, *What can happen?* and *What should happen to attain a specific objective*? (Börjeson et al., 2006).

Besides this philosophical perspective, the goal of the research determines the concrete approach to the system under study. Researchers can regard stable or changing system structures (short-term versus long-term scenarios). Moreover, the goal of the study implies whether only external factors will be considered, i.e. those that are beyond the control of an organization, or whether internal factors, i.e. strategic reactions of the organization, will be included as well (project goal of exploration versus decision support)[45]. Finally, the project goal determines the complexity of the scenario study and, considering available resources, whether the problem is solved by qualitative or quantitative techniques (van Notten et al., 2003). The research perspectives and associated scenario types will be subject to an in-depth discussion in the following chapter.

[45] Scenarios are generally established to provide support in decision making (focus on internal factors) or to gain a better understanding of the system structure (focus on external factors). However, analyses based on scenarios often allow both, understanding the system and deriving implications for decision makers (van Notten et al., 2003).

Figure 4.1: Scenario typology with three categories and six types



Source: Börjeson et al., 2006: 736.

4.1.3. Scenarios Types and Associated Assumptions

4.1.3.1. Forecasting Scenarios

As outlined in the scenario typology above it is possible to distinguish scenarios according to their philosophical views and their vantage point. Henceforth, scenarios based on today's system structure and the principle of causality shall be referred to as "Forecasting Scenarios" (van Notten, 2003). Predictive short- to mid-term scenarios are based on stable systems in which current trends unfold. Because this master thesis focuses on the long term predictive scenarios will not be discussed in detail.

In the long run "too many forces work against the possibility of attaining the right forecast" (Wack, 1985). Therefore, explorative, i.e. external and strategic scenarios are designed to analyze possible instead of probable futures. In explorative scenarios a comprehensive description of the current system is the vantage point for further analyses. Typically these descriptions focus on external factors that shape a system in the long run, including stakeholders and their power positions, trends in main factor markets and political decisions. In a subsequent step projections for these single factors can be combined to create scenarios

(Schoemaker, 1993). Many authors regard a "wide range of possibilities and competing perspectives" as crucial for a "good" scenario study (Schoemaker, 1995; Robinson, 1990). In order to organize the outcome of the analysis, "topics" should be chosen according to trends that play a predominant role in a scenario (Becker, 2004). The main criterion to evaluate the importance of a scenario is causality. Therefore, internal consistency and plausibility are crucial for evaluating the outcome.[46]

Explorative scenarios are especially useful for strategic issues. External scenarios can assist an organization in defining "robust" strategies, i.e. "flexible and adaptive solutions for an actor whose influence on external factors is small" (Börjeson, 2006). Strategic scenarios aim at appreciating the consequences of different policy options in the hands of the scenario user. This implies that the scenario user can use various strategies (internal factors, i.e. policy measures) to influence a target variable (e.g. CO_2 emissions). In essence, strategic scenarios indicate how the consequences of a policy decision vary depending on the external future development (Becker, 2004).

External as well as strategic forecasts entail assumptions concerning (1) time-series, historical and potential trends, (2) input data, and eventually (3) future probabilities. In long-term forecasting scenarios of a complex system, like global agricultural markets, assumptions are required to limit the complexity of the model. This applies to both, qualitative and quantitative approaches, although the latter fix causal relationships more stringently in extensive mathematical models. For this reason, Robinson (1990) criticizes the role assumptions play in these models by arguing that in long-term forecasts extreme scenarios will always reflect the assumptions embedded in the inputs or model structure. Particularly in long-term studies, however, scenario modellers and users might misperceive probabilities due to recent trends and make their assumptions accordingly (Gerardin, 1973). Furthermore, by assuming historical technological or societal cycles and relationships to apply to the future, researchers often over-simplify relationships and narrow their perspectives (Höjer/ Mattson, 2000).[47]

[46] Essentially, the scenario user has to check for (1) trend consistency, (2) outcome consistency, and (3) stakeholder consistency. In general, scenarios are consistent if trends are free of contradictions and fit into the chosen time frame. Outcome consistency refers to correlations between important factors. The correlation of factors within a scenario should - at least partly - be comparable to historical observations and causal models. Finally, scenarios are consistent if major stakeholders are not placed in positions they dislike and can change (Schoemaker, 1993). Analysis on trend and stakeholder consistency played an important role in Shell's "intuitive logics" approach that prepared the company for both oil-crises in 1973 and 1981 (Wack, 1985).

[47] The argument here is not that historical observations are unimportant. Technological, societal or economic connections can help to create a plausible image of the future. However, scenario users should broaden their perspective to consider all causal relationships of crucial factors in their analysis. Moreover, in strategic scenarios, the own ability to influence the future and to break certain trends should be considered (Höjer/ Mattsson, 2000).

4.1.3.2. Backcasting Approaches

In contrast to forecasting scenarios, backcasting scenarios start with desired end states and emphasize normative elements (philosophical view: teleology).[48] This approach requires "working backwards from a particular (desired) future end-point to the present in order to determine the physical feasibility of that future and what policy measures would be required to reach that point" (Robinson, 1982). "Backcasts are not intended to reveal or indicate what the future is *likely* to be but to indicate the relative feasibility and implications of different policy goals". The following framework underlines the normative character of this approach (Banister et al., 2000a: 116; Robinson, 1990: 824):

- First the problem and the desired solution at the end of the period must be defined. This implies the definition of current policy targets.
- Secondly the researcher has to describe (different) external conditions at the end of the period considered.
- Thereafter, *basic* physical processes of the current system (today) should be forecasted by considering main influencing factors and assumptions for future developments (exogenous variables). This step is indeed similar to long-term forecasts because it requires input data and assumptions, e.g. about future market situations.
- Finally, available means, i.e. strategies to solve the problem are elaborated to solve the problem under various external conditions at the end of the period (normative and causal).

As outlined earlier, preserving and transforming backcasting scenarios can be distinguished depending on whether they anticipate changes in the system structure or not. Typically, backcasting has a particular importance for political actors if "the task is to find long-term solutions to a major societal problem and when the policy-making involves substantial change" (Banister et al., 2000a: 115). Backcasting implies that decision makers vastly control the system in which their organization operates. This is a necessary condition of the backcasting approach.

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[48] The backcasting tradition evolved during the oil-crises in the seventies of the twentieth century. In an article on long-term electricity supply and demand, Lovins (1976) proposed a "backward-looking analysis" as a basis for discussing how to achieve a sustainable energy future. According to Lovins, it would be more beneficial to describe desirable futures and to assess how policy paths could lead to these futures, instead of extrapolating current trends showing ever rising demand for (fossil) energy sources (Quist/ Vergragt, 2006). Low energy demand, low dependency on fossil fuels and high shares of renewable energy sources were typical images of the future of initial backcasting analyses. Since then, backcasting - the term was introduced by Robinson (1982) - has been regularly applied in sustainability studies. In the past, Canadian, Swedish, and Dutch researchers have shown particular interest in backcasting approaches, applying them to energy (Anderson, 2001), transport (Banister et al., 2000a), and general sustainability issues (Quist/ Vergragt, 2006).

The principle assumptions refer to the external elements, i.e. the (societal and economic) situation at the end of the period (step 2 of the backcasting process). Under these conditions, the predefined target has to be achieved by strategic elements, i.e. policy interventions (Banister et al., 2000b). Furthermore, if the backcasting analysis concerns market activities (step 3 of the backcasting process), assumptions about supply and demand are crucial. As basic physical processes concerning consumption and production have to consider the current system and the end point economy, assumptions resemble those required for long-term forecasts. Hence, normative elements are mixed with causal aspects. This exposes the backcasting scenarios to some of the limits inherent in forecasting approaches (Robinson, 1990), but limits the idealization of the future image.

As in forecasting scenarios, the internal consistency of outcomes has to be tested and, if significant inconsistencies exist, basic assumptions about the current system or major trends have to be adjusted (Börjeson et al, 2006). However, after several unsuccessful iterations, a possible outcome of a backcasting study might be that the goal of the study itself is inconsistent, or that the desired future is impossible to achieve (Robinson, 1990).

4.1.4. The Methodological Approach for this Research

As outlined above, explorative, and normative approaches are competing, but also complementary perspectives of the scenario method (Börjeson et al., 2006; Ahlroth/ Höjer, 2007). Bearing in mind the research topic, the time horizon and the complex system structure, two scenario approaches would qualify for this master thesis: strategic scenarios (causal) and transforming scenarios (normative). Explorative external scenarios are not appropriate for this research because policies are a key element in biofuel markets and thus, external developments without any policy intervention are unimaginable. In order to distinguish this research from existing studies, the long-term backcasting perspective will dominate the analysis of EU biofuel policies. The two aspects favouring this approach are the characteristics of the current system and the driving forces of future biofuel markets.

The first aspect favouring the backcasting approach lies in the nature of the current system that characterizes trade in ethanol. According to Dreborg (1996), backcasting should be considered when

- the problem to be studied is complex and affects many sectors and levels of society (like international trade matters or environmental and sustainability problems);

- the time horizon is long enough to allow considerable scope for deliberate choice (which might be the case for an analysis from today to 2020);
- major change is, or might be required to solve the problem or to bring about an "ideal solution" and
- dominant trends are part of the problem and limit the informative value of forecasting scenarios.

All these criteria describe the current system of biofuel markets. However, the two latter arguments call for an approach that is different to simple forecasting scenarios. Indeed current studies highlight the complex interactions of trends in policies, stakeholder positions, markets and technology developments (OECD, 2008; Heinimö et al., 2007; Hamelinck/ Faaij, 2006). While the authors of all studies admit that policy decisions are the most important driver of future development,[49] they fail to address the role policies could play in developing the market and in overcoming major obstacles in current trends. Although many policy recommendations are given, the authors reject to base their research on a normative approach. Robinson (1988: 326) points at this dilemma by arguing:

> "[...] Using forecasts to justify policy decisions allows there to occur a curious reversal of cause and effect whereby present decisions are "caused" by predictions of future events; in fact, future events are themselves largely the result of such present decisions. [...] This reversal of cause and effect is often combined with an explicit or implicit assumption of the scientific nature of forecasting, allowing forecasts to be used to legitimize essentially normative policy decisions [...]".

This rationale paves the way for a different approach to the analyses of problems. It implies that policy makers and analysts should first define policy goals for the future, before elaborating policy paths to this future based on feasibility and choice.

The second aspect, favoring the backcasting approach, is driving forces and dominant trends. As the industry affects the areas of agriculture, environment, energy (-technology) and trade, which are traditionally subject to strong governmental intervention, it should be intuitive to regard a "desired solution" first, before elaborating strategies to achieve it. In contrast to existing studies and reports, the approach in this master thesis is that biofuel markets are

[49] For this reason, it is not surprising that in a recent (forecasting) scenario study on international trade in biomass, researchers from the Lappeenranta University of Technology in Finland identified future policy making on national and international level as second important factor for the future development of global biomass markets, behind issues related to viable production. However, the sheer number of political factors in comparison to other driving forces highlighted the relative influence of policies on the future development of biomass markets. The authors concluded "political decisions and actions probably are the most effective way to enhance the development of the bioenergy market and the utilization of biomass" (Heinimö et al., 2007).

primarily driven by political, i.e. normative decisions whereas market forces are important, but come second as they evolve their dynamics within a given political framework. Again, Robinson (1988: 326) provides a good idea about the role of the vantage point in policy analyses:

> "[...] In most cases, we are asking the wrong questions when we forecast. To the degree that the future is not already determined but remains to be created, then the search for the most likely future (i.e., the best prediction) is not only often misguided (since we are usually wrong) but actually counter-productive. This is so because the most likely future may not be the most desirable, and thus what are needed are not techniques that converge on likelihood but techniques that reveal the possibility, and test the feasibility and impacts, of alternative futures. The focus thus shifts from prediction and likelihood to feasibility and choice. This approach, of course, has significant implications for the way forecasts are prepared and used."

4.2. The Research Perspective and Model Implications

4.2.1. The Research Perspective in the Backcasting Framework

The first step of the backcasting approach consists in defining the general problem and the desired solution. The EU faces the following problems: (1) tight markets for fossil energy commodities associated with high prices and increased risk of disruption to supplies, (2) the need to decarbonize (road) transport fuels in the light of climate change, and (3) a decrease in the economic importance of rural areas associated with undesirable social effects. Ethanol is *one* potential means to tackle these problems. In the framework of this master thesis the objectives of the European Union in the respective policy areas shall represent *a part of* the desired solution to all these problems.

In order to relate this setting to the research perspective it is important to recall the distinction between policy objectives and policy strategies as defined in the backcasting literature (Banister et al., 2000a; Robinson, 1988, 1990). While the policy objective represents the desired solution to a problem, the strategy refers to the means available to achieve the objective. As it was argued in chapter 4.1.3.2, policy objectives should be achieved in the context of various (socio-economic) circumstances. Consequently, in order to achieve a fixed set of policy objectives deliberate strategies adapting to external circumstances are required. The goal of this master thesis is to assess the feasibility of EU policy objectives in relation to ethanol in a "free trade in sustainable biofuels" scenario in 2020. One major requirement is that the policy strategy, i.e. the "Alternative Ethanol Strategy", fits into such a setting. Consequently, while focusing on the set of policy objectives, possible strategies should be based on the principles of the H-O trade theory and respective approaches in environmental economics. Furthermore, these policies should promote sustainable development of ethanol markets. This reflects the essence of the research perspective of this master thesis and will determine what is to be observed and scrutinized, the kind of questions that are supposed to be asked, how these questions are to be structured, and how the results of scientific investigations should be interpreted (Kuhn, 1970).

4.2.2. The Context of "Free Trade in Sustainable Biofuels"

While the previous chapter defined the role of policy objectives and strategies, this chapter is devoted to the construction of the scenario "free trade in sustainable ethanol". In this step of the backcasting approach, the external elements have to be identified. Based on major societal trends, these elements are usually beyond the control of policy makers and describe the context in which future policymaking takes place (Banister et al., 2000b). Two major (external) developments are decisive for further analyses within this master thesis: (1) the spirit of environmental awareness and the promotion of sustainability and (2) the degree of global cooperation. Both trends are based on the scenarios developed by the UN's Intergovernmental Panel on Climate Change (IPCC) for calculating the future extent of GHG-emissions (Nakicenovic et al., 1998).

The societal spirit of environmental awareness can be contrasted to a society that purely strives for economic benefits. The former situation describes a world in which policy makers and citizens jointly promote environmental and sustainability issues (Banister et al., 2000a). The latter context would refer to a society that is aware of environmental problems but that has a rather passive attitude towards these issues (Heinimö et al., 2007). In the EU and in other Western societies major trends cause a shift from a society based on purely economic rationales towards higher environmental awareness and sustainability. This indeed reflects the current discussion regarding "sustainable biofuels" in respect to food security, preservation of ecosystems and GHG-balances. By contrast, the attitude that prevailed in Brazil and the USA when both countries launched their ethanol production in the seventies was based on economic reasoning, as the aim was to develop alternative energy commodities. Later these policies were altered or complemented to take environmental benefits or societal concerns into account.

The second external element concerns the degree of global co-operation. In this case, a global spirit of co-operation could be contrasted with a "polarized" world in which the main global economies compete for important natural resources and protect their markets. Current WTO negotiations represent a concrete measure for polarization or co-operation. Heinimö et al. (2007), Hoogwijk et al. (2005), and Banister et al. (2000a), as well as the EU in a scenario study on the future of agriculture in the EU (EC DG-AGRI, 2006) highlight the importance of international trade relations when describing different global futures.

When combining possible developments of the two external elements, four plausible scenarios for 2020 could be built (Heinimö et al., 2007):

1. low importance of sustainability and high degree of global co-operation;
2. low importance of sustainability and low degree of global co-operation;
3. high importance of sustainability and low degree of global co-operation;
4. high importance of sustainability and high degree of global co-operation.

The following figure illustrates the scenario building process and the features associated with each scenario.

Figure 4.2: External trends and plausible scenarios

		Contextual Element II: SOCIETAL VALUES	
		BEHAVIOUR IS FREE-RIDING; ECONOMIC BENEFITS DOMINATE	**ENVIRONMENTAL & SUSTAINABILITY BENEFITS DOMINATE**
Contextual Element I: COOPERATION	**COOPERATION IN TRADE & ENVIRONMENTAL ISSUES**	**1A** **UNDESIRABLE FOR 2020** • Ethanol is an energy commodity; • no trade barriers exist • no environmental standards are defined; • Rationale: additional energy source to reduce the dependency on crude oil.	**1B** **DESIRABLE FOR 2020** • Ethanol as a sustainable energy commodity; • Certification fixes generally accepted product/ -ion standards; • No trade barriers; • Rationale: minimization of GHG-abatement costs on global level.
	BILATERAL & VOLUNTARY ACCORDS ON INTERNATIONAL LEVEL	**2A** **TODAY** • Ethanol is an alternative fuel; • trade occurs only in favour of local markets; • tariffs are common; • no or few environmental standards; • Rationale: ethanol is required to decrease dependency on crude oil.	**2B** **MOST LIKELY FOR 2020** • Ethanol is an alternative fuel with an emphasis is on environmental benefits; • trade occurs only in favour of local markets; • tariffs are common; • Rationale: regional interests dominate policy objectives at the expense of free trade.

Source: own illustration based on Heinimö et al. (2007).

It is the fourth scenario that is particularly appealing from an economic *and* environmental perspective. According to Heinimö et al. (2007: 34) this scenario is characterized by "large trade volumes internationally and the use of biomass in accordance with sustainable development" and thus, "seems to be the scenario with the most desired results". The need for sustainable bioenergy trade is generally accepted and accounted for by international standards. In this context ethanol is a sustainable energy commodity and, since there are no trade barriers, the benchmark for the use of ethanol is the overall reduction of GHG-emissions at the lowest cost. Only in this scenario the principles of the H-O theory and environmental economics are put into practice and respective policy strategies are required. The following figure provides more information about the future image, which will serve as a reference for further discussion within this master thesis.

Figure 4.3: The "Green Prosperous" scenario as background for further study

The state of sustainability standards:

- There is strong global green regulation that provides an unambiguous framework for sustainable biomass production.
- A transparent certification system of biomass production and trade is in use, based on international agreements on free trade and climate change mitigation.
- Driving force: Increased worry about the overexploitation and unsustainable utilization of biomass resources has been taken into account in these agreements.

The state of technological development and production:

- Second-generation technologies are widely in use.
- Countries with first and/ or second-generation feedstock resources are more efficient due to free market conditions, which stimulate innovation in the production and utilization of dedicated energy crops.
- Several markets, include farming and forestry, have developed and benefit from the sustainable utilization of biomass.
- Biomass production plays a crucial role in improving the economic situation in developing countries.
- Driving forces: Incentives and obligations for using biomass as well as technological improvements and innovations have played a significant role.

Accompanying trends:

- The public opinion has been an essential factor affecting the emergence of the global market of biomass: global markets for biomass and related products have in general a positive image.
- In the context of various international agreements on trade and climate change mitigation, investing in "green projects" is increasingly considered as an opportunity of economic profit.

Source: Heinimö et al. (2007: Appendix IV 1(4))

4.2.3. "Free Trade in Sustainable Ethanol": Scenario Assumptions

Scenarios are always related to assumptions about future developments (Börjeson et al., 2006; Schoemaker, 1993). The backcasting analysis applied in this master thesis is based on the assumption that a spirit of global cooperation exists and that all countries jointly promote the sustainable development of biofuels. This scenario implies an optimal outcome in multilateral negotiations on free trade (in the context of the WTO Doha Development Round and further agendas).

On the one hand this vantage point of analysis has to be challenged because the EU depends on the goals of other participants in multilateral negotiations. If main agricultural producers seek to limit access to their markets, the EU will not be prepared to agree on a facilitated access to its own market and the desired future of liberalized and sustainable markets cannot be achieved. On the other hand, the Union has implemented one of the most distorted agricultural trade policy regimes. If the EU aims at liberalizing this regime, there is a possibility that other countries will join Europe and open their markets for agricultural products as well. For this reason, the EU determines to a certain extent outcomes in negotiations on agricultural trade. Nevertheless, the Union depends on the general spirit of cooperation. This refers in the same way to environmental problems. Game theory is the crucial approach to explaining this situation: "[...] even those who want to act according in the common interest, may fail to do so because of the logic (structure of incentives) inherent in the situation." (Banister et al., 2000a: 133). Hence, there has to be an incentive for all participants in WTO-negotiations to liberalize trade rules. In the same way, global environmental issues, which usually suffer from the "free-rider" problem, should be designed to make those that do *not* participate worse off (Kolstad/ Toman, 2005).[50]

As outlined earlier, the research perspective is based on straightforward arguments for free trade. Strategies employed by the EU to achieve its policy objectives should be evaluated according to these criteria. But it is important to note that if the EU is not willing to cooperate with other states, and aims for bilateral rather than multilateral outcomes in trade negotiations, the policy objectives are likely to reflect this protectionist attitude. So the crucial question is whether only the means, i.e. the policy strategies are based on protectionism, or whether the policy objective itself is trade distorting or necessarily implies protectionist be-

[50] As the scenario of free trade in sustainable biofuels is assumed as given, it is not required to investigate within this master thesis ways and means to bring about the desired situation. A vast array of literature exists on institutional interactions between WTO and Kyoto agreements (e.g. Shin, 2004; Brewer, 2002; Sampson, 2000) and on game theoretic approaches to tackle problems in respective areas (compare Barrett, 2005, for a literature overview).

havior. If the latter is true, the policy objective is simply not compatible with free trade and/ or sustainable development. In this case, the EU would reach its desired outcome; however, this would be at the expense of the globally more desirable solution as described earlier. Alternatively, the policy objective would have to be dropped in a free-trade scenario. If only the policy strategies are based on trade-distorting measures, but if the policy objective itself can be attained in other ways, "creative" policymaking is required to achieve the objective in the context of a sustainable free trade scenario (Dreborg, 1996).

These arguments are close to those from Robinson (1990: 838):

> "One possible and important outcome of a backcasting analysis is the conclusion, reached perhaps after several unsuccessful iterations of the analysis, that the goals, constraints and targets [...] are themselves inconsistent or impossible to achieve in a satisfactory manner."
>
> [...]
>
> "Such a conclusion would be an example of backcasting serving to test the feasibility and consistency of a particular set of goals and constraints. In fact, since different scenarios can be multiplied indefinitely for a given set of goals, no finite set of backcasts can be said to disprove or falsify the feasibility or consistency of that set of goals. Nevertheless, an inability to reach a balanced outcome through several iterations can be said to represent strong *prima facie* evidence that the goals and constraints as defined present problems."

4.3. The Validity and Limits of the Study

The present research is focused on the policy framework for biofuels in the European Union. Although biofuel policies have a similar structure in many other industrialized countries, discussions and conclusions within this master thesis are only valid in the specific EU context. Moreover, no analysis will be provided to check the impact of the proposed scenario and the policy recommendations on Member State level. Regarding validity of results an important question is whether other researchers would make similar findings (Becker, 2004). Under the present research setting, the complexity of the research requires to concentrate on the conceptual features of a free trade scenario. However, the rationale is that the free trade in sustainably produced ethanol is very distinct from the current state of affairs so that the focus should be structural issues rather than on detailed results. Consequently, other researchers taking a similar research perspective and disposing of the same instruments of analysis should make the same findings as presented here. They may, however, come to different results if they relax one or more of the following limits.

Table 4.1: Limits of the study and their possible impact on the result

Limit	Possible impact on the result
Policy area: The focus is on those policy areas that directly interrelate with the EU Biofuels Strategy. Other policy areas, e.g. transport policy or EU cohesion policy, play an equally important role in achieving some of the policy objectives.	Including more policy areas and considering associated strategies could equally contribute to achieve the objectives - eventually in a more efficient way.
No consideration of other transport fuel alternatives: Only ethanol and no other alternative transport fuels are considered.	The result could change as a broader discussion on alternative transport fuels could entail a different view on ethanol as transport fuel.
Exactitude of the research model: In the present research no macro-economic model is used to simulate concrete impacts of liberalized markets. The results under free trade can only be estimated by referring to data and assumptions from other studies. Advantages and limits of this approach have been discussed earlier.	More detailed results, including quantitative assessments of policy options, could improve the comparison of certain policy strategies.
Impact of other research approaches: Game theory is the crucial approach to investigate the incentives for single countries to join multilateral accords regarding free trade and climate change. Stakeholder analyses on the whole subject could provide a better idea how to design specific policy instruments, and thus, how to create better incentives for single market actors. On regional or national level, case studies are useful for evaluating the opportunities ethanol production offers.	Extending the analysis to include considerations from game theory and stakeholder analysis could reveal that some policy strategies are inadequate to achieve the desired objectives, as they do not provide adequate incentives for some stakeholders.
Detailed country analysis: It is not possible to conduct a detailed country analysis for each third country in the sample. However, evaluation of past policy efforts, technical, and agronomic constraints in third countries should provide a sufficient picture of the future supply.	More detailed country analyses could be used for tailoring individual policy measures for each country. This is particularly relevant for detailed food versus fuel analyses.
Technical barriers to trade: Technical standards, such as fuel standards can possibly limit trade and represent a source for trade distortion.	The impact on the result is difficult to assess; however, the issue is deemed rather negligible because differences in fuel quality are more important for biodiesel (Kojima et al., 2007).
Extent of policy recommendation: Often dissemination (sermons, in policy analysis) proves to be a useful policy instrument. But as major change is required to arrive at a sustainable trade scenario, the present	Information campaigns can be useful for informing farmers about the features of biofuel feedstocks or consumers about the use or sustainable production of biofuels. They can facilitate the achievement of policy

analysis focuses on the role of incentives and market regulation (carrots and beats, in policy analysis).	objectives. Nevertheless, their impact is difficult to assess and their use should be case-specific (Becker, 2004).

Source: own illustration.

Finally it is important to note that the scenario representing the background of the thesis has a strong focus on economic and ecological sustainability. Issues related to socially sustainable development can only be addressed relatively roughly. It is, for instance, only possible to provide a conceptual view on the "food vs. fuel" issue under free trade; detailed country analyses as required for this issue cannot be provided and, hence, policy recommendations in relation to this issue have a more general character.

4.4. The Sources and the Fidelity of Data

The research is founded upon secondary sources. They will be addressed in turn. Valuable information came from industry analysts and scholars working on the subject. A general discussion with Prof. Dr. Gernot Klepper, an expert for economics of climate change and pollution abatement at the Kiel Institute for World Economics (IFW), was helpful for better understanding actual drivers and future trends of the ethanol industry. On various occasions Dr. Jan M. Henke and Dr. Norbert Schmitz from Cologne-based *meò-consulting*, a consultancy specialized in biofuel markets, road transport technology assessment, and sustainability certification, were contacted in order to discuss latest industry trends and EU policies. In recent years the consultancy firm has been managing multi-disciplinary research projects with numerous stakeholders, supported by German governmental agencies and ministries. The idea to focus on a single, desirable scenario and the respective policy implications evolved during discussions with Jan M. Henke.

Traditionally, publications from the US and Brazil play an important role due to the early development of ethanol markets in both countries. In recent years, however, many scholars and international organizations have turned their attention to various aspects of emerging biofuel markets all over the world. The concluding remarks of chapter 4.2.2 have already sketched out these major trends and associated research fields. As the subject interrelates with numerous interests in the areas of agriculture, environment, development and energy policy, there is a significant amount of biased sources. Due to this bias, it makes sense to consider the fidelity of data in the context of a general overview of available sources. Depending on the organization that publishes the information, it is possible to distinguish the information from "objective" to "biased".

- Intergovernmental organizations (e.g. the United Nations, UN, the Organization for Economic Co-operation and Development, OECD, and their respective, associated institutions): these organizations can be said to have the most objective view on the biofuel issue because they operate independently from their funding members. Moreover, they tend to have the most "global" view on controversial subjects, carefully weighting opportunities and threats.[51]
- The European Union and other or associated governments: on the one hand, the EU and other governments provide the most reliable and detailed statistics on production and trade as well as other macro-economic data. On the other hand, specific information on ethanol markets and policy implications are sometimes - intentionally or unintentionally - misinterpreted and lead to a biased conclusion.
- The scientific community: Scientific provide opinions of various scholars and researchers. The most influential scientific journal is "Biomass and Bioenergy", published by a research institute of the University of Utrecht (Netherlands). It provides latest information on ethanol technology and (techno-) economic performance. Joint assessment of various ethanol-related aspects comes from the Centre for Agriculture and Rural Development, CARD (Iowa State University), which also collaborates with the US Department of Agriculture (USDA) on annual, global, agricultural outlooks. Both sources provide very specialized and objective insights into the subject. "Energy Policy" provides the most in-depth policy analysis. The journal is influential and a platform for various qualified viewpoints on ethanol production and development.
- Industry-specific information: The most important periodical for the biofuel industry is F.O. Licht's "Ethanol and Biofuels Report". The in-depth coverage of latest market developments is, however, too optimistic and sometimes neglects essential counterarguments. By contrast, more general market reports are provided from US embassies across the world (USDA's Global Agriculture Information Network, GAIN) or by intergovernmental organizations, as mentioned above.

[51] There are several biofuel initiatives launched by the UN, OECD (IEA) and

Comparing information and evaluating their importance in terms of the research objective is crucial. The unstable economic and policy environment has made this task particularly challenging. It is important to note that very recent shifts in EU biofuel policy - initiated by the "Turmes Report" (2008/0016 (COD)) - have not been considered. It would be worthwhile to consider these changes in a separate chapter at the end of the master thesis.

4.5. The Research Sample

The major research will concern the European Union. For some analyses, however, it is important to evaluate data and information from other countries. As it was argued in Chapter 2.8, all countries would have access to the European market under this condition, but the theory of comparative advantage suggests that only the most competitive producers will be able to participate in trade. In contrast to existing studies (e.g. Walter et al., 2007), this research widens the perspective beyond current producers and includes those countries that have significant potential to establish a competitive ethanol industry.

As low feedstock costs are the most crucial factor it makes sense to regard the most competitive producers of sugarcane before considering other feedstocks. Based on data from the Statistical Office of the FAO (FAOstat, 2008) the initial sample includes all countries in which sugarcane was produced during the last 10 years. In order to identify producers with comparative advantages in cane production, the two major criteria are efficient production (yield) and scale effects (total production).[52]

1. High yields are the consequence of favorable climatic conditions and, thus, the typical case for Ricardo's comparative advantage. In the context of renewable energy, however, it may also be argued that climatic conditions represent factor endowments (de Vries et al., 2007). Regarding yields, the sample is limited to those countries in which average yields per hectare were equal or higher than the global average from 1998 to 2007.
2. Total production of feedstock recognizes the typical interpretation of resource endowment according to the H-O-theory. To consider scale effects, only those

[52] Other forecasts often define competitiveness of sugarcane production in terms of sugar exports. The approach in this master thesis is different because markets for agricultural products, and sugar in particular, are highly distorted and a favorable export position does not indicate a comparative advantage according to strict economic theory. Sugarcane yield is the most typical indicator for comparative advantage, whereas the expressiveness of production figures might still be inaccurate due to policy intervention.

countries are included in the sample that accounted for 95% of average global production from 1998 to 2007.

However, even if a country is a relatively small producer, high yields due to climatic conditions can nevertheless favour sugarcane production. In the same way, economies of scale can potentially balance low yields. The following, third criterion extends the relatively strict definition of competitive producers made above.

3. Countries showing lower sugarcane yields are included if their share of average global production during the last ten years exceeded 1%. Producers with high yields, i.e. 50% above average yields, but small market shares are included if their share of average global production from 1998 to 2007 exceeded 0.1%.

In the USA and in China, corn-to-ethanol is the most common production route. Although the feedstock is not as competitive as sugarcane, low-cost producers of corn and high cost producers of cane might show similar costs. For this reason, the sample is extended to the most competitive corn producers. However, criteria for selecting these producers have to take into account that there is no actual comparative advantage in corn production. Only polar and sub-arctic conditions inhibit the cultivation of the crop. As economies of scale are more important, the sample considers those countries that exceeded 1% of average global production from 1998 to 2007. Global corn production is dominated by the US and China that accounted for 39.7% and 19.2% of average global production respectively. Other countries, including Brazil (5.9%), Mexico (3.0%) and Argentina (2.5%), produced significantly less in the same period. While corn-to-ethanol is not an option for Brazil, Mexico and Argentina are countries in which both, cane and corn, might lead to similar ethanol costs. The same is true for South Africa (1.6%) and China (FAOstat, 2008; GAIN, 2008a,b).

Figure 4.4: Sample of (potential) cane-to-ethanol producers

Countries	Geopolitical classification		Production	Global share	Cumulated	Avg Yield in tons/ ha	Performance to avg	(1)	(2)
			Avg Production (1998-2007)			Avg Yield (1998-2007)		Criterion No. ... fulfilled	
Argentina	LAC	2	19.807.000	1,5%	85,5%	68,7	1,2	YES	YES
Australia	IND	1	36.444.733	2,7%	74,4%	85,8	1,5	YES	YES
Brazil	LAC	2	392.264.072	29,4%	29,4%	71,8	1,3	YES	YES
Colombia	LAC	3	36.824.924	2,8%	71,6%	88,5	1,5	YES	YES
Cuba	LAC	2	24.966.000	1,9%	82,4%	31,4	0,5	NO	YES
Ecuador	LAC	3	6.235.579	0,5%	92,4%	73,8	1,3	YES	YES
Egypt	NEA	2	15.789.368	1,2%	88,1%	118,6	2,1	YES	YES
El Salvador	LAC	2	4.995.102	0,4%	93,5%	78,7	1,4	YES	YES
Ethiopia	SSA	8	2.260.253	0,2%	97,2%	101,0	1,8	YES	NO
Guatemala	LAC	2	18.283.783	1,4%	86,9%	90,2	1,6	YES	YES
Honduras	LAC	2	4.573.937	0,3%	94,2%	75,2	1,3	YES	YES
India	SA	6	284.523.120	21,3%	50,7%	67,3	1,2	YES	YES
Indonesia	EA	2	25.701.900	1,9%	80,6%	70,3	1,2	YES	YES
Iran	NEA	3	4.141.756	0,3%	95,2%	87,6	1,5	YES	NO
Kenya	SSA	8	4.461.953	0,3%	94,9%	83,8	1,5	YES	YES
Malawi	SSA	6	2.235.000	0,2%	97,3%	106,6	1,9	YES	NO
Mauritius	SSA	2	5.005.211	0,4%	93,2%	70,9	1,2	YES	YES
Mexico	SSA	3	48.190.815	3,6%	68,9%	74,4	1,3	YES	YES
Pakistan	NEA	6	49.623.460	3,7%	65,3%	48,3	0,8	NO	YES
Peru	LAC	2	7.633.668	0,6%	90,5%	118,2	2,1	YES	YES
Philippines	EA	2	27.480.319	2,1%	78,6%	73,4	1,3	YES	YES
South Africa	IND	2	21.375.280	1,6%	84,0%	53,7	0,9	NO	YES
Sudan	SSA	8	6.321.746	0,5%	91,9%	92,7	1,6	YES	YES
Swaziland	SSA	2	4.529.431	0,3%	94,6%	99,7	1,7	YES	YES
Tanzania	SSA	6	1.940.780	0,1%	98,0%	108,2	1,9	YES	NO
Thailand	EA	2	56.169.787	4,2%	61,5%	56,4	1,0	NO	YES
Uganda	SSA	6	1.777.009	0,1%	98,2%	88,0	1,5	YES	NO
Venezuela	LAC	3	8.987.375	0,7%	89,9%	68,5	1,2	YES	YES
Viet Nam*	EA	7	15.755.630	1,2%	89,2%	53,0	0,9	NO	YES
Zambia	SSA	6	2.140.000	0,2%	97,7%	104,4	1,8	YES	NO
Zimbabwe	SSA	8	4.113.950	0,3%	95,5%	94,4	1,6	YES	NO

Key	LAC = Latin America/ Caribbean - EA = East Asia - SA = South Asia - NEA = Near -east & North Africa - SSA = Africa, sub-Saharan - IND = Industrialized countries. 1 Industrialized country - 2 middle-income - 3 middle-income oil exporters - 6 low-income - 7 low-income oil exporters - 8 low-income, severe crisis/ war.
*	Vietnam is the only low-income oil exporter included in the sample. In order to avoid a separate analysis for just one country, Vietnam is considered as middle-income oil exporter (3) in further analyses.

Source: own illustration.

Figure 4.5: Sample of (potential) corn-to-ethanol producers

Countries	Geopolitical classification		Avg Production (1998-2007)	
			Avg production	Share of global production (avg)
Argentina	LAC	2	16.639.646	2,5%
China	EA	2	128.692.514	19,3%
Mexico	LAC	3	19.925.360	3,0%
South Africa	IND	2	9.032.300	1,4%
USA	IND	1	264.662.163	39,7%

Source: own illustration.

In Europe, France (2.2%), Italy (1.5%), Romania (1.3%) and Hungary (1.1%) are the most important corn producers. Since corn does not improve the cost position of these countries, wheat and sugar beet are - like in other European States - preferred inputs in the ethanol manufacturing process (F.O. Licht, 2007). Canadian farmers account for 1.3% of average global corn production of which an increasing share is supplied to domestic ethanol facilities. Wheat as a feedstock is the second option for the Canadian ethanol industry (GAIN 2008c). European and Canadian producers are the least competitive producers and likely to be forced out of a liberalized market for ethanol.[53]

For ligno-cellulosic ethanol, Hamelinck and Faaij (2006) mention that low-cost biomass based on agricultural residues is available in Latin America, Africa, Asia and Eastern Europe. In the medium term, however, climatic factors favoring high biomass productivity are less important than technological progress. Hence no region has a comparative advantage in the production of second-generation feedstocks - at least within the timeframe considered.

[53] Corn is also an alternative feedstock for European ethanol producers; however, it has about the same costs as wheat (EC, COM (2006) 845).

Chapter V

Analysis of Policy Objectives and Strategies for Ethanol in the EU

This chapter provides an overview of major European policy objectives in the area of biofuels. More concretely, it will be shown what role ethanol plays in the context of broader policy objectives and how the biofuel contributes to each of these goals. Bearing in mind the ideal image of future ethanol trade, it is possible to analyze how current policies shape ethanol markets and what policy changes are eventually required.

5.1. Biofuel Policies and Broader Policy Objectives

5.1.1. A Brief History of European Biofuel Policies

The first EU directives that directly referred to biofuels were published in 2003. Directive 2003/30/EC encouraged Member States (MS) to set *indicative* targets for "biomass-based fuels" to displace at least 2% (by 2005; 5.75% by 2010) of transport fuels (EC, 2003/30/EC). At the same time, directive 2003/96/EC allowed Member States to exempt or reduce excise duties in order to promote biofuels (EC, 2003/96/EC). Notably the first directive was a key policy instrument because it laid the basis for stronger action in the field of biofuels. It was, however, not a "proper legal" and a rather "moral" one because no blending obligations were introduced (Del Guayo, 2008). Although most MS promoted biofuels, they failed to reach the 2% target by 1%. Only Germany (3.8% biodiesel) and Sweden (2.2% bioethanol) surpassed their national targets in 2005, mainly due to extensive tax exemption policies and the promotion of high-blend or pure biofuels (EC, COM (2006) 845). In the light of this failure, the EU's "Biomass Action Plan" (BAP), published in December 2005, set out measures to further promote biomass in heating, electricity and transport (EC, COM (2005) 628). In terms of biofuels, the BAP was also a blueprint of what the EU set out in its "Biofuel Strategy" two months later. In the "Biofuels Strategy" of February 2006 the European Commission set *mandatory* blending targets for each MS in order to meet the envisaged 5.75% objective in 2010. Moreover, the policy strategy defines seven policy axes to pave the way for biofuel development in the EU until 2020 (EC, COM (2006) 34):

I. Stimulating demand for biofuels
II. Capturing environmental benefits
III. Developing the production and distribution of biofuels
IV. Expanding feedstock supplies
V. Enhancing trade opportunities
VI. Supporting developing countries
VII. Supporting research and development.

As it will be described in the following chapters, the emphasis of the EU is on developing countries and on improvements in cost efficiency. The Commission acknowledges that "biomass productivity is highest in tropical environments and the production costs of biofuels, notably ethanol, are comparatively low in a number of developing countries" (EC, COM (2006) 34: 6). Moreover, the Commission underlines that (European) ethanol only breaks-even with gasoline at crude oil prices of 90 EUR per barrel (bbl) and, thus, calls for measures to optimize the cultivation of feedstocks, to promote research into second generation biofuels, and to support demonstration projects.

Although the European Commission defined a 5.75% blending target in February 2006, it announced only one month later that the 2010 renewable energy targets were likely to be missed by 1 to 2% (EC, COM (2006) 105). In its 'Biofuel Progress Report', published in January 2007, the Commission specified that if all MS "achieve the shares they have targeted, biofuels' share [...] will reach 5.45% - a shortfall of 0.3%" - and added that "the experience of 2005 suggests that in practice the shortfall will be rather greater" (EC, COM (2006) 105: 7). Despite these setbacks, the EU continued to foster biofuels: in its communications 'An Energy Policy for Europe' (EC, COM (2007) 1) and 'Renewable Energy Roadmap' (EC, COM (2006) 848) the Commission increased the envisaged overall share of renewable energy in the EU by 2020 to at least 20%, indicating that the minimum biofuel incorporation should reach 10% in all Member States. The 10% blending target[54] for 2020 is the basis for all further discussions. In the very long term, i.e. by 2030, the European Union strives for a 25% blending target (EC DGR, 2006).

[54] The target is defined on a volume basis.

5.1.2. The Biofuels Strategy Within the Broader Policy Framework

Feedstock and biofuel production interrelate with policies in the areas of "energy", "agriculture and rural development", and "environment and sustainability". The EU's external relations with third countries influence policy goals in each of these areas and represent an additional perspective on the subject (EC, COM (2006) 845; Henke, 2005). Before further analyzing EU policy objectives and strategies in relation to ethanol, this chapter links each strategic axis stipulated in the Biofuels Strategy to its principle policy area. In this way it is possible to directly compare broader policy objectives and their implication concerning ethanol. The following table provides an overview of the classification.[55]

Table 5.1: The Biofuel Strategy in the context of broader policy objectives

	The EU Strategy for Biofuels: Policy Axis No.						
Policy Area	I.	II.	III.	IV.	V.	VI.	VII.
Energy	●						●
Environment & Sustainability		●					
Agriculture & Rural Development			●	●			
Trade & External Relations					●	●	

I. Stimulating demand for biofuels
II. Capturing environmental benefits
III. Developing the production (and distribution) of biofuels
IV. Expanding feedstock supplies
V. Enhancing trade opportunities
VI. Supporting developing countries
VII. Supporting research and development

Source: own illustration.

[55] The assignment of policy axes to policy areas emanates from comments and references in the Biofuels Strategy. The policy axes related to rural development and external relation are relatively easy to assign (III. to VI). It is, however, more difficult to distinguish between energy and sustainability policies and to assign policy axes of the Biofuels Strategy to a single major policy area. This is because "the environmental constraint is likely to be a dominant force in the [energy] market, and [because] the existing capital stock is ill suited to a low-carbon economy, it would be odd not to incorporate environmental considerations [in energy policy]" (Helm, 2002: 183; words in brackets added by the author). In the context of this master thesis, stimulating demand for low-carbon fuels (axis I) and fostering new technologies (VII) are regarded as major areas of energy policy. The definition of environmental criteria and of minimum environmental benefits, by contrast, is regarded as a task of environmental policy makers.

The following chapters define for each policy area separately (1) general objectives, and (2) concrete objectives in terms of ethanol; each subchapter concludes with (3) an analysis of the current policy strategy as stipulated in the EU Biofuels Strategy (EC, COM (2006) 34). The analysis on trade aspects starts with the current policy strategy concerning trade in biofuels before it will be explained why and how trade policy is required to balance the objectives of the policy areas mentioned above.

5.2. Ethanol and Energy Policy

5.2.1. Objectives of the EU Energy Policy

The first common EU energy strategy was defined in the Green Paper 'Towards a European Strategy for the Security of Energy Supply' (EC, COM (2000) 769). Although having been updated six years later, the following principle statement from the first Green Paper still holds true:

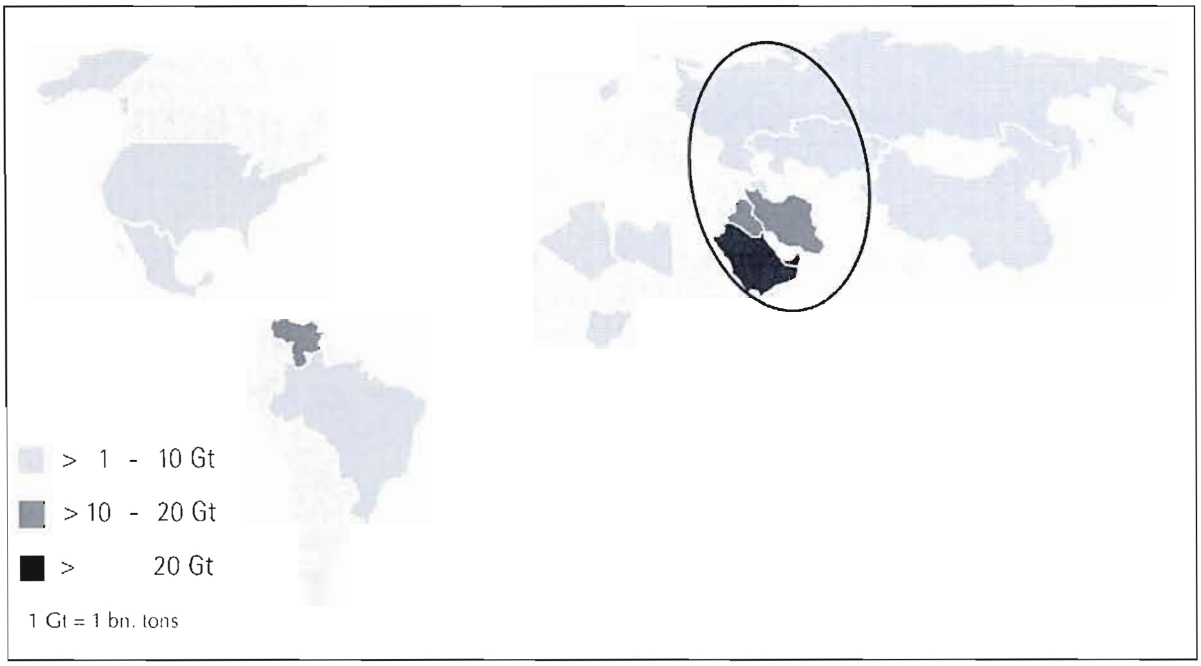
> "The European Union's long-term strategy for energy supply security must be geared to ensuring, for the well-being of its citizens and the proper functioning of the economy, the uninterrupted physical availability of energy products on the market, at a price which is affordable for all consumers (private and industrial), while respecting environmental concerns and looking towards sustainable development [...]."
>
> (EC, COM (2000) 769: 2).

This excerpt underlines the three principle objectives in energy policy: security of supply, competitiveness and sustainability. Security of supply is highly related with the EU's external relations since the Union meets about 50% of its energy demand by imports (EC, COM (2006) 105). The more the EU is able to diversify its import share by energy product and/ or geographical region, the more MS can reduce the risk of disruption in external supply. The following comment describes the positive effect of energy diversification:

> "Security of supply does not seek to maximise energy self-sufficiency or to minimise dependence, but aims to reduce the risks linked to such dependence. Among the objectives to be pursued are those balancing between and diversifying of the various sources of supply (by product and by geographical region)."
>
> (EC, COM (2000) 769: 2).

The current concentration of fossil energy resources (particularly oil and gas) in a few countries of the Former Soviet Republic (FSR) and the Middle East is not desirable from a European point of view. The fact that important petroleum suppliers act in a cartel (Organization of Petroleum Exporting Countries, OPEC) adds to energy insecurity and geographical dependency. In the light of depleting reserves the risk of supply shortages rises because the market becomes narrower and dependency on politically unstable countries or regions can be expected to rise. Moreover, scarce energy resources provoke political tensions and conflicts, thus threatening security of supply. The geographical diversification of energy imports is therefore the heart of European "foreign energy policy" (EC, COM (2006) 105). The following figure illustrates the current dependency in the petroleum market and thereby the need for geographical diversification.

Figure 5.1: The "strategic ellipse" of energy supplies



Source: REpower (2007: 12)

5.2.2. The Definition of Policy Objectives for Ethanol

5.2.2.1. Competitiveness and Sustainability Objectives

An important objective is to reconcile competitive energy supply and GHG-savings. Hence the most competitive energy sources are those that abate respective emissions at lowest costs. The objectives of EU sustainability policies, i.e. the extent of carbon savings will be defined in Chapter 5.3. They provide the benchmark for minimum GHG-savings for ethanol. Rational market actors will then seek to minimize costs for the required GHG-savings by procuring ethanol from low cost providers. Defined in this way the objective clearly promotes consumer interests (low-cost fuel) and, thus, fulfils in essence the standard for EU competition policy. As all externalities are priced in, this situation can also be described as welfare maximizing (Roeller et al., 2007).

5.2.2.2. Geographical Diversification of Supply and Domestic Production

As a substitute for petroleum-based gasoline, fuel ethanol diversifies current energy resources regardless of its country of origin. Hence the blending target of 10% for 2020 represents the desired diversification of gasoline by ethanol (EC, COM (2006) 848). So policy objective for ethanol should be defined in terms of geographical diversification, including domestic production.

The EU does not state any targeted shares of domestic ethanol production in 2020. For 2030 and beyond, however, the EU envisages producing 50% of its biofuels domestically (EC DGR, 2006). This ratio corresponds to the current share of domestic energy production in relation to overall energy consumption. In its latest "Green Paper" on future energy policy, the EC estimates the import share[56] to rise in the next 20 to 30 years to around 70% of the Union's energy requirements if no policy action is being taken. Import dependency of this magnitude is undesirable from a European perspective (EC, COM (2006) 105). As the EU obviously regards the import ratio of the current energy portfolio, i.e. 50%, as optimal, and import shares beyond 70% as critical, any import ratio within this range should fulfil the policy objective for domestic ethanol production in 2020. Covering only 50% of the EU's ethanol consumption by imports is, therefore, a very ambitious target, whereas any dependency on foreign ethanol that is close to, or surpasses 70% should be avoided. Against the background of a 10% blending target in 2020 domestic ethanol production capacities should cover 3 to 5% of total gasoline consumption.

The remaining quantity should be imported. In this context, another policy focus is on geographical diversification of energy imports. As described earlier, ethanol could represent an ideal case since countries with high biomass productivity do not have (significant) petroleum or gas reserves. Considering the envisaged share of imported ethanol in 2020 in relation

[56] The energy import share relates total annual imports to total annual consumption (Eurostat, 2008a); it represents the energy demand that cannot be covered by domestic production.

to total gasoline consumption (5 to 7%), one might argue that the biofuel can be sourced from only one country, e.g. Brazil (FAO, 2008a). In this case, however, the EU would neglect the biomass potential in other countries and would eventually swap the dependency on an oligopolistic market for petroleum against the dependency on a very oligopolistic, but growing market for ethanol. The EU has therefore an interest in actively promoting the development of ethanol markets in as many counties as possible (EC, COM (2006) 34).

In the very long term, the goal of the EU should be to avoid similar import dependencies as in petroleum markets. For this reason, dispersion of current petroleum imports is one benchmark for measuring the desirable (minimum) diversification of ethanol imports. Drawing on EU-27 import data for petroleum oil (crude) from 2002 to 2006, it is possible to derive the average dispersion of imports (Eurostat-comext, 2008)[57]. The results are contrasted with the dispersion of ethanol imports in the same period (Eurostat-comext, 2008). The following table shows the cumulated share of the major import partners in comparison to all imports. It is important to note that the sample of ethanol imports would have to be adjusted to account for those countries that export petroleum *and* ethanol to the EU, because no geographical diversification would occur in this case. However, this limit will be neglected in further course of this master thesis since the most important petroleum exporters are neither major suppliers for ethanol nor competitive sugarcane producers. In the same way, no major ethanol producer is an important petroleum supplier for the EU.

Figure 5.2: Geographical dispersion of petroleum and ethanol imports (2002-06 avg.)

2002-06 avg.	**Petroleum (all exporters)**	**Petroleum (OPEC and other exporters)**	**Ethanol (undenatured, strength >80%)**
Cumulated share top 5 importers	73.1%	92.1%	63.3%
Cumulated share top 10 importers	89.6%	97.6%	78.9%

Source: based on Eurostat-comext (2008)

[57] The import data refers to "petroleum oils and oils obtained from bituminous minerals, crude" (HS 6) and does not cover refined products, like gasoline. Although imported crude oil can also be refined to other products than transport fuels, it is nonetheless a good proxy for the dependency of the transport sector on these regions.
A similar problem exists for ethanol trade data. It is important to bear in mind that the current product classification in international trade does not allow for a distinction between fuel ethanol and ethanol used for other purposes. Hence it is not possible to calculate an *exact* measure of concentration for fuel ethanol imports.

The analysis of import data confirms the high concentration in petroleum markets. The first column shows the dependency on the petroleum exporters, assuming no oligopolistic behaviour. Because this sample includes six OPEC members, the second column is added to consider the "OPEC-effect". In this case, the six cartel members are regarded as *one* country while five minor producers complement the sample to ensure comparable results. Particularly in this case the lack of geographical diversification is striking. The cumulated imports for ethanol indicate a somewhat better diversification. Considering that the current dispersion of trade partners for ethanol is the result of trade distortion, the cumulated import shares can be regarded as desirable for the EU. In fact current dispersion of global ethanol production would suggest that there is an even higher concentration in this market than in petroleum markets. Also in a 2020 free-trade scenario, the geographical dispersion of imports should be comparable to today's level. If there is a stronger concentration in future ethanol markets, fears of a future "biomass-OPEC" (Zhang et al., 2007) might be justified. Finally it should be noted that there is no appropriate measure for long-term security of supply, which the EU seeks to address by ethanol blends. The general rule, applies that "the less diverse the energy sources relied on by a region, sector or industry, the more harm it will suffer if access to one of these sources is affected by a change in physical conditions or by war." (IEA and Jansen et al., cited by EC, SEC (2006) 1721).

At this point it is important to note that it is of course not possible to exactly forecast future ethanol imports into the EU. Nevertheless it is possible to estimate trade flows based on the H-O-V-theorem, which relates a country's endowments to world endowments and thus, determines the export potential. As described by Debaere (2003), the H-O-V-model is very suitable for predicting trade flows if countries have significantly different factor endowments. This effect should be particularly pronounced in liberalized markets for ethanol. Based on this rationale, the analysis of the structural dispersion of resources should allow for estimating the origin of ethanol imports. In this framework the diversification potential can be assessed.

5.2.3. Energy Policy in the Context of the EU Biofuels Strategy

The following table summarizes the first policy axis of the EU's Biofuel Strategy that seeks to stimulate demand (EC, COM (2006) 34).

Table 5.2: Policy strategies to stimulate demand for biofuels

Principle measures to be taken under the first axis of the Biofuels Strategy
a) Amend directive 2003/30/EC to set obligatory national targets for the market share of (sustainably produced) biofuels;
b) Encourage MS to promote second-generation fuels by including them in their national blending targets;
c) Promote the public procurement of clean and efficient vehicles, e.g. FFVs.[58]

Stimulating demand for biofuels and setting national blending targets is the essential energy policy measure of the Biofuels Strategy. Like in the case of other directives on European level, Member States are in charge of transforming directive 2003/30/EC into national law. Although they are free to choose the kind of policy instrument to implement the directive, the introduction of blending targets is most likely to ensure fixed market shares in 2020.[59] These obligations eventually lead to additional costs for gasoline consumers if ethanol is more costly than fossil fuels (like in the case of European ethanol); in either case further costs occur on the distributor side for blending ethanol into gasoline (Henniges, 2006). Due to directive 2003/96/EC, governments in Member States are free to choose whether they bear these additional costs via (partial) tax exemptions or whether they make the final consumer pay for it (Kutas et al., 2007).[60] If ethanol is more expensive than gasoline, welfare losses occur in any case. Therefore, governments should have an interest in keeping these losses as low as possible and should opt for the cheapest fuel available (Fritsch et al., 2007). Blending obligations are particularly appealing for promoting second-generation biofuels. Since distributors would have to incorporate a fixed amount of these fuels, they would opt for the cheapest biofuel to keep their prices low, thus spurring innovations in the industry (EC, COM (2006) 34). On the other hand such rules would not provide sufficient policy stability for companies to invest in these technology and capital-intensive areas. Currently no EU Member State has set targets for 2nd generation ethanol.

The seventh policy axis of the Biofuels Strategy seeks to improve the competitiveness of European biofuel production, thus responding to overall objective of efficient energy production.

[58] Policy measures in italics will not be discussed in detail.
[59] Compare arguments from chapter III and Weitzman's (1974) seminal article on "Prices vs. Quantities".
[60] Austria, Slovakia and Spain provide full tax exemptions, while governments in the Netherlands, Slovenia and the United Kingdom opted for a partial tax exemption. Finland, Germany, Greece and Luxemburg abolished tax exemptions for low-blended fuels like E-5 or E-10 (rules differ for high-blend fuels; Kutas et al., 2007).

Table 5.3: Policy measures to support research and development in biofuels

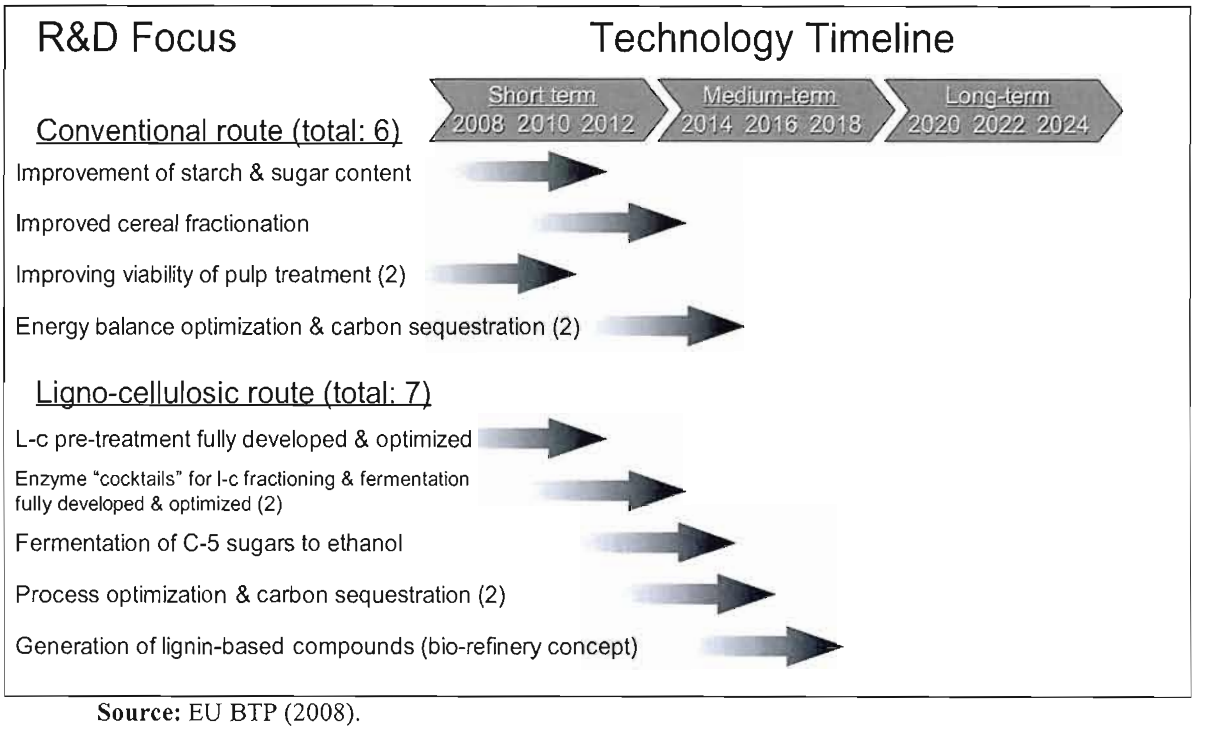
Measures to be taken under the seventh axis of the Biofuels Strategy
a) Support the development of biofuels and strengthening the competitiveness of the industry;
b) Research the bio-refinery concept[61] and second-generation biofuels;
c) Encourage the development of a 'biofuel technology platform' and support the implementation of strategic research agendas proposed by these platforms.

Low carbon technologies and alternative transport fuels in particular remain expensive and face high market barriers. Hence the EU's R&D efforts focus on increasing the competitiveness of current and future ethanol technologies (EC, COM (2006) 34). Regarding research into second-generation ethanol, the major problem is the energy innovation process, which suffers from long lead times - from initial conception to market penetration. Furthermore, the scope of investment required and often pre-mature technology add to investor risks. Nevertheless, as outlined by Hamelinck et al. (2005a, 2006), the technology can be significantly more viable than conventional ethanol concepts. Consequently it would contribute the environmental goal of GHG-reduction and to rural development objectives since farmers potentially provide more competitive feedstocks than they currently do.

All research into conventional and second-generation ethanol contributes to more competitive energy production and to self-sufficiency. However, further research in *conventional* ethanol production is unlikely to close the gap to more competitive producers (like Brazil or the USA), as not technological, but climatic circumstances influence production costs (compare chapter II and III). However, the EU's principle of technological neutrality, meaning that all promising future technologies regardless of their current costs are promoted, does not allow focusing on select technologies (EC, COM (2007) 2). The following figure provides an idea of the current research agenda of the European Biofuels Technology Platform (EU BTP, 2008). Although the emphasis is on the development of ligno-cellulosic ethanol, research efforts also concentrate on improving benefits from sugar- or starch-based ethanol.

[61] Bio-refineries are comparable to petroleum refineries. Like petroleum refineries, bio-refineries process their main input (residues from agriculture or MSW) into fuels or materials and, thus, maximize output from given inputs.

Figure 5.3: Strategic research in ethanol in the context of the BTP-agenda



Source: EU BTP (2008).

Considering that conventional ethanol production is based on established processes, policy strategies should focus on more innovative technologies. If processes are well known and offer little cost reductions it is best to opt for the most efficient techniques, i.e. to trade the product and its associated GHG-benefits (static efficiency). In this case, current prices should be close to current marginal costs. If technologies can be improved significantly by innovation (dynamic efficiency), efforts should be made to achieve potential cost reductions. Major problems exist, however, when low prices in the short run reduce incentives to invest in capacities that are promising in the long run (Midttun/ Gautesen, 2006; Roeller et al., 2007).[62]

[62] Even though these principles are straightforward, they are unlikely to be implemented in the near future. As the biofuel technology platform, which is currently actively shaping policy strategies, is industry-led, any recommendation focusing R&D efforts completely on second-generation ethanol would undermine the position of first-generation ethanol producers in the group.

5.3. Ethanol in the Context of Environment and Sustainability Policies

5.3.1. Objectives of EU Environmental and Sustainability Policies

> "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs."
> World Commission on Environment and Development (WCED, 1987: Chapter 2, 1).

The EU committed to sustainable development in a 2001 strategy paper. Herein, three major dimensions of sustainable development are distinguished, namely economically, socially, and ecologically sustainable development (EC, COM (2001) 264). From an ecological perspective, climate change is the most obvious threat to sustainable development and, therefore, the EU strives for a 20% reduction of GHG by 2020. In this context it is particularly important to tackle transport emissions as the sector shows the strongest dependence on GHG-emitting fossil energy sources, i.e. crude oil (EC, COM (2000) 769). On EU-level efforts aim at linking the price of transport fuels to associated emissions (compare chapter III) in order to reduce demand and to initiate a shift towards less-polluting transport modes. This increases at the same time the relative competitiveness of sustainable 1st generation and 2nd generation biofuels. In addition, it is a main objective of the EU to (further) reduce life-cycle emissions from all transport fuels (EC, COM (2007) 2).

According to the Commission a global cap and trade scheme, including as much sectors as possible, is the most important tool for achieving ambitious GHG-reduction targets (e.g. 20 to 30% by 2020). In the context of its Kyoto obligations, the EU aims at expanding CDM projects (in developing countries) and improving access to financial resources. In conjunction with other measures this should spur investments in "state-of-the-art" energy technology and infrastructure (EC, COM (2006) 847).

Besides ecological sustainability, the EU seeks to promote economical and social sustainability. Economically sustainable growth is economic growth that supports social progress and cohesion as well as ecological sustainability, as mentioned above. In the same way, socially sustainable development should respect the need for economic performance. On international level the EU regards trade as a means to ensure global sustainability (EC, COM (2001) 264; COM (2002) 82).

5.3.2. The Definition of Policy Objectives for Ethanol

According to the European Union, priority must be given to ensure that production of feedstocks and biofuels lead to highest possible GHG-savings (EC, COM (2006) 845). In this context a benchmark of 20% as proposed for the overall energy portfolio is too low. Though the discussion about appropriate GHG-reduction standards is still in progress, the European Commission aims at higher GHG-savings to give a clear signal to markets that it pays off to reduce overall life-cycle emissions of biofuels further and, thus, to decarbonise transport fuels. A recent contribution to the discussion comes from the German Ministry for Agriculture (BMELV). From 2011 onwards the bill proposes minimum GHG-savings of 40% for all biofuels. Moreover, as demanded by the European Commission, the bill proposes to reward biofuels that offer higher GHG-savings.[63] Based on discussions with industry analysts, minimum GHG-savings from displacing gasoline with ethanol should be 60% in 2020; a more ambitious target is, however, 80%. Second-generation ethanol should bring savings of the order of 90%. Against the background of a 10% blending target, this is equivalent to GHG-savings in the range of 6 to 8% for first generation fuels. Any blending of cellulosic ethanol should improve the potential GHG-abatement.

In order to prevent land-use changes as described in chapter II, a non-discriminatory international standard is important for promoting sustainable production and trade in developing countries, where cultivation of feedstocks poses a potential threat to ecosystems. According to the bill of the BMELV (2007), good agricultural practices or standards comparable to those established by the EU (compare following chapter) would be sufficient to ensure sustainable production. In order to fulfil the criteria of the EU, biomass production (1) should not lead to significant emissions of toxic or ozone-depleting substances, (2) should not negatively impact soil fertility, (3) should not be associated with diminishing water availability or quality, (4) should not have a negative impact on globally or regionally important ecosystems, and (5) should consider the appropriate use of fertilizers, pesticides and herbicides (BMELV, 2007). Certifying the amount of GHG-savings and the compliance with predefined standards would also promote investments in CDM projects in these countries (EC, COM (2006) 34).

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[63] More concretely, fuels with a more favorable emission balance count proportionally stronger towards the blending target. If, for instance, ethanol from Brazil provides emission savings of 80% compared to average savings of 40% from European ethanol, it would count twice as much towards the blending target. Furthermore the bill fosters innovation in the industry in that the average GHG-saving from ethanol in the preceding year sets the benchmark for minimum savings in the following year. Hence, if the bill were adopted in the context of a common European directive, it would initiate a dynamic innovation process in the industry (BMELV, 2007).

In the context of the "Road Map for Renewable Energy in Europe" the EU Parliament asked the Commission to include more criteria than in the German bill: the European Parliament called on the Commission to include social criteria such as rising food prices and the displacement of people in a mandatory certification scheme (Vis et al., 2008).

5.3.3. Environment and Sustainability Policy in the Context of the EU Biofuels Strategy

In order to complete this subchapter on ethanol and sustainability aspects, the following table provides an overview of envisaged policy initiatives of the EU in relation to biofuels. As described earlier much of the policy strategies have recently become the focus of initiatives aiming at improving the sustainability of the fuel.

Table 5.4: Policy measures for capturing the environmental benefits of biofuels

	Measures to be taken under the second axis of the Biofuels Strategy
a)	Examine how the use of biofuels can count towards CO2 emission reduction targets, ensuring optimal GHG-benefits from their use;
b)	Ensure sustainable production of biofuel feedstock in the EU and in developing countries;
c)	*Examine the effect of higher biofuel incorporation in fossil fuels and eventually revising EU-wide fuel standards.*

In relation to the desired free trade and sustainability scenario, the major question is to what extent environmental criteria for ethanol can be enforced in liberalized markets. Even if there is a high spirit of co-operation and even if societies are highly aware of environmental and sustainability problems, certain criteria defining sustainability may be perceived as trade distorting. Furthermore, in early 2007 the European Commission initiated a public consultation to obtain *inter alia* the view of stakeholders on issues related to sustainable bioenergy supply. Besides minimum GHG-savings and the protection of areas with high conservation value, as mentioned above in the BMELV proposal, there is also the idea to make social sustainability criteria part of the Biofuels Strategy. In this way it would be possible to prevent the competition between food and fuel and to promote the economic development in rural areas where feedstock is grown (Vis et al., 2008). The task is, however, to define non-discriminating standards on an international level without jeopardizing economical, ecological and socially sustainable development (Bruehwiler/ Hauser, 2008). Alternatively the European Parliament suggested to "seek co-operation with the WTO and similar international organization to secure acceptance of specific sustainability criteria [...] and thus to promote the most sustainable means of production of biofuels worldwide [...]" (European Parliament Resolution of 25 September 2007, cited by Vis et al., 2008: 12).

5.4. Ethanol and Agricultural Policies

5.4.1. *Objectives of the EU Agricultural and Rural Development Policies*

Rural development and particularly agriculture have an important societal dimension as outlined in the following statement:

> "Agriculture continues to be the largest user of rural land, as well as a key determinant of the quality of the countryside and the environment." [...] "The European model of agriculture reflects the multifunctional role farming plays in the richness and diversity of landscapes, food products and cultural and natural heritage."
>
> (EC, 2006/144/EC).

Both, agriculture and rural development represent the two pillars of agricultural policy in Europe. Precedent reforms of the European Common Agricultural Policy (CAP) contributed to a shift from promoting production to ensure food supply security, to promoting sustainable agriculture focussing on high-quality/ organic products (EC, 2006/144/EC). The reformed CAP grants basic income support to farmers (single payment scheme, SPS)[64] while expecting them to generate additional revenue by selling their products on "free markets". From a budgetary perspective, total support for farmers is comparable to past outlays because the SPS is based on the production in historic reference periods. From 2005 onwards however, coupled or decoupled payments are modulated in favour of additional rural development measures. This means that in the future farmers should increasingly rely on income from free markets (EC, COM (2008) 306). All these measures are at the heart of the CAP's principle objectives: promoting rural (economic) development and increasing the competitiveness of European agriculture.

In order to benefit from income support under the CAP, European farmers have to comply with "certain conditions in the areas of public, animal and plant health, environment

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[64] The SPS is the support mechanism for the EU15, while the Single Area Payment Scheme (SAPS) has been established for new MS (EU10 as well as Bulgaria and Romania). The SPS represents the former level of support for farmers under the ancient CAP-regime. For new member states, the SAPS grants fixed revenues per hectare of agricultural land up to a national ceiling resulting from the individual accession agreements.

and animal welfare" ("cross-compliance") to ensure sustainable agriculture (EC, 796/2004). The cross-compliance rule establishes sustainable agricultural development as another objective of the reformed CAP.

Finally, international trade plays an important role in agriculture. High factor costs make it difficult for farmers in industrialized countries to compete with low cost producers in developing countries (DC) or least developed countries (LDC) on global agricultural markets:

> "The European farming sector today is under increasing pressure, with globalisation and liberalisation of national and international markets making it very difficult or European farmers to compete with countries producing at a lower cost. As this trend continues, farmers will find it more difficult to forge a decent income and the least competitive producers will be forced out of the sector."
>
> (EP, 2006, (2004/2259(INI))).

Historically, the EU, like other industrialized regions, has policies in place to protect the domestic market, thus causing global distortions in production, trade, and prices of respective commodities (Kojima et al., 2007). The CAP reforms mentioned above aligned the EU's policies more - though not completely - to international trade rules. While - on the one hand - the EU aims at further liberalizing trade and enhancing the situation of DC and LDC within the current Doha Development Agenda (DDA), the Community fears - on the other hand - to jeopardize the importance of its rural areas and the existence of the farming sector in its current form (EU CAP, 2004). Hence, the EU's position on trade liberalization in agricultural goods is ambiguous.

5.4.2. The Definition of Policy Objectives for Ethanol

For the EU ethanol is a means to diversify income in rural areas. The creation of new market outlets for the farm sector is a way to improve commodity prices and support farm incomes (OECD, 2008a). The objective of income diversification is inherently linked to land-use competition. Under current EU policies, food and feed crops vastly compete for land resources in the Union. So while the total arable land in the EU remains largely unchanged, additional demand from the energy sector has - at least - a stabilizing effect on crop prices. As a new industry, the ethanol sector also creates additional demand for plant construction and engineering services as well as for capital goods. Consequently, the fuel is a potential source for creating jobs and income in many sectors, thus contributing to economic growth (Nusser et al., 2007). In contrast to other policy objectives, however, there is no straightforward measure to check the extent to which farmers and rural areas benefit from the production of ethanol and respective feedstocks (OECD, 2008a). In the context of this master thesis it is only possible to estimate income trends in agriculture and to derive the implicit policy goals. Analyses on EU-level do not have a particular focus on ethanol. Nevertheless, they provide a general understanding how the ethanol industry affects rural income diversification in the EU. Input-output analyses represent a tool to capture complex macro-economic effects, such as the impact of a new (biofuels) industry on the economy. Using such a model, the EU estimates that its biofuel policies account for 105,000 to 144,000 jobs in the whole biofuels industry in 2020 (EC, SEC (2006) 1721). The following table outlines the impact of different (what-if) scenarios on employment in the EU biofuels sector.

Table 5.5: Estimated of employment effects (European Commission)

	Blending target of 7%	Blending target of 14%
Base case	Total employment effects: +105,000	Total employment effects: +144,000. Agriculture: +190,000; biofuel industry: +46,000; food industry: +14,000. Services: -35,000; petroleum fuel sector: -21,000; transport -16,000; energy sector -14,000; other industries -22,000.
Assumption technology exports	If domestic biofuel production and export opportunities of the construction and engineering sectors are assumed to be independent, employment falls to 77,000 (7% scenario) and 105,000 (14% scenario) respectively.	
Assumed reduction in oil demand	A major assumption refers to a reduction in oil demand due to biofuel production. Based on historical price elasticities, the EU assumes oil prices to fall by 1.5% (7% blend) and 3.0% (14% blend). If the effect does not occur, employment falls to -13,000 and -32,000 respectively.[65]	

Source: EC, SEC (2006) 1721.

Overall the EU estimates positive employment effects in biofuel-related sectors to outweigh negative effects in other industries. Consequently the EU achieves additional and or more diversified income in rural areas at the expense of the work force in other sectors. Re-

[65] This can be interpreted as the negative effect of rising oil prices on economic activity in general, and on overall employment in particular.

laxing major assumptions about technology export or reduced oil demand, however, reveals the actual uncertainty associated with the I-O-model. Neuwahl et al. (2008) apply similar I-O-models as the EU, but provide more details about the impact of different (what-if) scenarios on employment.[66] Across various scenarios the authors observe relatively higher (total) employment effects when domestic, first-generation biofuels are blended with gasoline. The biofuels industry and engineering sectors are most likely to benefit from increased use of 2nd generation biofuels. As mentioned in the EU study (EC, SEC (2006) 1721), other sectors like energy, (transport) services, and (petroleum) fuels, loose jobs as they suffer from the new fuel substitute (energy and refinery sector) or simply cannot benefit from it (e.g. service).[67]

Table 5.6: Employment impacts of four blending scenarios (Neuwahl et al., 2008)

Sector / Scenario	Agriculture	Biofuel Industry	Industry (broad)	Other Sectors	Total
7% blend; focus on domestic 1st gen. fuel & 1/5 imports	118,000 - 121,000	14,000 - 15,000	25,000 - 26,000	(88,000) - (57,000)	73,000 - 100,000
15% blend; focus on domestic 1st gen. & 1/3 imports	176,000 - 187,000	32,000 - 34,000	38,000 - 62,000	(178,000) - (137,000)	70,000 - 182,000
15% blend; focus on 2nd, and domestic 1st generation (1/3)	77,000 - 83,000	59,000 - 62,000	55,000 - 72,000	(234,000) - (194,000)	(40,000) - 20,000
12% blend; 50% domestic & foreign 1st generation fuel	65,000 - 72,000	29,000 - 30,000	48,000 - 66,000	(181,000) - (128,000)	(38,000) - 38,000

Source: Neuwahl et al. (2008).

Again, the margin of uncertainty is considerable. If the European biofuels industry cannot benefit from exports as anticipated in the scenarios, total employment falls by 30,000 to 50,000. If petroleum prices remain stable despite increased biofuel production in the EU, the results suggest negative effects on employment in the magnitude of 50,000 to 100,000. Possible price estimation errors lead to even higher deviations. Consequently, Neuwahl et al. (2008) conclude that EU biofuel policies produce "approximately neutral net employment effects". For ethanol production in Germany, Breuer and Holm (2007), as well as Nusser et al.

[66] The I-O analysis is based on data for the EU-25 (2001) for 57 sectors; it is adjusted and complemented by 7 biofuel sectors. This I-O-analysis is coupled to EU-models for energy and agriculture and thus integrated into a macro-economic framework. Bottom-up techno-economic data is based on EUCAR (2006, cited by Neuwahl et al.; a study on biofuel technologies commissioned by the EU).

[67] Ranges indicate alternative policy support options, namely obligatory blending versus subsidised biofuels cost disadvantage. For the purpose of this research, however, general tendencies in employment are more important.

(2007) and Schöpe (2006), who both use I-O-models for the German economy, make similar findings.

Another question is whether EU biofuel policies actually create *new* job opportunities in agriculture, as suggested by Neuwahl et al. (2008) and by the EU. For ethanol production in Germany, for instance, there are only slight employment benefits in agriculture (3,000 to 4,000). But these benefits can only be expected if formerly fallow land comes into cultivation, leading to additional jobs. If farmers only shift land from food to feedstock production, additional employment effects are negligible (Nusser et al., 2007). These considerations shed a different light on the employment benefits as mentioned by the EU (EC, SEC (2006) 1721) and Neuwahl et al. (2008), making them even more vague. Hence, there is no additional benefit if no additional land is brought into cultivation. At the other extreme, all areas that farmers had to set aside under CAP rules (approximately 10% of total arable land) could serve to produce ethanol feedstock (Henke et al., 2003). How much of this area is actually devoted to grow ethanol feedstocks is unknown.

Nusser et al. (2007) also investigates the potential employment effects of second-generation feedstocks like poplar and miscanthus. The results suggest that the production of 5,000 tonnes of feedstock is associated with approximately one job in agriculture and 2.7 times that much in handling and processing industries (2020 estimates). Employment benefits for conventional ethanol are much higher; the cultivation of only 1,000 tonnes of feedstock (wheat) involves one additional job in agriculture and twice that much in the biofuels and associated industries (2010 estimates). As mentioned above potential job creation in agriculture occurs if fallow land comes into cultivation. The use of existing cropland for cellulosic feedstocks only secures current jobs in agriculture, but does not create any additional employment (Nusser et al., 2007).

The EU objective in terms of ethanol is to diversify rural income by creating new outlets for the farm sector. However, the objective, which is generally associated with "rural development", is very difficult to grasp. The following aspects from the preceding discussion shall nevertheless be considered in further analyses:

- Strong focus on first-generation feedstock like wheat, rye or sugar beet creates an important outlet for farmers and has the most positive effect on income diversification;
- Production of feedstocks destined for second-generation ethanol is associated with significantly less employment benefits in the agricultural sector;

- Additional employment in the agricultural sector can eventually be expected if fallow land comes into cultivation;
- Value creation in upstream and downstream sectors, i.e. in the engineering and biofuel production/ distribution industry, potentially contributes to diversifying rural income, as the geographical location of these industries determines beneficiaries. In this context technology-intensive industries - as required for second-generation technologies - are expected to create jobs.at the expense of the agricultural sector.
- Finally, from a macro-economic perspective, negative employment effects in other sectors are likely to offset additional employment in the biofuels sector.

5.4.3. *The Role of Ethanol in the EU Agricultural Policies*

In order to achieve income diversification in rural areas, the EU Biofuels Strategy includes two policy strategies. The third policy axis of the Biofuels Strategy addresses the development of respective industrial structures in the EU. It aims at diversifying rural income by supporting biofuel production and distribution facilities.

Table 5.7: Policy measures to develop the production and distribution of biofuels

Measures to be taken under the third axis of the Biofuels Strategy
a) Encourage MS and (rural) regions to take into account the benefits of biofuels when setting up national implementation plans;
b) Consider the opportunities biomass and biofuels offer in the context of rural development programs;
c) *Ensure that biofuels are not discriminated by relevant industries, i.e. oil companies/ distributors, and examining technical justifications that limit biofuel blending.*

In principle the European Commission seeks to encourage in particular new MS in Central and Eastern Europe to seize the opportunity to launch an own biofuel industry. In these regions there is large potential for growing energy crops due to low labour costs and high resource availability.[68] Support measures could include farmer training or investment aid in relation to biomass-specific equipment and assets (EC, 2006/144/EC). According to the Biofuels Strategy, resources devoted to rural development programmes should depend on the

[68] Bulgaria and Romania have 0.7 hectare of agricultural land per capita, compared to 0.4 in the EU25 (EC, COM (2006), 845). Moreover, agriculture accounts for 2% of GDP in old MS, 3% in new MS for more than 10% of GDP in Romania and Bulgaria. The sector employs on average 4% of the workforce in the EU15, 12% in the EU10 and a considerably higher percentage in Bulgaria and Romania (EC, 2006/144/EC).

specific situation, i.e. strength, weakness or opportunities in the MS or region. In this way the importance of economic efficiency can be reconciled with the objective of income diversification (EC, COM (2006) 34). In the context of EU rural development programmes, four ethanol plants qualified for one-off support in recent years, receiving state aid in the magnitude of 93.725 MEUR (EU State Aid, 2003-08). In addition several rural development schemes in Member States provide support for investments in ethanol plants on national level so that actual investment aids in the EU exceed the amount above (compare Kutas et al., 2007 for a detailed description of national programs).

Table 5.8: Current and future ethanol production capacity in the EU-27[69]

	Currently operating (end of 2006)	Under construction (2007-08)	Projects (2008-09)	Projects (2008-09) cellulosic ethanol
In tsd. cbm	3,395	2,195	13,397	444
No of plants	37	16	111	4

Source: Based on F.O. Licht (2007).

The following, fourth, policy axis of the Biofuels Strategy addresses support mechanisms on farm level. The support is directed at the cultivation of feedstock for ethanol on existing and fallow (set-aside) land.

Table 5.9: Relevant policy measures to expand the production of biofuel feedstocks

Measures to be taken under the fourth axis of the Biofuels Strategy
a) Evaluate the implementation of the energy crop scheme by the end of 2006;
b) Divert cereals from intervention stocks, which would otherwise be exported, to biofuel production;
c) Make sugar production for bioethanol eligible for payments under the non-food regime on set-aside land and for the energy crop premium;
d) Monitor the effect of biofuel production on commodity and co-product prices, their availability for competing industries, and the impact on food supply and prices in the EU and developing countries; [...]

In the EU, feedstock production in general is affected by the CAP and, in the case of beets, by specific rules for the common sugar market. Under the rules for the common market in cereals, wheat benefits from a guaranteed price of at least 101.31 EUR per ton (EC,

[69] Information about envisaged projects are sometimes subject to significant uncertainty. The number and capacity of future projects can therefore be considered to represent an optimistic outlook.

2003/1784/EC), though the intervention mechanism has not been used very frequently over recent years due to high international prices (Kutas et al., 2007). Moreover the CAP includes two specific rules to encourage farmers to grow energy crops: the energy crop scheme and the non-food set-aside scheme.

Under the first scheme, farmers growing energy crops on regular land receive 45 EUR per hectare if they have concluded a contract with a processor.[70] The premium aims at shifting land currently used for food production towards non-food production, thus contributing to income diversification. However, the incentive is only beneficial for those farmers with low market margins because the scheme represents a high administrative burden and limits the flexibility and freedom in the decision of marketing of crops (due to the contract with the processor farmers can no longer decide whether they sell their product in food- or non-food markets) (EC, COM (2006) 500).

The non-food set-aside (NFSA) scheme allows farmers to grow non-food crops on fallow land. Thus farmers benefit from the sale of energy crops and from regular set-aside payments, which compensate them for withdrawing land from the production of *food* crops (EC, 2003/1782/EC). As outlined in the previous chapter, cultivating feedstocks on formerly fallow land represents a potential source of additional employment *and* income diversification in the agricultural sector.

In the light of the recent surge in prices, European farmers are able to compete on global cereal markets. By contrast, sugar beet growers in the EU are still dependent on minimum prices as fixed in the "Common Organisation of the Markets in the Sugar Sector". Total revenue for these farmers is both, coupled to a certain amount (quota) of "standard quality" beets, and decoupled, based on EU support to compensate the loss of revenue in the context of the sugar market reform.[71] According to the respective council regulation, sugar produced in

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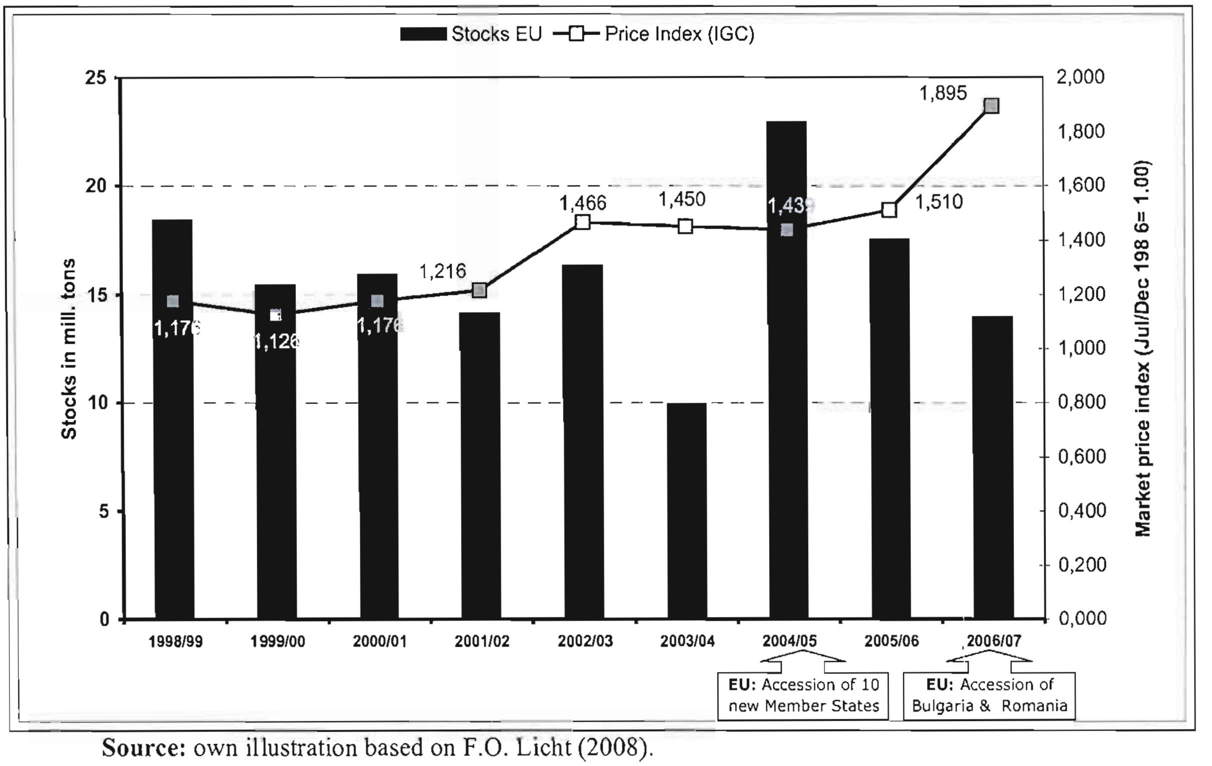
[70] Due to a budgetary ceiling, the maximum guaranteed area is 2 million hectares. If the total area for which support is claimed exceeds this threshold, the aid is reduced proportionally.

[71] In the EU a price mechanism for sugar beet exists for both, sugar beet farmers and processors. On the supply side, the EU support scheme guarantees minimum prices per ton of sugar beet. The minimum price for quota beet is 32.86 EUR/t (for the marketing year 2006/ 2007), 29.78 EUR/t (2007/ 2008), 27.83 EUR/t (2008/2009), 26.29 EUR/t (2009/ 2010). To compensate farmers for lower beet prices, decoupled (SFS) payments are introduced. This reorganization forces least competitive farmers out of the market (Noble, 2007).
For processors, production quota, measured in tons of white sugar equivalent (wse), apply. Under the new sugar market organization, they amount to 14.6 million tons, a reduction of 4 tons compared to the old regime (production in the EU25 varied from 18 to 19 million tons wse). Sugar processors receive a minimum (ex-factory gate) price for raw or white premium sugar. Thus, the sugar regime locks margins of processors. Having been protected from competition outside the EU, these companies tended to consolidate to increase margins via economies of scale under the old sugar regime. The latest reforms, however, have reduced processor returns and, encouraged by EU-policies, these companies are seeking to diversify their activities, *inter alia* into ethanol production (Goldberg et al., 2005; Noble, 2007).

excess of the quota is subject to a levy of 500 EUR/ ton. Using surplus sugar for industrial purposes, like ethanol production, is one option to avoid this fine. In the same way, sugar beet can be directly grown for non-food purposes (EC, 2006/318/EC). Nevertheless, the price for sugar or sugar beet produced out-of-quota has to equal at least the minimum (quota) price, i.e. 27.83 EUR/ ton (for the marketing year 2008/ 2009). In this way any overproduction is channelled to other sectors, thus limiting sugar production and creating additional outlets for farmers. The minimum price for sugar (beet) means, however, that no cheap input from excess supply is available for ethanol production (Noble, 2007). Since sugar beet farmers have not been eligible for any energy crop schemes in the past, policies in the context of the Biofuels Strategy allow them to receive the same support as cereal growers, thus creating incentives for growing more sugar beet for the industrial sector in the EU. Finally, ethanol plays a special role in reducing intervention stocks for cereals. Like in other industrialized countries, the EU accumulated cereal stocks when farm support mechanisms were still designed to promote production and to support prices. As farmers produced more than markets could absorb, the EU created stocks. But even during the surge in wheat prices in recent years, the EU was not able to significantly reduce its stocks because it took over additional stocks from new member states.

Figure 5.4: Development of international prices and EU stocks for wheat



Source: own illustration based on F.O. Licht (2008).

Analyzing the policy strategies in the "closed system" of the EU domestic market, the promotion of ethanol feedstocks contributes to diversifying income in rural areas. Also other objectives of the CAP, like competitiveness and sustainable agriculture, are addressed in the context of the current policy strategy. Rural development payments for ethanol plants are conditional on an economic assessment of the potential location. In the same way the modulation of income support and the increasing reliance on market prices contribute to make farming, and thus energy crop production, in the EU more competitive. In the EU15, this supports a trend towards large-scale farms because marginal (high-cost) producers will be forced out of the market (Schrader, 2004). By contrast, low cost producers in new Member States could benefit from this development (EC DG-AGRI, 2006). Finally, any EU-support for farmers depends on the cross-compliance rules, thus ensuring that sustainability criteria apply to the production of ethanol feedstocks.

When assessing the policy strategies from a free-trade perspective, it is obvious that the EU's notion of "competitiveness" in feedstock production only refers to the domestic market. The current policy strategy promotes the creation of additional outlets for farmers, regardless of comparative disadvantages on international markets. Despite these disadvantages, the current strategy neglects policy actions that potentially improve the viability of feedstock production in the EU. Under the fourth policy axis the EU provides incentives for farmers to grow all sorts of biofuel feedstocks, without taking into account different levels of international competitiveness. The third policy axis of the Biofuels Strategy also implies trade distortions. As sugarcane, the most competitive feedstock for ethanol, is too bulky to be shipped to Europe, the whole ethanol industry depends on domestic, but unviable feedstocks (Kutas et al., 2007). The significant number of ethanol projects in the coming years indicates that market actors regard the current policy framework sufficiently stable for long-term investments. Consequently, investments in (first-generation) ethanol plants supported by European or national institutions create a trade distorting bias. This is because concessions in (multilateral) trade negotiations favouring low-cost producers diminish or even destroy the value of these investments.

There are two potentially competitive inputs for ethanol production in the EU. Rye as feedstock is one option, because the EU has abolished all intervention mechanisms in the light of significant stocks; thus, farmers growing rye are fully exposed to international competition (EC, 2003/1784/EC). However, low prices provide no incentive for farmers to grow rye and are undesirable from a policy perspective since they do not create significant income in rural areas. This points at the main dilemma of the current Biofuels Strategy and of bioenergy production in general: there is an inherent contradiction between stable, or possibly increasing farm income and competitive feedstock supply (Henke/ Klepper, 2006). By setting intervention prices for sugar and cereals the EU's common organization of sugar and cereal markets even limits the competitiveness of domestic feedstock production. Although competitive input could come from intervention stocks for cereals or sugar, even the EC admits that this source of supply does not represent a source of sustained economic advantage (EC, COM (2006) 34). In addition two sustainability issues are linked to the use of cereals from intervention stocks. If the global supply for cereals is low and prices are high, intervention agencies would face the typical food versus fuel problem; in this case diverting cereals to ethanol production has to be weighted against the provision of food aid for those suffering most from high prices. If moderate world prices for cereals prevail, additional supply from intervention stocks could lower prices at the expense of European farmers and those in third countries. So if the EU seeks to balance supply and demand on European or global markets, the main question is whether the Union depends on ethanol production to reduce its stocks. This argument should be considered against the background of decreasing wheat stocks over the last ten years, even in the absence of significant ethanol production from 1999 to 2004 (compare last figure; F.O. Licht, 2007).

5.5. The Special Role of Trade in Ethanol

In the previous chapters it has become apparent that trade distortions are required to keep up production of 1st generation ethanol in the EU. Two policy axes of the Biofuels Strategy address border protection issues for ethanol; at the same time they outline the promotion of the biofuels sector in developing countries.

Table 5.10: Relevant policy measures to enhance trade in biofuels

Measures to be taken under the fifth axis of the Biofuels Strategy
a) Assess the advantages, disadvantages and legal implications a separate nomenclature code for biofuels entails;
b) Maintain market access conditions no less favorable than currently in force and maintain market access conditions on a preferential level for ACP countries, while taking into account the problem of preference erosion;
c) Pursue a balanced approach in ongoing trade negotiations with ethanol producing countries and regions while respecting the interests of domestic producers and the EU's trade partners; [...].

In the context of the Biomass Action Plan (EC, COM (2005) 628, annex 11), the EU assessed three options dealing with market access in biofuels in 2010: a minimum share for imports, a maximum share for imports and a balanced approach.

- **The first option addresses ethanol autarky:** EU analyses show that a 5.75% share in biofuels from sugar beet, cereals and oilseeds (rape; for biodiesel production) would require 17 million hectares of agricultural land, compared to a total arable area of 97 million hectares. Hence biofuel autarky appears technically feasible. Besides agronomic limits, however, the solution is not desirable because the autarky implies a closed European market in which excessive increases in demand would lead to a surge in raw material prices, which jeopardizes sustainability objectives. In addition, the EU would not address potential benefits related to biofuels in developing countries.
- **Under the second option, the EU would allow for a maximum share of imports:** For biodiesel, this option is most attractive because European biodiesel production is internationally competitive and oilseed growers or biodiesel producers in other countries, notably developing countries, would benefit from open markets. An uncompetitive ethanol industry on the other hand would face cheap imports. European ethanol producers and feedstock growers, being unable to compete on price on global markets, are likely to give up production in the light of imports from (major) sugarcane producers. According to the EU's analysis, this means that all conventional ethanol consumed in the EU would have to be imported. This policy option comes close to the idea of free trade in sustainable ethanol, the leitmotif of this master thesis. However, without providing any evidence the EU makes the general assumption that imported biofuels under this scenario are *per se* not sustainable. The comments made in the respective paragraphs of the biomass action plan are the strongest statement of the EU against trade liberalization in biofuels.
- **Consequently, the EU pursues a "balanced approach":** This approach implies the current market access conditions as outlined earlier. Only they "respect the interests of domestic producers and EU trading partners" (EC, COM (2005) 628: 40). It is worth to note that in the context of the "balanced approach" the EU assumes sustainable cultivation of feedstock, as this criterion has not been considered for the other two options.

The balanced approach means that the EU does not intend to change its current import duty and preference system. The regular tariff for most favoured nations (MFN) amounts to 19.2 EUR per hl when ethanol is imported under HS-code 2207-01 ("undenatured alcohol"); under the alternative classification of HS-code 2207-02 ("denatured alcohol"), the duty amounts to 10.2 EUR per hl. The distinction exists because undenatured alcohol is potable and thus represents a potential competition for the European spirits sector. Denatured alcohol, by contrast, is not potable and can only be used for industrial purposes or as a fuel (EC, COM (2006) 34).[72] For some time, (20%) gasoline blended with (80%) ethanol was imported in Sweden as "other chemicals" under HS-heading 3824, for which a 6.5% duty applies. The practice changed when the Swedish government revised the tax exemption rules and required ethanol to be imported under higher tariff lines in order to be eligible for lower excise duty. Nevertheless ethanol is still being imported in the EU under HS-code 3824 if the lower duty compensates for the absence of national tax exemptions (Kutas et al., 2007). As there are three possible HS-codes under which ethanol can be imported, it is almost impossible to verify the actual end-use (industrial, pharmaceutical and beverage). Moreover, as a chemical product, there are no differences in quality that could justify a separate nomenclature code. Therefore a separate nomenclature code for fuel ethanol, as suggested in the Biofuels Strategy, is almost impossible to implement or would not hold against a critical examination.

In the present policy setting, only the "Everything But Arms" (EBA) initiative for least developed countries (LDC) provides unrestricted duty free access for ethanol producers. The "Generalised System of Preferences" (GSP) regime grants enhanced market access for developing countries, which commit to core international conventions on human and labour rights, environmental protection and good governance. However, in the framework of the new GSP-regime (valid from 2009 to 2011) there is a distinction between non-sensitive products, which can be imported duty free, and sensitive goods, for which special rules apply. For ethanol, as a sensitive product under the GSP-scheme, tariffs are reduced by 30% (EC, 2008/732/EC). The following table summarises market access conditions for ethanol imports into the EU under different trade regimes.

[72] Nevertheless, most ethanol enters the EU under code 2207-01 as undenatured alcohol due to better marketing possibilities: denatured ethanol cannot be reconverted into potable alcohol.

Table 5.11: Tariffs for ethanol imports into the EU (valid from January 2009)

	MFN	GSP	EBA
Customs duty HS 2207-01	19.2 EUR/ hl	13.44 EUR/ hl	Duty free
Customs duty HS 2207-02	10.2 EUR/ hl	7.14 EUR/ hl	

Source: EC, COM (2006) 34; EC, 2008/732/EC

It is important to note that the GSP and EBA initiatives are politically motivated and do not reflect any comparative advantage. Therefore it is not surprising that only 5 out of 50 EBA-countries and 12 out of 90 GSP beneficiaries are included in the sample defined in Chapter 4.5 (compare Table 5.13).

The 6th policy axis puts the emphasis on those countries that are particularly affected by the reform of the EU sugar market organization.

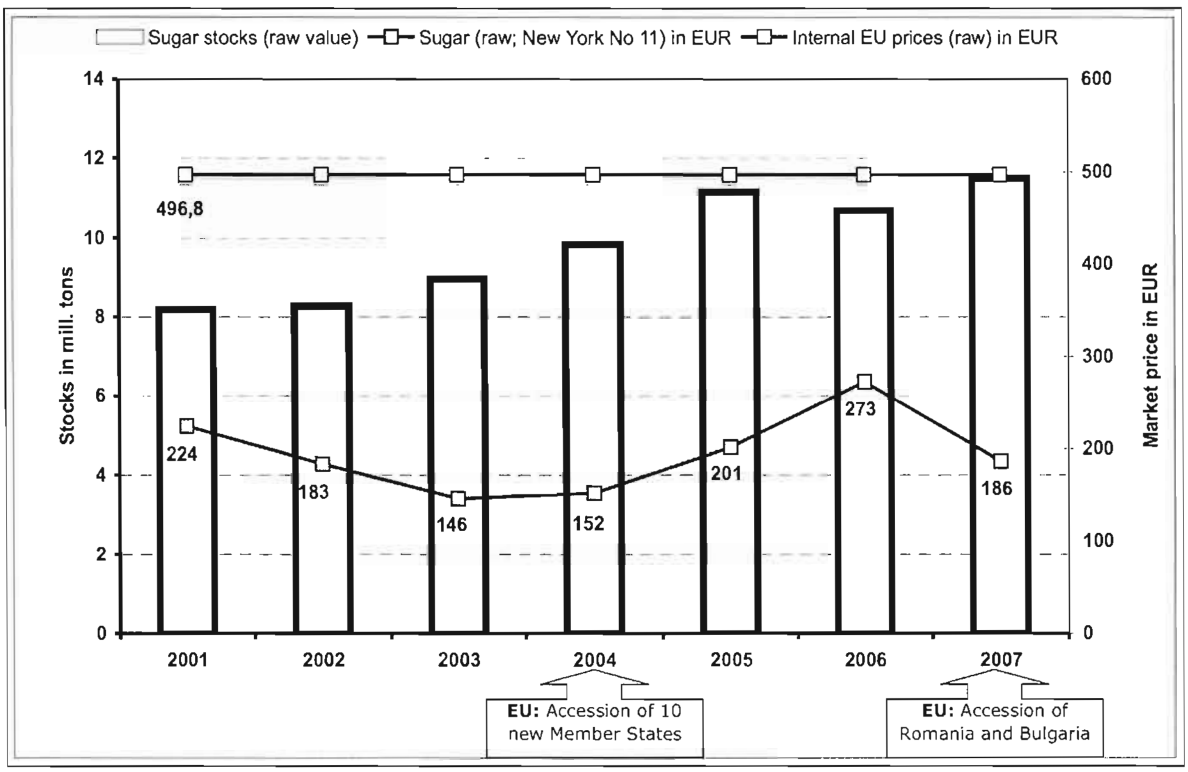
Table 5.12: Policy measures to support biofuels in developing countries

Measures to be taken under the sixth axis of the Biofuels Strategy
a) Support the development of bioethanol production in those countries that are particularly affected by the reform of the EU sugar regime;
b) Develop a coherent biofuel assistance package for these countries;
c) Examine how the EU can assist these countries in developing national biofuel platforms and regional action plans that consider economically and environmentally sustainable production.

As described earlier, sugar and ethanol markets are highly interwoven. In many developing countries, sugar cane has been cultivated for centuries. As former colonies of European states, countries in Africa, the Caribbean, in the Pacific (ACP countries) and India were granted duty-free access for 1.3 million tons "white sugar equivalent" (wse) p.a., thus benefiting from Community prices that were higher than on the world market. Under the so-called "Sugar Protocol" (SP), established in 1975, the EU imported sugar from these countries although there was already significant excess supply in the Community due to production-tied subsidies. The EU exported this excess supply at world market prices, however, paying processors internal prices for a quantity up to 2.4 million tons. A ruling of the WTO panel in 2005 set an end to this practice, forcing the EU to reform its sugar regime and particularly to end export subsidies (Goldberg et al., 2005).

In the context of the sugar market reform, all exports of sugar are limited to 1.4 million tons per year, which is significantly less than exports in previous years (5 to 6 million tons p.a.). Most importantly, however, reference prices decrease by 40% for sugar beet (pre-reform: 43.60 EUR/ ton; post-reform: 26.29 EUR/ ton in the marketing year 2009/ 2010), by 36% for white sugar (pre-reform: 631.90 EUR/ ton wse; post-reform: 404.40 EUR/ ton wse in 2009/ 2010) and by 33% for raw sugar (pre-reform: 496.80 EUR/ ton; post-reform: 335.20 EUR/ ton in 2009/ 2010) (EC, 318/2006/EC; Noble, 2007). It is important to note that these price levels are still a far cry from world market prices for raw sugar, which are more than 50% lower than in the EU (F.O. Lichts, 2008).

Figure 5.5: EU sugar stocks and internal prices compared to world market prices



Source: F.O. Lichts (2008).

For Sugar Protocol countries the reform of the EU market organization means a shrinking market as the import quota limits exports at EU internal prices to 1.3 million tons. Though being more competitive than European producers, these countries have particular problems in coping with price cuts and timescale. They were traditionally less exposed to the world market due to customs-free access into the EU (Goldberg et al., 2005). Switching part of the production from sugar to ethanol is an opportunity for these countries to alleviate the consequence of the new sugar market organization in the EU. Moreover, ethanol production in these countries could contribute to greater energy security, improved foreign exchange and trade balances, and to rural and economic development (EC, COM (2005) 628). The framework of the Biofuels Strategy promotes developing countries in shifting more production capacities to ethanol. In this context, business-to-business co-operations in the area of renewable energies and joint initiatives of development and environmental agencies play an important role (both in the framework of CDM-projects) (EC, COM (2006) 34).

Like the EBA and GSP initiatives, the Sugar Protocol can also be regarded as an essentially political initiative, given that only 8 out of 19 Sugar Protocol countries are competitive producers according to the sample criteria.[73] This low figure is not surprising as the sugar industry in many SP countries - particularly in the Caribbean - was already making losses before the EU reformed its sugar market (Roseboom, 2007). It is noteworthy that neither the sugar market reform nor the Biofuels Strategy provide for duty free access for ethanol; nevertheless many SP countries benefit from market access conditions either under the GSP or the EBA-initiative (EC, COM (2006) 34). The following table lists all countries from the sample according to their current market access conditions. Sugar Protocol countries are marked by one asterisk. Two asterisks indicate those countries that have unlimited duty free access to the EU until the end of 2008 under the expiring GSP+ initiative. The letter "E" hints at past exports to the EU.

[73] Originally Suriname and Uganda were among those countries benefiting from the Sugar Protocol, but as they stopped exporting sugar to the EU they lost their preferential access status. Uganda, which is also included in the sample, has also duty free access under the EBA initiative (Roseboom, 2007).

Table 5.13: Competitive producers listed according to trade agreements

MFN (regular tariffs)		**EBA (duty free)**		**GSP (from Jan. 2009: 30% red.)**	
Avg. export share 2002-04: 30%		**Avg. export share 2002-04:** 61% duty free; 9% reduced tariff.			
Australia		Ethiopia	E	Colombia**	
Brazil	E	Malawi*	E	Cuba	
Egypt	E	Tanzania		Ecuador**	E
India*		Uganda		El Salvador**	E
Indonesia*		Zambia*		Guatemala*/**	E
Pakistan**	E			Honduras**	
Philippines	E			Kenya*	E
Thailand	E			Mauritius*	E
Vietnam				Peru**	E
Mauritius				Swaziland*	E
Argentina	*E*			Venezuela**	
China				Zimbabwe*	E
Mexico					
*South Africa***	*E*				
USA	*E*				

Source: own summary based on EC, 2008/732/EC; EC, COM (2006) 34; Eurostat-comext (2008).

As mentioned above countries under the EBA agreement have the most favorable market access conditions. The special arrangement for a country remains unchanged as long as it is recognized and classified as LDC by the UN. Countries enjoying preferential access under the GSP-regime face more uncertain market access conditions. In particular the following clause of the underlines that the main concern of the EU is its domestic market:

> "Where a country originating in a beneficiary country is imported on terms which cause, or threaten to cause, serious difficulties to a community producer of like or directly competing products, normal Common Customs Tariff duties on that product may be reintroduced at any time at a request of a Member State or on the Commission's initiative."
>
> (EC, 2008/732/EC: Article 20, I).

> "In examining whether there are serious difficulties the Commission shall take account, *inter alia*, of the following factors concerning Community producers, where the information is available: (a) market share; (b) production; [...] (h) employment; (i) imports; (j) prices."
>
> (EC, 2008/732/EC: Article 20, IV).

Roughly speaking, Article 20 addresses in detail the "problem of preference erosion" mentioned in the context of the 5th policy axis of the Biofuels Strategy. This clause refers to situations in which biofuel imports under preference agreements become too dominant. In the past, this was the case of Pakistan, a country which was more competitive than others having unlimited duty-free access at that time. With production costs close to those of Brazil, Pakistan became the "most aggressive and competitive" exporter to the EU and was therefore excluded from the GSP-preference list in 2005 (EC, COM (2006) 34). Given the fact that Pakistan had unlimited duty free access to EU ethanol markets, most market analysts agree that trade liberalization in ethanol is sufficient to promote the development of ethanol industries in many other countries as well. Accompanied by respective standards, it would also be an important means to promote economic, ecological and socially sustainable development. Given the current system of tariff (preferences), however, the EU's commitment to support developing countries remains ambiguous and suggests that there are more superior goals for the Commission.

Chapter VI

Policy Objectives and Sustainability: The Analysis of Trade-Offs

This chapter analyzes the of major trade-offs that exist between the single European policy objectives in terms of ethanol. In the context of the first analysis it will become clear to what extent policy objectives converge or contradict each other in the short and long term. During this process, those policy objectives emerge that are compliant with free trade. Thereafter it will be evaluated to what extent it is possible to combine sustainability principles with the idea of free-trade. Based on a broad range of sustainability criteria for ethanol, opportunities and limits of certifying sustainable ethanol production will be analyzed. Moreover, it is possible to identify possible trade-offs with EU policy objectives. These conflicts require special attention in the context of an "Alternative EU Strategy for Ethanol", which will be outlined in the last chapter.

6.1. The Trade-offs in European Ethanol Policies

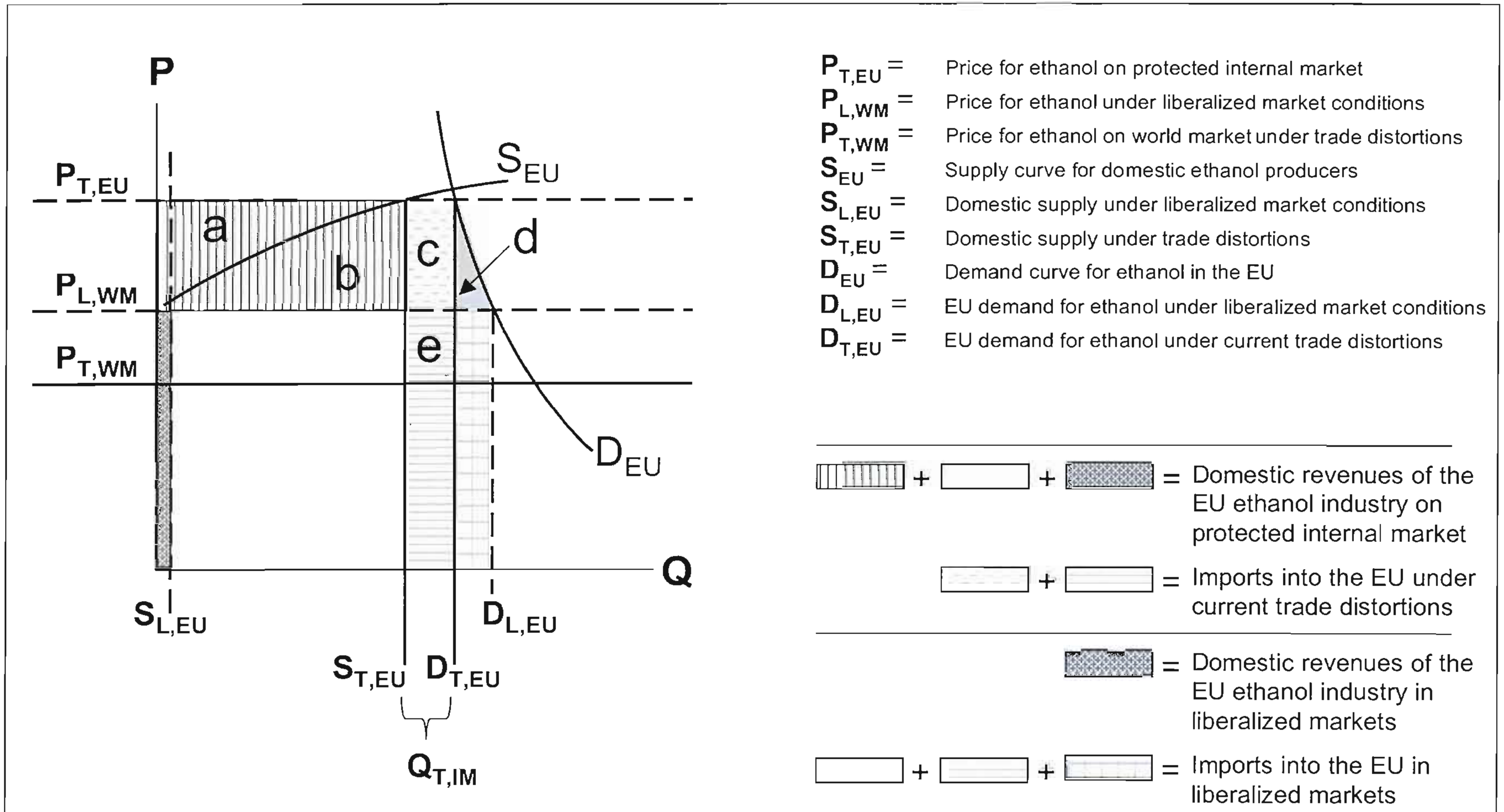
6.1.1. Evaluating the Welfare Impact of the Current Trade Regime

By referring to the standard trade model presented in Chapter 3 it is possible to evaluate the most important (welfare) costs and benefits of current policy measures in a qualitative and quantitative manner. For estimating welfare costs and benefits from current trade distortions two different approaches will be used. One is based on actual market and EU budget data from 2005 and 2006, which has mainly been derived from a study by Kutas et al., 2007. The other one is based on econometric analyses by the OECD (OECD, 2008b). The authors of that study compute the average impact of policy actions for the period from 2013 to 2017; thus, their time horizon differs from the one chosen by Kutas et al. (2007). The OECD analysis shall be cited for estimating the impact of long-term policy shifts and for comparing the situation in 2005 and 2006 with a possible free trade scenario. However, it is important to note that it is hardly possible to quantify the *exact* and *total* net effect of a tariff on welfare (Krugman/ Obstfeld, 2008). Therefore, the following analysis only provides a rough sketch of the actual situation and some ambiguity remains due to different underlying assumptions.

Nonetheless it can be considered sufficient for conceptualizing and evaluating the trade-offs of current EU ethanol policies.

As mentioned by numerous authors (Del Guayo, 2008; Henniges, 2006; Henke/ Klepper, 2006, Henke et al., 2003), the key policy measure to promote biofuels in the EU was the introduction of (partial) tax exemptions and blending mandates. Both instruments *created* the market for ethanol, while tariffs are the key policy strategy to *maintain* a domestic ethanol industry and, thus, to maintain demand for ethanol feedstocks. Consequently, the demand curve for ethanol in the following figure is an "artificial" one as it would not exist in the absence of policy intervention. Based on previous discussions, the supply curve takes into account that European producers can only supply ethanol at relatively high prices. The demand curve considers the fact that energy demand is relatively inelastic: as technology allowing a more efficient use of energy is not available in the short-term the only way to reduce the energy need is to lower consumption (Helm, 2002). Therefore price movements have weak immediate effect on demand.

Figure 6.1: Welfare benefits and losses of current EU tariffs



Note: the figure is only designed to *illustrate* the effects of current trade rules, and not to indicate the relative magnitude of welfare benefits and costs.

Source: own illustration.

The current price level of ethanol on a distorted world market is represented $P_{T,WM}$. Prices on the protected EU market can be illustrated by $P_{T,EU}$. Undistorted world markets would lead to a higher price for the fuel ($P_{L,WM}$). This price level is due to lower supply as high-cost producers are no longer able to compete with low-cost producers (S_T => S_L) and due to rising demand in the light of lower prices (D_T => D_L). The regions labelled *a*, *b*, *c*, *d*, *e*, represent the sum of costs and benefits that can be attributed to producers, consumers and the government. The net welfare cost of a tariff equals the consumer loss (*a* + *b* + *c* + *d*), after subtracting producer gains (*a*) and government revenue (*c* + *e*). In essence, the question is whether the loss of economic efficiency due to the tariff (*b* + *d*) can be balanced by gains from terms of trade that arise if the tariff lowers world market prices. Only in that case overall welfare benefits occur (Krugman/ Obstfeld, 2008). The following table summarizes the major assumptions that are required to estimate welfare gains and costs for 2005 and 2006.

Table 6.1: Underlying assumptions for estimating welfare benefits and losses

2005	$P_{T,EU}$	$P_{Transport}$	$P_{L,WM}$	$P_{T,WM}$	$S_{L,EU}$	$S_{T,EU}$	$D_{T,EU}$	$Q_{T,IM}$	$D_{L,EU}$
Kutas et al. 2007	0,55	0,08		0,27		914.000	1.167.000	253.000	
OECD, 2008b			0,3078		0				1.225.350
(original assumptions made in %)			+14%		-50%				+5%

2006	$P_{T,EU}$	$P_{Transport}$	$P_{L,WM}$	$P_{T,WM}$	$S_{L,EU}$	$S_{T,EU}$	$D_{T,EU}$	$Q_{T,IM}$	$D_{L,EU}$
Kutas et al. 2007	0,65	0,08		0,38		1.492.000	1.725.000	233.000	
OECD, 2008b			0,4332		0				1.811.250
(original assumptions made in %)			+14%		-50%				+5%

Source: own illustration, based on Kutas et al. (2007) and OECD (2008b)

For EU ethanol producers, tariffs are vital to compete on the internal market with cheaper imports. As tariffs create a domestic market for EU ethanol producers, there would be literally no supply from European producers. This fact is illustrated by the dark-grey shaded area in Figure 6.1 ($S_{L,EU}$; $P_{L,WM}$). Sales in the protected market can be described by the area ($S_{T,EU}$, $P_{T,EU}$). Leaving aside proceeds from EU support schemes, estimated revenues from domestically produced ethanol amounted to 503 MEUR in 2005 and 970 MEUR in 2006. The value of imported ethanol at EU prices ($Q_{T,IM}$; $P_{T,EU}$) was 139 MEUR and 151 MEUR in 2005 and 2006 respectively. In Figure 6.1 the area marked by ($S_{T,EU}$; $P_{T,EU}$) represents total ethanol sales in the EU, which amounted to 642 MEUR in 2005 and to 1,121 MEUR in 2006.

According to analyses from the OECD (2008b), the price for ethanol on free markets would be - in the long term - 14% higher than under the current setting.[74] Considering Brazilian export prices as a benchmark for current world market prices, the price in undistorted markets ($P_{L,WM}$) can be estimated at 0.31EUR/litre in 2005 ($P_{T,WM\ (2005)}$ = 0.27EUR/litre) and 0.43EUR/litre in 2006 ($P_{T,WM\ (2006)}$ = 0.38EUR/litre). Bearing in mind transport and handling charges of 0.08 EUR/litre, the price difference between European ethanol ($P_{T,EU}$) and imported ethanol at undistorted world market prices ($P_{L,WM}$) would have been 0.16 EUR/litre in 2005 and 0.14 EUR/litre in 2006.

The analysis of welfare costs and benefits starts on the producer level. Area *a*, below the price $P_{T,EU}$ but above the supply curve can be interpreted as a welfare benefit, i.e. profit for the ethanol industry and for associated sectors involved in ethanol production (e.g. manufacturing; compare Neuwahl et al., 2008). At the same time it is an indirect support for European farmers who benefit from higher feedstock prices due to competing uses for the crops they grow. It is a complex task to unravel the monetary benefits associated with area *a*, and in particular the actual surplus for feedstock producers. A rough estimate of profit margins in the ethanol sector comes from Schmitz (2003), who assumes a 10% profit margin on total ethanol costs. For blending and distributing ethanol, similar margins can be assumed. Applying this margin on 2005 and 2006 sales of domestically produced ethanol, area *a* can be estimated at 46MEUR in 2005 and 88MEUR in 2006.[75] Alternatively a lower, 5%, margin may be assumed: in this case profits decrease to 26MEUR (2005) and 51MEUR (2006). Region *b* in Figure 6.1 is typically associated with efficiency losses. These so-called dead-weight costs incur as the tariff creates wrong incentives for producers, who had only supplied the quantity ($S_{L,EU}$) in the case of free-trade (production distortion loss). A high estimate for efficiency losses is based on the price level that exists in distorted markets ($P_{T,EU}$); in this case the assumption would be that a change in EU trade policy has no effect on the world market price for ethanol (b_{2005} = 137MEUR; b_{2006} = 195MEUR). As tariffs are abolished prices on world markets are expected to rise and, therefore, a low estimate for the production distortion loss is based on the price on liberalized world markets ($P_{L,WM}$). Respective estimates for efficiency

[74] This applies for a scenario in which all other consumption incentives, e.g. blending mandates and tax credits, remain in place.

[75] Profits from blending and distributing imported ethanol are neglected.

losses are 102MEUR for 2005 and 153MEUR for 2006. In either case it is important add transport and handling charges to the reference price.

Area *c* and *e* in Figure 6.1 represent government revenues due to tariffs. Assuming that all ethanol imported into the EU was subject to the maximum tariff rate of 0.192 EUR/litre, maximum budget revenues can be estimated at 49MEUR (2005) and 45MEUR (2006). These figures tend to overestimate actual revenues because it can be expected that some ethanol has been imported under preferential trade agreements. Indeed, distinguishing imports from countries with preferential market access and imports from most favoured nations suggests an average tariff per litre of 0.08 EUR/litre in 2005 and 0.09 EUR/litre in 2006; respective revenues would amount to 20 MEUR in 2005 and 21 MEUR in 2006. As mentioned earlier it is unknown how much ethanol has been imported for what purpose. In either case revenues from tariffs represent a welfare gain for the governments of the EU member states; any amount between 20 MEUR and the maximum values mentioned above would be a good proxy for actual revenues. The amount associated with region *e*, representing the terms of trade gain, can be estimated by multiplying the difference between ($P_{L,WM}$) and ($P_{T,EU}$) by the import quantity in the respective year. When assuming no effect of EU trade policies on world market prices for ethanol, there is no such welfare gain and area *e* is close to nil.

EU consumers loose from tariffs on ethanol as they face a higher price than under undistorted market conditions. They pay for the profits of ethanol producers and blenders (*a*), they bear the dead-weight costs of inefficient production (*b*) as well as higher costs due to the tariff (*c*). Moreover, consumers suffer a welfare loss (*d*) as they would have consumed more and at lower prices in the absence of tariffs. Other things being equal, the OECD (2008b) estimates that EU demand would rise by approx. 5% in the absence of trade distortions. Subtracting revenues from European ethanol sales in free markets ($P_{L,WM}$; $D_{T,EU}$ *1.05) from revenues in the EU under trade distortions ($P_{T,EU}$; $D_{T,EU}$) leads to a welfare loss of 167 MEUR and 191 MEUR in 2005 and 2006 respectively (*d*).

The overall welfare benefits and costs due to trade distortions are summarized in the following table. Welfare benefits occur due to tariffs and producer gains, while consumers suffer significant losses due to inefficient production.

The production distortion loss (*b*) has the most important welfare impact, but is at the same time very difficult to estimate. Whether the difference between distorted and undistorted markets is based on current world market prices for ethanol (Kutas et al., 2007) or on potential free trade prices (OECD, 2008b) has a significant impact on welfare estimates. Moreover it should be noted that the difference between potential revenues under free trade and revenues in distorted markets (based on OECD data) deviates from the estimates based on 2005/ 2006 data, computed by Kutas et al. (2007). Applying OECD results on 2005 and 2006 data suggests lower efficiency losses than actual data from both years; this implies that the increase in ethanol consumption in free markets in 2005 and 2006 would have been lower than suggested by the OECD (2013 to 2017 average), or that increasing demand for ethanol in free markets would have balanced part of the welfare gains for consumers under liberalization. Due to this ambiguity, the consumer loss due to distorted consumption (*d*) under the current trade regime is assumed to be zero. Nevertheless, the estimated welfare losses for consumers (*b* and *d*) outweigh the potential terms of trade gain (*e*), despite the uncertainty associated with the efficiency losses.

Table 6.2: Estimated welfare gains and losses due to the EU's current ethanol trade policy (in kEUR)

Year	Area in trade model		Producer gains Estimate	Producer gains Assumption	Government gains Estimate	Government gains Assumption	Consumer loss Estimate	Consumer loss Assumption	
2005	a	High est.	45.700	TC + 10%			-45.700		**0**
		Low est.	26.458	TC +5%			-26.458		**0**
	b	High est.					-137.100	$P_{T,EU} - P_{T,WM}$	**-137.100**
		Low est.					-102.551	$P_{T,EU} - P_{L,WM}$	**-102.551**
	c	High est.			39.013	0,192	-39.013		**0**
		Low est.			20.493	0,081	-20.493		**0**
	d	High est.					**0**		**0**
		Low est.					**0**		**0**
	e	High est.			9.563		0		**9.563**
		Low est.			0		0		**0**
	Total	High est.	**45.700**		**48.576**		**-221.813**		**-127.537**
		Low est.	**26.458**		**20.493**		**-168.744**		**-121.793**
	Comparison: OECD (2008b)						*-166.659*		
2006	a	High est.	88.164	TC + 10%			-88.164		**0**
		Low est.	51.042	TC +5%			-51.042		
	b	High est.					-195.316	$P_{T,EU} - P_{T,WM}$	**-195.316**
		Low est.					-153.063	$P_{T,EU} - P_{L,WM}$	**-153.063**
	c	High est.			32.340	0,192	-32.340		**0**
		Low est.			21.203	0,091	-21.203		**0**
	d	High est.					**0**		**0**
		Low est.					**0**		**0**
	e	High est.			12.396		0		**12.396**
		Low est.			0		0		**0**
	Total	High est.	**88.164**		**44.736**		**-315.820**		**-182.921**
		Low est.	**51.042**		**21.203**		**-225.309**		**-153.063**
	Comparison: OECD (2008b)						*-191.717*		

Source: own illustration.

6.1.2. Evaluating Welfare Impacts of Other Policy Measures of the Biofuels Strategy

This subchapter addresses other welfare impacts of other policy measures related to the Biofuels Strategy. In this context welfare impacts on producers and consumers side will be distinguished. The following chapter focuses on the EU by summarizing all welfare impacts and relating them to the objectives of policy makers.

The EU's policy strategy to foster ethanol production in member states includes various instruments on farm-level, stipulated in the 4th axis of the Biofuels Strategy, and on manufacturing and distribution level, stipulated in the 3rd and 7th axis of the Strategy. For feedstock producers, the crucial mechanisms are a review of the promotion of energy crops concluded that the NFSA scheme is a significant measure to promote the production of energy crops. More than 95% of non-food crops grown on set-aside were dedicated to energy crops (EC, COM (2006) 500). Since fallow land has to be "maintained in good agricultural and environmental condition" (EC, 2003/1782/EC), cultivating energy crops increases the farmers' margin. By contrast, the energy crop scheme, introduced as an incentive to grow energy crops on regular farmland, does not provide sufficient benefits for farmers to change land-use (EC, COM (2006) 500). As mentioned earlier, reasons include limitation in marketing opportunities and the administrative burden for claiming the aid, which only amounts to 45 EUR/ha. Indeed the NFSA scheme can be considered more effective than the energy crop support (EC, COM (2006) 500), which is due to be abolished. The lack of effectiveness is also reflected by total support estimates for ethanol. Payments under the NFSA scheme in 2005 and 2006 were three to six times higher than payments under the energy crop scheme (compare Table 6.3).

Other support mechanism for feedstock processors include R&D support and investment aids. These measures are difficult to include in welfare estimates; however, due to different reasons. Measures in relation to R&D support under the 7th policy axis of the Biofuels Strategy concern all sorts of biofuels - 1st and 2nd generation. As it has been argued earlier, the production of 1st generation ethanol is based on mature technologies and, thus, support payments can be considered as detrimental to overall welfare. Due to the potential competitiveness of 2nd generation fuels, R&D support can be seen as an investment in future welfare benefits. From 2002 to 2006 the EU has provided funds for fourteen projects, totalling 49MEUR. For the sake of simplicity the assumption is that the EU contributes 10 MEUR in each year, 2005 and 2006, to research activities. Although Kutas et al. (2007) claim that less than 50% of this amount was devoted to 2nd generation technologies, many of the research has been conducted in the area of the biorefinery concept, which is not per se uncompetitive or not useful for more advanced technologies. Nonetheless it should be noted that the current research agenda includes significant R&D investments in mature technologies that are only viable within the EU, but not in free markets.

Investment aids for ethanol manufacturers are an important measure under the 3rd axis of the Biofuels Strategy as they may enhance the economic development of rural areas. The ethanol plant of German beet processor *Südzucker* in Eastern Germany is one example. In 2005 the company received one-off payments from the EU representing 24% of the total investment (43 MEUR); moreover, the provincial government provided grants for operating expenditures in the context of its rural development scheme (State Support, 2005). In particular the investment aid from the EU is said to have been decisive for *Südzucker's* investment decision. Furthermore the EU granted an investment aid of 25MEUR to another ethanol producer from Eastern Germany (Brandenburg) in the same year. In 2006, another ethanol producer from Austria claimed an investment aid amounting to 7% of eligible costs. Total support amounted to 8MEUR in that case.[76] The difficulty in measuring state support is due to the fact that the kind of support, rates and eligibility criteria vary from one Member State to the other. In the case of the ethanol plant in Brandenburg, for instance, the Federal Government provided loan guarantees worth 10 MEUR in addition to the investment aid. Therefore it is not only difficult to evaluate the importance of support payments in the context of investment decisions, but also to identify and evaluate additional support, like loan guarantees.

Another support measure is the so-called crisis distillation aid in the context of the Common Market Organization for wine. This kind of support has not been mentioned yet as fuel ethanol produced from wine out of intervention stocks is not seen as a sustainable source of supply in the European Biofuels Strategy (EC, COM(2006) 34). In order to maintain a certain price level on wine markets, surplus quantities are withdrawn, distilled and marketed as fuel or industrial ethanol. Costs per hectolitre of wine amount to 24 EUR: 11 EUR for distillation and disposal, and 13 EUR for compensating farmers. The quantity of wine from crisis distillation used for fuel ethanol was 207,000 cbm in 2005 and 342,000cbm in 2006. Respective support payments can be estimated at 50MEUR (2005) and 82MEUR (2006). As mentioned in the EU Biofuels Strategy the distillation aid is rather an element of the EU agricultural policy than of a long-term biofuels policy. Depending on the point of view, the distillation aid may be considered as a support for farmers; it is definitely not a support for ethanol

[76] Henceforth, investment aids granted in 2005 and 2006 are distributed over the lifetime of the plant (assumption 10 years, based on Schmitz, 2003) to give a precise picture of average capital grants per year.

producers as wine from crisis intervention competes with "regular" ethanol supply. The following table summarizes the most important benefits for ethanol feedstock producers and processors in 2005 and 2006.

Table 6.3: Subsidies paid for ethanol feedstock producers and processors (in kEUR)

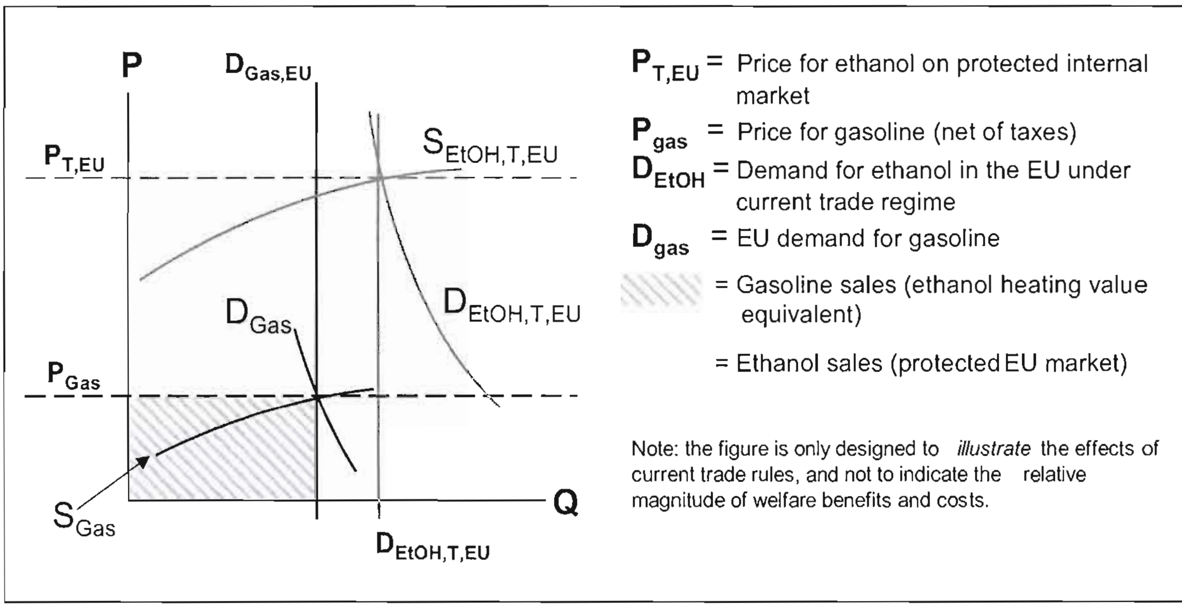
Axis of the Biofuels Strategy & policy instrument		Producer benefits 2005	Producer benefits 2006
4th axis	Non-food set-aside scheme (NFSA)	29,000	29,000
	Energy crop scheme (45EUR/ha)	5,000	10,000
-	Distillation aid for wine producers (24EUR/hl)	(high estimate: 50,000)	(high estimate: 82,000)
Total benefits feedstock producers low / (high) estimate		34,000 (84,000)	39,000 (121,000)
7th axis	Support for R&D	10,000	10,000
3rd axis	Investment aids: - direct capital grants	68,000	8,000
	- distributed over 10 years	6,800	7,600
Total benefits ethanol producers		16,800	17,600
Total producer support low/ (high) estimate		**50,800 (162,000)**	**46,600 (139,000)**

Source: own illustration.

From a consumer perspective the first axis of the Biofuels Strategy is the most relevant. Instead of a "moral commitment" to use biofuels, the Biofuels Strategy requires member states to blend gasoline with ethanol. In this way the EU has created the market for the fuel. There is an immediate welfare effect of this policy as consumers have to bear the differential between gasoline and ethanol prices. Furthermore, it is important to consider the difference in terms of heating value. Since the EU defines the blending mandate in terms of heating value and *not* on a volumetric basis, the quantity required to displace one unit of gasoline is 25 to 50% higher due to the lower heating value of ethanol.[77] Data about the average net gasoline price (net of taxes and distribution costs) comes from the association of the German Petroleum Industry (MWV, 2008). A high estimate of the welfare loss is based on a substitution ratio of 0.65 that is common in higher blends, e.g. E85. In lower blends ethanol usually substitutes more gasoline (factor 0.8). Figure 6.2 illustrates the price and quantity differential, while Table 6.4 summarizes the estimated welfare effect in 2005 and 2006.

[77] The actual quantity depends on the blending ratio: in low blends 0.8 units of ethanol displace one unit of gasoline, while the substitution in high blends is close to the actual heating value ratio of 0.65 (compare chapter 2).

Figure 6.2: Illustration of welfare effects due to the blending mandate



Source: own illustration.

Table 6.4: Estimated consumer loss due to ethanol blending in 2005 and 2006

		2005		2006	
		Ethanol T,EU	**Gasoline net tax & distrib.**	**Ethanol T,EU**	**Gasoline net tax & distrib.**
Price		0,55	0,32	0,65	0,37
Differential		0,23		0,28	
Heating value (HV)	low est	0,8	1	0,8	1
	high est	0,65	1	0,65	1
Consumption	EtOH	1.167.000	0	1.725.000	0
Gasoline equ.	HV 0.8	933.600		1.380.000	
	HV 0.65	758.550		1.121.250	
Difference in demand	HV 0.8	-233.400		-345.000	
	HV 0.65	-408.450		-603.750	
Est welfare loss	HV 0.8	-53.682		-96.600	
	HV 0.65	-93.944		-169.050	

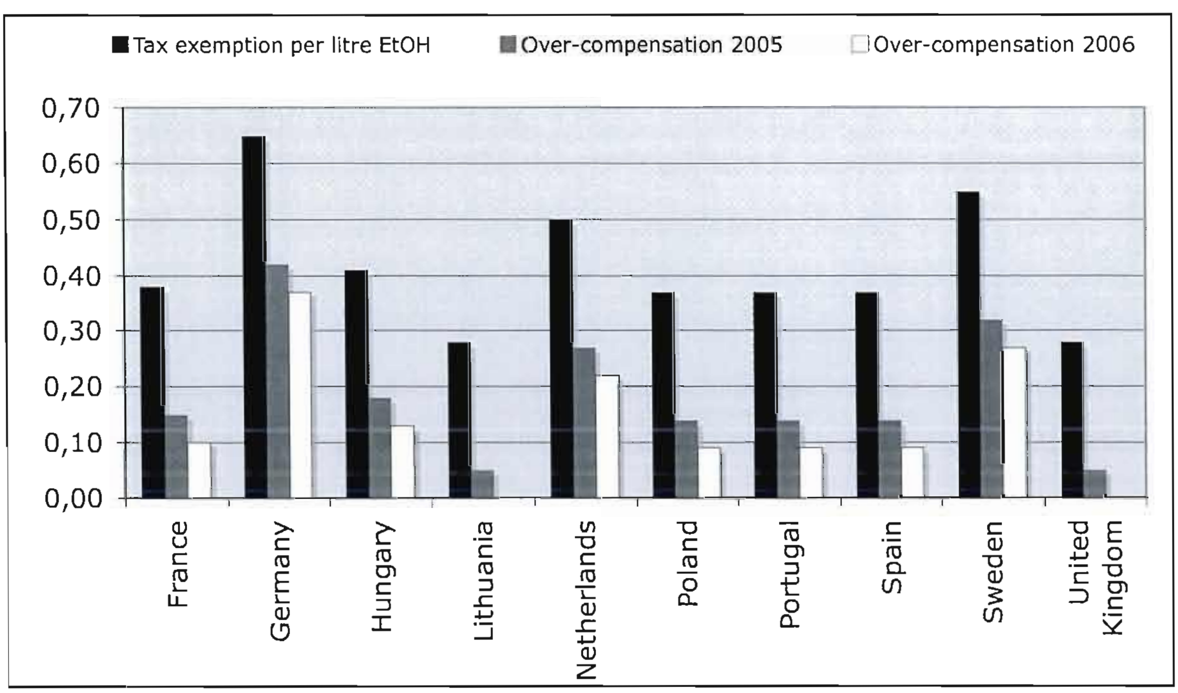
Source: own illustration; data based on Kutas et al. (2007); MWV (2008).

Depending on the assumed substitution ratio, consumers paid 54 to 94MEUR more for their transport fuel than they would have paid in the absence of ethanol blends in 2005. The estimated loss in consumer welfare in 2006 can be estimated at 97MEUR to 169MEUR. The high estimates are, however, somewhat unrealistic because low blends of ethanol dominate in the EU. In low blends like E5 or E10 the substitution ratio is relatively high, i.e. at about 0.8, which make the lower estimates in the above figure more realistic.

Higher costs for consumers occur due to the differential between gasoline and ethanol. As mentioned earlier, governments have to decide whether consumers bear the additional cost or whether they fully or partially exempt ethanol from excise taxes. If such a concessions exists on national level, the first axis of the Biofuels Strategy directly affects the public budgets of member states in the form of foregone tax revenues. In that case, governments bear all or part of the cost of biofuel policies, particularly higher costs due to tariffs, while consumer welfare remains unaffected. It is important to note that against the background of volatile raw material prices, balancing the differential between gasoline and ethanol prices turns out to be problematic. Indeed tax concessions are more likely to lead to over- or under-compensation than to the "right" level of support. This argument is supported by the fact that, according to Kutas et al. (2007), modifications in the tax exemption rates have been infrequent.

The relative magnitude of tax exemptions varies from one member state to the other, with different levels of support from and year to the other. An EU-wide estimate is made by Kutas et al. (2007): the authors appreciate that the reductions in or exemptions from fuel-excise tax amount to 508MEUR (2005) and 829MEUR (2006). This amount is significantly higher than the average differential between gasoline and ethanol in the respective years (compare Table 6.4). The reason for this is that tax concessions per litre of ethanol have in fact been significantly higher than suggested by the price differential, thus leading to significant over-compensation.

Figure 6.3: Tax exemption for ethanol and estimated over-compensation in 2005 & 2006



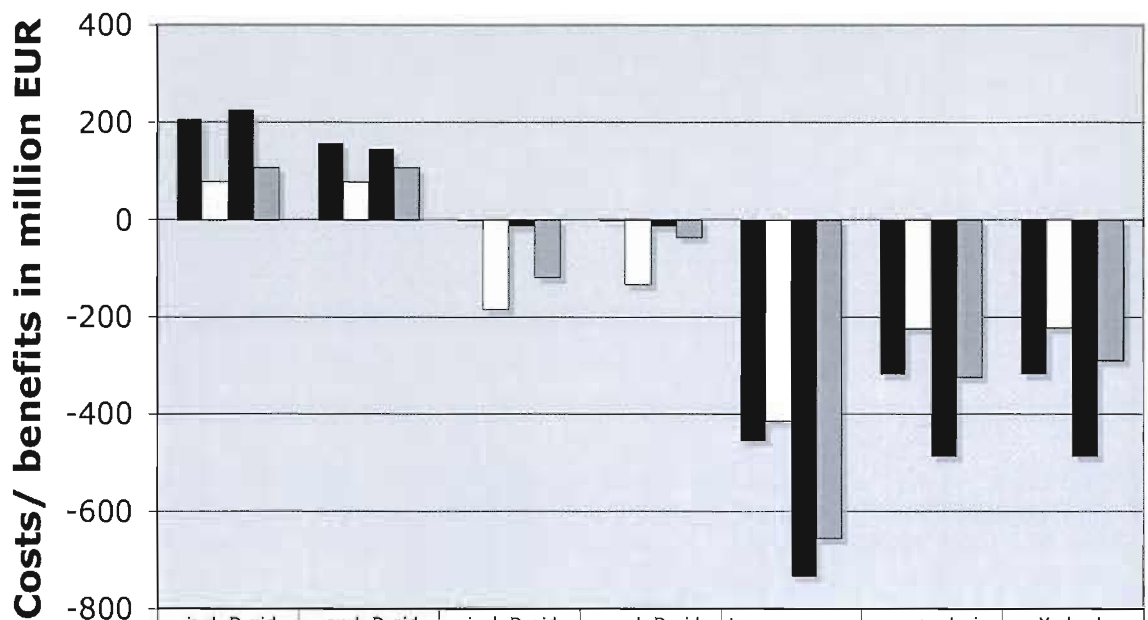
Source: own illustration based on own research and Kutas et al. (2007).

As a consequence of over-compensation, significant welfare benefits occur for producers and consumers at the expense of public budgets. How the benefits are distributed among ethanol producers and the blending sector (especially petroleum refiners), and to what extent the over-compensation is transferred to feedstock producers and consumers is too complex to be unravelled. Due to the lack of information and the magnitude of support in relation to other support instruments, welfare effects associated with tax exemptions will be discussed separately from other measures.

6.1.3. Evaluation of Current Policy Measures and Trade-Offs

The following figure summarizes the results of the previous discussion. It shows high and low welfare estimates for 2005 and 2006. Another distinction is required to account for the welfare impact of the distillation aid, which is not a policy instrument within the Biofuels Strategy. Considering this support measure widens the group of beneficiaries to winegrowers; their focus is, however, not the production of ethanol. Therefore, the estimates excluding distillation aid are more likely to reflect the actual welfare impact of the Biofuels Strategy. Tax exemptions are another item that is difficult to account for: as mentioned earlier, it is unknown to what extent producers, farmers, petroleum companies (as blenders) or consumers benefit from these exemptions. The figure below only considers the over-compensation on government side; in fact, this amount may increase producer margins or consumer benefits. The subsequent table relates support to single policy axes of the Biofuels Strategy.

Figure 6.4: Overview of estimated welfare costs and benefits of the Biofuels Strategy



	Producer		Government			Consumer	
	incl. D-aid	excl. D-aid	incl. D-aid	excl. D-aid	tax over-comp	own analysis	X-check
■ 2005 High est.	208	158	-2	-2	-454	-316	-316
□ 2005 Low est.	77	77	-183	-133	-414	-222	-220
■ 2006 High est.	227	145	-12	-12	-733	-485	-485
▒ 2006 Low est.	108	108	-118	-36	-655	-322	-288

Source: own illustration.

Table 6.5: Evaluation of the effectiveness of current policy strategies

Biofuels Strategy: Axis No.	Policy Objectives: Minimum costs for given amount of GHG-savings	Policy Objectives: Geographically diversified ethanol imports	Policy Objectives: Domestic Production	Policy Objectives: Increase & diversification of rural incomes	Avg. cost/ benefit in MEUR: Consumer 2005 2006	Avg. cost/ benefit in MEUR: Producer 2005 2006	Avg. cost/ benefit in MEUR: Govt. 2005 2006
I. Mandates & excise tax exemptions	*				- 74 - 133	Benefits unknown	- 434 - 694
V. & VI. Preference schemes & promotion of dvpg. countries	– –	+ +	+ +	+ +	- 195 - 271	+ 36 + 70	+ 35 + 33
II. Capturing environmental benefits[1)]	+ / ++	0	– / 0	– / 0	See comments.		
III. & IV. Promoting ethanol production feedstock supply	– / 0	0	+	+	/	+ 76 + 47	- 76 - 47
VII. Technology development	+	0	+	+	/	+ 10	- 10
Total effectiveness[2)] | cost	– / **0**	+ +	+	+	**- 269** **- 404**	**+ 87** **+ 127**	**- 450** **- 718**

1) The (positive) impact on environmental benefits and the (negative) impact on domestic ethanol production depend on how ambitious minimum GHG-savings are defined.
2) The overall effectiveness summarizes the combined effect of policy measures by adding up the single evaluations: "+" => 1; "–" => -1; "0" => 0, and so forth. Each policy axis is equally weighted, the result is divided by the number of policy axes affecting the objective; i.e. if a policy axis has no effect on the objective ("0"), it is excluded.

Legend - contribution to policy objective:
** Key policy measure for all objectives; ++ measure of vital importance for single policy objective; + positive contribution to policy objective; 0 neutral, i.e. neither positive nor negative contribution to policy objective; – inconsistent with, or contradictory to policy objective; – –significantly negative impact.*

Source: own illustration.

Both figures illustrate the focus of the current EU Biofuels Strategy: due to current blending mandates and tariffs consumer pay for the ethanol production as they bear higher costs for ethanol - compared to gasoline - and suffer dead-weight costs because of trade distortions. Leaving aside tax exemptions, EU member states pay - on average - less than 50MEUR to ethanol producers, as tariff revenues reduce support payments. When not considering distillation aids for winegrowers, this amount is even lower. The amounts paid to feedstock growers are below 40MEUR in each year, while ethanol producers and research institutions benefit from average capital grants that lie in a range between 16 to 18MEUR per year. Considering tax exemptions in the welfare estimates leads to significant budgetary deficits for governments. It is difficult to determine to what extent tax exemptions increase margins for producers or decrease consumer losses. In either case consumers and the governments pay for maintaining a domestic ethanol industry.

Table 6.5 also evaluates how each policy axis of the Biofuels Strategy contributes to the attainment of policy objectives. As mentioned earlier, the first axis of the EU strategy is decisive for creating the ethanol market. Tariffs and the use of preference schemes is very effective in terms of protecting the market and bringing about a desired level of supply diversification. Finally, they are the typical instrument for increasing rural income by protecting domestic farmers from low-cost producers. However, it should be noted that tariffs essentially contradict the need for competitive energy as required by respective EU strategies. The need for capturing environmental benefits - as defined under the 2nd axis of the Biofuels Strategy, addresses the need to decarbonise transport fuels. Whether this requirement has any impact on other policy objectives depends on how strictly the objective for GHG-abatement is defined. When being set at a very high level, domestic ethanol producers might find it difficult to redesign their plant or change their energy concept. This might lead to temporary bottlenecks in the processing industry and to oversupply of feedstock producers during the phase of redesign. As outlined earlier, measures to promote feedstock supply under the 4th axis of the Biofuels Strategy (NFSA and energy-crop payments) have a positive effect on feedstock supply. Investment aid for ethanol plants - granted in the context of rural development programs - is equally important to build-up a production base and to create outlets for feedstock producers. Both measures have a slightly negative impact on decreasing GHG-emissions, because if domestic ethanol was displaced by Brazilian ethanol, higher GHG-savings would be possible.

The trade-offs in terms of policy objectives and overall welfare become even more obvious when considering the efficiency of the current Biofuels Strategy. As already mentioned in the introduction of the master thesis, there is no reason to challenge market intervention by governments if markets fail to bring about a desirable solution to a problem. Therefore the additional, *private* costs mentioned above do not necessarily represent a loss in overall welfare. In other words, governmental intervention to adjust *private* benefits and costs are justified if the *social* costs and benefits are improved by the respective measures. The main criterion for welfare maximization in the short term is static efficiency, i.e. a situation where current prices are close to current marginal costs and include - as far as possible - externalities. The main criterion for welfare maximization in the long term is dynamic efficiency, i.e. a situation where consumption and investment is optimized over time. This implies that short-term efficiency has to be carefully weighted against long-term efficiency, or differently stated, the optimal level of welfare in the short-term welfare (Fritsch et al., 2007; Roeller et al., 2007). The objectives behind the EU Biofuels Strategy are supposed to maximize social welfare: each of the objectives is in the interest of the society as a whole, as the following table outlines.

Table 6.6: Policy objectives in relation to private benefits and social benefits

Policy issue	Potential social cost
GHG-savings	- Rising global temperatures with serious consequences for economies and ecosystems - globally and in the EU.
Diversification of energy supply	- Disruption of supply due to the lack of alternative energy sources, suppliers or technologies; - Negative impact on economic activity and on overall income/ GDP.
Domestic energy supply	- Disruption of supply due to the high level of import dependency and the lack of alternative, domestic technologies.
Increase & diversification of rural income	- Continuous, decreasing incomes, ageing working population; - Unemployment in rural areas, low population density and depopulation, poor access to services, social exclusion and a narrower range of employment options; - Negative impact on the countryside and the wider environment due to lower farming/forestry activity.

Source: own illustration.

The EU can address all the issues mentioned above by mandating the use of ethanol in gasoline. In a broader context, the current policy strategy for ethanol has to be at least as beneficial as similar measures in the road transport sector or in other areas of economic activity.

Considering GHG-savings, the current structure of the Biofuels Strategy leads to much lower emissions compared to the use of gasoline. As mentioned earlier, this performance can be improved by importing ethanol from countries that produce the fuel from sugarcane. GHG-benefits per cbm would in this case rise. But even in this case, there are other measures that tend to be statically more efficient, as the following table shows.

Table 6.7: Measures to promote fuel efficiency/ GHG-savings in the road transport sector

	Potential for savings of crude oil (in mtoe)	**Est. cost of GHG-savings (EUR/toe)**
Measures addressing fuel efficiency		
- Making driving costs more km-dependent	3 - 15	
- Limitation of maximum speed, acceleration or power-to-weight-ratio of new cars and trucks	11	
- Fuel efficient tyres and measures for fuel efficient tyre pressure	15	
- Fuel price increases	22	
- Maximum emission standards for new cars plus more stringent voluntary agreement for the fuel efficiency of new cars and lorries after 2008/2009	28	
Impact assessment CO2 and cars		
- Fuel efficient mobile air conditioning systems	1	36
- Low rolling resistance tyres	2	4
- Tyre pressure monitoring systems	3	- 273
- Reducing fuel consumption in light commercial vehicles	5	557
- Reducing fuel consumption in passenger cars	20	71 - 505
Estimate EU working paper		
- Biofuels (7% blending scenario - 14% blending scenario)	23 - 43	120 - 399

Source: EC, SEC(2006) 1721.

There is significant potential to reduce fuel consumption and to completely save associated GHG-emission by making vehicles more fuel efficient. These measures are relatively cheap and statically more efficient than the use of biofuels. However, they are "politically challenging", like an increase in fuel taxes, or face significant resistance from the automotive industry, like several fuel efficiency measures (EC, SEC(2006) 1721). Market intervention is justified if the objective is to save GHG-emissions beyond the potential that can be achieved by efficiency measures in the short term. Policy intervention in favour of ethanol is justified, but it should focus on the lowest cost alternative, e.g. ethanol from Brazil. To maximize overall welfare in the future, policies should create sufficient incentives to promote those fuels that achieve the highest GHG-savings at given costs.

The use of ethanol can contribute to both, GHG-savings and a more diversified fuel mix: in terms of geographical diversification and fuel type. The challenge from the perspective of supply security is to establish reliable relationships with ethanol producers other than Brazil. A 100% dependency on the country is not desirable, despite the fact that Brazilian ethanol would diversify the current imports of fossil transport fuels. As there are currently no other, non-fossil fuels available on a large scale, biofuels remain the only option for decreasing crude oil dependency and for diversifying the geographical diversification of transport fuel imports. In order to achieve a higher share of domestic transport fuel production biofuels are one of the very few options of the EU under the given technology endowment. Regarding ethanol, however, there are significant trade-offs between competitiveness, i.e. competitive GHG-abatement and domestic production. In this context the efficiency losses due to current tariffs for ethanol can be directly interpreted as the consumers premium for domestic production, supply diversification and associated security of supply. In the long term, however, technological progress in the production of ligno-cellulosic ethanol has the potential to reconcile domestic production and security of supply; in that case, tariffs would no longer be required if ethanol from ligno-cellulosic biomass is competitive with 1st generation ethanol from sugarcane.

The remaining issue policymakers seek to address with the Biofuels Strategy is the increase and diversification of rural income. For the European Union farming in Europe has broad societal benefits, which the EU sees in the diversity of the landscape as well as in the maintenance of cultural and natural heritage (EC, 2006/144/EC). If all farming activity leads to respective benefits in rural communities then policies might be justified that help farmers to benefit from a growing market for biomass-based energy. In this context EU competition principles, which are defined in the consumer interest, should be the benchmark for all policy strategies. For this reason it is important to focus on those forms of bioenergy that are competitive in the short term, thus ensuring a certain level of static efficiency. For technologies that may become viable in the long term, incentives for technological progress are required to ensure dynamic efficiency (Roeller et al, 2007). Agriculture in a broad sense covers not only farming but also forestry. Therefore the production of ethanol has to be weighted against other options of energy production, notably the in the forestry sector. Wahlund et al. (2004:

542) find that among different bioenergy processing options "the production of fuel pellets [from wood] for coal substitution gives the highest potential and lowest cost for reduction of CO_2 among the alternatives studied [...]". As this option is already commercially available, the results from Wahlund et al. (2004) suggest that it would be compatible with the static efficiency criterion. Furthermore the authors conclude that "biomass-based motor fuels certainly give CO_2 reduction too, but considerably lower than fuel pellets for coal substitution, and besides at a higher cost. The motor fuel alternatives reduce only about half of the amount of CO_2 compared to the fuel pellets options [...]". Indeed many authors mention that there are cheaper ways to produce domestic bioenergy or renewable energy in general (Henke/ Klepper, 2006;). In an extensive study on the prospects of bioenergy in Germany, Isermeyer (2008) finds that fuel pellets from wood for heat and power are associated with much lower costs for GHG-abatement (from -10EUR/t$CO_{2\text{-eq}}$ to 75EUR/$CO_{2\text{-eq}}$, depending on the conversion method). In addition, the potential GHG-savings per hectare are five to nine times higher than those for ethanol, which shows significantly lower energy yields per ha (based on wheat). If the objective is to make farmers become suppliers of sustainable energy, then Isermeyer (2008) concludes that other bioenergy options are more beneficial from the perspective of social welfare.

It is obvious that current EU ethanol production is not an ideal solution when considering the criterion of static efficiency. In the long term, technological development may increase the competitiveness of domestic ethanol production. Support in the EU could indeed be justified if the industry was new and ethanol production was based on advanced technology (Kutas et al., 2007; Midtun/ Gautesen, 2006). Regarding ethanol as an advanced technology, the European bioethanol association, eBio, argues in this way. The interest group regularly points at significant government support for the nascent ethanol sectors in Brazil and the US in the seventies and eighties (eBio, 2005). However, as described earlier, in the light of comparative, i.e. sustained economic disadvantages, it is impossible for the Europe's conventional ethanol producers to achieve similar cost levels as their Brazilian competitors; therefore, policy measures that seek to improve the competitiveness of domestic ethanol production will fail. Tariffs to prevent large-scale imports of ethanol (from sugarcane) are therefore vital for the industry, regardless of the time horizon. Without any trade barriers, support directed towards the agricultural sector and ethanol production (3rd axis of the Biofuels Strategy), and R&D in first-generation fuels (7th axis of the Biofuels Strategy) does not make sense. Thanks to the tariff, economic value creation occurs in the farm sector and in industries related to ethanol production (compare Neuwahl et al., 2008). Nevertheless it is important to bear in mind that value creation in the agricultural sector is limited to new land brought into cultivation.

In summary, efficiency losses due to trade distortions and relatively low environmental benefits represent overall welfare losses, which "pay" for security of supply, i.e. domestic ethanol production and diversified imports, as well as for economic development and more diversified income in rural areas. Consequently the EU currently trades off competitiveness and higher GHG-abatement for security of supply and benefits in the agricultural sector in the short term. With the rise of more advanced technologies the trade offs shift: in that case the production of competitive, domestic and more environmentally friendly fuels from cellulosic biomass will be at the expense of value creation in the farm sector.

An important premise of this research is that all policy objectives have the same importance for the EU. If the EU can expect domestic ethanol production in the long term, then it might be more beneficial from the perspective of social welfare to adjust current policy strategies accordingly. The welfare benefits would in that case include lower costs for ethanol, higher GHG-benefits as well as increased supply security, due to the lower dependency on crude oil from countries in the Near East. The additional benefits of the current Biofuels Strategy include measures to foster domestic production, while tariffs are a significant measure to achieve geographical diversification of ethanol imports. When assuming that geographical diversification of imports can also be achieved by eliminating trade distortions (compare Kojima et al., 2007), and that domestic production is less of an issue in the future, only the objective of income creation in rural economies would remain unaddressed. If all policy objectives have the same importance, then this trade-off would have to be accepted as it optimizes social welfare. The implications of the current EU Biofuels Strategy, however, suggest that the primary interest of the EU is to an create additional outlet for farmers, especially for growers of cereals, sugar beet (for ethanol) and oilseeds (for biodiesel) so that this group can achieve higher incomes as demand for crops and land-use competition increases. The implied objectives of the Biofuels Strategy are therefore focused on rural development, while other policy objectives have a lower significance.

6.1.4. Sustainability Concerns for Justifying Trade Distortions

Finally it can be argued from an EU perspective that tariffs are justified on the grounds of ecological sustainability. To avoid externalities associated with the clearance of rainforests and natural habitats for feedstock production, tariffs can be a useful instrument for slowing market growth and keeping demand - from the EU - at a "sustainable" level. In the absence of trade barriers, the EU believes that developing countries exploit the potential to produce biomass at low cost regardless of associated environmental and ecological damage. As free trade and sustainability are deemed incompatible, liberalization is undesirable due to these side effects. (EC, COM (2005) 628). Ethanol produced within the EU is - per se - regarded as sustainable due to the cross-compliance rules within the CAP. Hence it can be concluded that a future scheme for certifying sustainable ethanol production is regarded as a way to limit trade. The following statement from eBio, the organizations that advocates the interests of the EU ethanol industry, underlines the assumption:

> "[Regarding the certification scheme] the industry is supportive but should not become the victim; the better should not become the enemy of the good."
> eBio (2008: 7).

A broader perspective on sustainable ethanol production, however, reveals the weakness of this argument: current trade barriers that led to an increase in ethanol production based on cereals have contributed significantly to the rise in food prices like wheat or corn. In the absence of trade barriers the rise in cereal prices would have been less pronounced (FAO, 2008b). Furthermore, the fact that areas in developing countries have been cleared for the production of ethanol feedstock is an obvious sign that current trade distortions have not been "helpful" in protecting these highly valuable resources.

6.1.5. Conclusion: Current Policy Trade-Offs in the EU Biofuels Strategy

So what are the major trade-offs of the current Biofuels Strategy? And, against the background of sustainable free trade, what policy objectives are at risk on the short term and on the long term?

Currently the EU trades-off competitiveness of supply and lower GHG-emissions against domestic supply and higher income in rural areas. The situation can be considered as balanced if the EU attributes a higher weighting for the latter policy areas than for the former ones. Only under this setting can the situation be considered as welfare optimizing in the short-term. The study by Rubin et al. (2008) leads to similar results for the US: policies in the US are designed to increase domestic production and higher crop prices. Hence, ethanol policies in both regions are designed in the interest of the domestic farm sector rather than in the interest of social welfare.

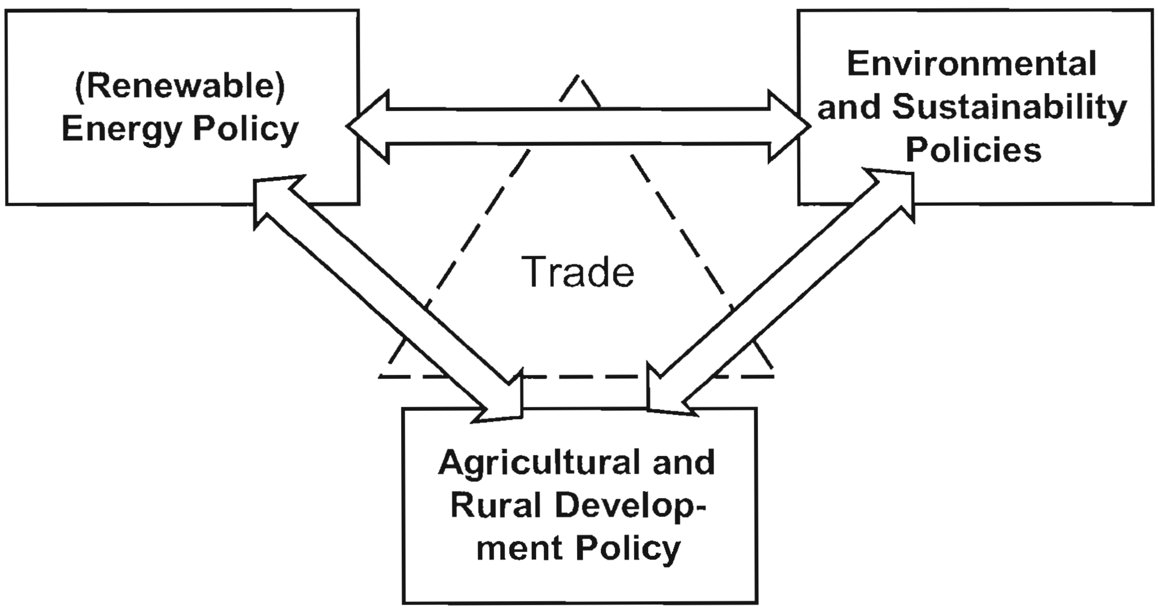
In the long term technological progress may finally improve the competitiveness of domestic supply in relation to imports. In this way domestic supply, competitiveness and GHG-abatement can be united. Under the current policy setting these issues would be traded against rural development benefits. To consider the policy objectives as balanced, policymakers would attribute an even higher importance to rural income creation in the long term than in the short term.

Against this background it is obvious that 1st generation ethanol production would have no future in liberalized markets. This policy objective is definitely at risk in the short and long term as soon as markets are liberalized. In the short-term, however, further policy objectives are at risk. In terms of geographical diversification of supply, an overdependence on ethanol from Brazil is literally certain as preferential tariffs cannot help to diversify the origin of ethanol imports. Furthermore domestic energy supply is not granted because it takes time to ramp up capacities for 2nd generation ethanol in the EU. However, more competitive GHG-abatement by the use of ethanol can be assumed as Brazilian ethanol has much higher GHG-savings at lower costs than ethanol from the EU; nonetheless sustainability concerns remain.

In the long term prospects are good to achieve a reasonable balance of policy objectives. But significant efforts will be required to promote sustainable ethanol production in third countries in order to diversify the geographical supply, to ramp up production capacities for 2nd generation ethanol to ensure sufficient domestic supply, and to seize the opportunities from the supply of cellulosic feedstocks in rural areas.

Figure 6.5: The trade-offs between different policy objectives

Policy objective	Efficiency (static)	Efficiency (dynamic)
Minimum GHG-abatement costs	YES	YES
Diversification of supply	NO	(YES)
Domestic energy supply	NO	(YES)
Diversifying & increasing rural income	NO	1st gen. NO; 2nd gen. (YES)



Source: own illustration.

6.2. The Image of Sustainable Free Trade: Opportunities and Limits

6.2.1. A Primer on Standards, Certificates, and Labels

The most important question is to what extent the notion of sustainability complies with, or contradicts international trade rules. The World Trade Organization (WTO) is the only global organization dealing with trade rules between countries, while embracing the free trade idea.[78] Although the topic is too large to be covered in detail within this thesis, some general WTO rules that are important for ethanol should be analyzed to distinguish between those sustainability criteria that can be included in a WTO-compliant certification scheme, and those that have to be addressed by adequate international or EU policies. There is a broad consensus that only WTO-compliant rules should be included in an international scheme for sustainable biofuels; for the image of sustainable free trade this requirement is imperative. Several international organizations and interest groups are currently preparing proposals for such a certification scheme, which ensures sustainable production and, thus, facilitates sustainable bioenergy trade. As described in Chapter 2, the most urgent issues refer to more sustainable production of feedstocks. The main concerns are related to land-use change affecting areas with high levels of biodiversity and certain social criteria, e.g. no forced labour or no child labour.

Before describing the respective WTO framework, it is important to define the relationship between standards, certificates, and labels (compare Dankers, 2003; Henke, 2007b):

- *Standards* are referred to as

  "...documented agreements containing technical specifications or other precise criteria to be used consistently as rules, guidelines or definitions, to ensure that materials, products, processes and services are fit for their purpose."

  ISO (1996), cited by Dankers (2003).

  Product Standards can be distinguished from *Process Standards*. The former define the characteristics of a product; the latter define criteria for the production process, i.e. how products are made. Based on the discussion in Chapter 2

[78] "At its heart are the WTO agreements, negotiated and signed by the bulk of the world's trading nations and ratified in their parliaments. Its main function is to ensure that trade flows as smoothly, predictably and freely as possible. WTO, established in 1995 and currently with more than 130 members, is the successor of the General Agreement on Tariffs and Trade (GATT). The GATT Agreement of 1994 is now the principal WTO Agreement for trade in goods. The system encourages countries to settle their differences through consultation. Failing that, they can follow a stage-by-stage procedure that includes the possibility of a ruling by a panel of experts, and the chance to appeal against the ruling." (Dankers, 2003: 73)

it is clear that issues of social and ecological sustainability are in essence related to process standards. *Process Standards* can further be distinguished into *Management Standards* and *Performance Standards. Management Standards* set criteria for processes related to management and administrative activities, whereas *Performance Standards* include verifiable criteria for the production process, i.e. "what actually happens in the field", like "non use of certain pesticides, or the availability of sanitary services." (Dankers, 2003: 7).

- By issuing a *Certificate*, i.e. by *Certification*, a third-party confirms that a product or process complies with the respective standards. Thanks to the *Certificate* the buyer knows that the manufacturer has fulfilled the certified *Product* or *Process Standards*. An independent *Certification Body* assures the compliance with the standards to be certified. This *Certification Body* has no interest in the (economic) relationship between buyer and seller. What adds to the credibility of a *Certification Body* is the fact that it is *accredited* by a standard-setting body, like the International Organization for Standardization (ISO) or by another governmental or parastatal organization.
- A certification *Label* indicates the compliance with certain standards. Both, the standard-setting body and the *Certification Body* may *label* products or processes as compliant with predefined standards. *Certification Bodies* may also certify against their own, possibly more stringent standards to create their own *Label* and to account for criteria that exceed the standards of "usual" *Labels* issued by standard-setting bodies.

Dankers (2003) describes the definition of agricultural standards as a particular challenge: first, because agricultural standards have to account for differences in climate, soils, and ecosystems and, second, because farming is often an integral part of cultural diversity. For this reason it is not astonishing that international environmental and social standards are often normative, accounting for local peculiarities rather than for issues that are important on the international level.

For certifying biofuels it is important that the criteria and the complexity of the certification process do not turn out as a trade barrier. Developing countries should play an active role in elaborating sustainability criteria, as it is currently the case for many international platforms that discuss sustainability standards. Criteria and related certification schemes must be easy to apply, should not be too time consuming and should avoid unnecessary administration or financial burden. Furthermore, in developing countries, certification and labelling requirements should be coupled to financial and technical assistance to ensure that a local certification body can be in charge of certifying sustainability criteria (UNCTAD, 2006).

6.2.2. Sustainable Free Trade and WTO Rules

6.2.2.1. WTO Rules Concerning Standards: Art. III of GATT 1994

In order to ensure the sustainable production of feedstocks and ethanol, certain criteria in relation to the production process have to be made mandatory. In this context a certification scheme that defines more restrictive standards for imported than for domestic products is definitely not in compliance with WTO rules. Hence the EU sustainability principles in agriculture, the Cross Compliance Rules, must include the same criteria as demanded from foreign producers. The crucial question here is whether it is allowed to make the certification mandatory for all imports, thus establishing a potential trade barrier. (UNCTAD, 2006; Bruehwiler/ Hauser, 2008).

The respective provision is Art. III:4 GATT (cited by Bruehwiler/ Hauser, 2008) does not allow any treatment by law, regulation and requirement that is *less favourable* than the treatment accorded to *like products* of national origin. The emphasis hints at the two crucial criteria that the WTO defines: the products have to be "like", and the treatment of the imported product shall not be "less favourable". For analyzing whether imported ethanol (and related feedstock) is *like* domestic ethanol (and related feedstock), one has to consider

a) the properties, nature and quality of the product;
b) the end-use of the products;
c) consumer's tastes and habits; and
d) their tariff classification within the Harmonized System (HS) code

(Bruehwiler/ Hauser, 2008).

Regarding the product itself, the end-use and the tariff classification there is no difference between imported and domestic ethanol. Differently stated, criteria (a), (b) and (d) do not make a distinction between certified and non-certified ethanol, i.e. between a fuel that is produced according to sustainability principles and one that is not. When it comes to consumer tastes and preferences (c), however, things are less clear, because consumers cannot distinguish - from a physical perspective - between sustainable and non-sustainable fuels since both products fulfil the same purpose. If consumers know that the production of labelled ethanol has not led to environmental damage, they are in a position to distinguish between "environmental friendly" and *potentially* unsustainable ethanol. In this case certified ethanol and uncertified ethanol would no longer be "*like*" products (Bruehwiler/ Hauser, 2006; UNCTAD, 2008). Consequently, certification *can* make a difference. The question whether products are *like* or not has been the subject of a large number of cases in the GATT/ WTO dispute resolution system, which have *inter alia* led to the criteria (a) to (d) mentioned above. Moreover the certificate itself, which informs the consumer about "sustainable" production, has to be based on non-discriminatory criteria. Howse et al. (2006: 27) give a very good outline of the preceding discussion:

> "The question here may be to what extent are there objective norms, criteria and methods for evaluating the relationship of a particular product to sustainability [...]? The more remote the distinguishing conditions in the [certification] scheme are from features (albeit non-physical) that consumers can associate, if properly informed, with a particular product, the more probable the WTO adjudicator will find that the products themselves are "like".

Hence, objective norms, criteria and methods that apply to both, domestic and imported products, are indispensable for establishing the criteria of certification schemes. Only criteria based on international standards, e.g. defined by the ISO, can make sustainable ethanol *unlike* from unsustainable ethanol.

It is noteworthy that even if objective criteria exist, there is still the possibility of discrimination. It is possible to think of a situation where one country requires a (non-obligatory) step in the production process, as defined by international standards, that another cannot fulfil due to national circumstances, e.g. a lack resources or knowledge. In this case the country with high production standards would discriminate goods from the other country. According to the *like* criterion, this would be a protection of the domestic industry, which is in compliance with WTO disciplines. Nonetheless, the country would treat foreign producers *less favourable* than domestic producers (UNCTAD, 2008). The respective certification criterion may therefore be challenged at the WTO. However, if the country that requires the standard has previously initiated negotiations among different states, has considered the variety of conditions in other countries, and has included internationally recognized standards, the "discriminating" rule may turn out to be non-discriminatory. The fact that sustainability schemes are currently developed by many countries and stakeholders ensure that no country is treated *less favourably*. In this sense, it is even possible for a single country to allow more stringent sustainability criteria as long as these are based on international standards (Howse et al., 2006).

6.2.2.2. WTO Rules Concerning Standards: Art. XX of GATT 1994

Beyond GATT Art. III:4, a country may argue that unequal treatment of foreign and domestic products is justified because it sees important non-trade policy objectives at risk if the good is being traded. In this sense unequal treatment, e.g. the distinction between unsustainable and sustainable ethanol, is justified in the area of policy objectives in other, more important policy fields, which have no direct relation to trade. The consequence is that the unequal treatment cannot be challenged within the WTO dispute resolution process. Paragraphs (b) and (g) of GATT Art. XX (General Exemptions from GATT) are relevant for biofuels. Paragraph (b) concerns the protection of human, animal, or plant life and health. It is of crucial importance that the respective, trade-distorting provision

a) is part of the policies designed to protect human, animal and plant life or health, and
b) is not a provision in the context of another policy area.

(Howse et al., 2006; UNCTAD, 2008)

Furthermore it is important that the discriminatory clause is *necessary* for achieving the policy objective. Measures that distort trade, but only make marginal or insignificant contribution to the achievement of the policy objective are not regarded as "necessary", according to Art. XX (d). In this context a "necessary" measure is interpreted as a measure that is the "least-trade-restrictive" to achieve the policy objective (UNCTAD, 2008). Finally, Howse et al. (2006: 28) note that if the measures that help to achieve the policy objective are necessary, then they "must be taken in tandem with comparable measures on production or consumption that apply to the domestic market".

Paragraph (g) permits GATT-inconsistent policies if they aim at the conservation of exhaustible natural resources. Again, in order to apply paragraph (g) several conditions have to be fulfilled (UNCTAD, 2008):

a) The trade-distorting measure must fall within the range of policies related to the conservation of exhaustible natural resources, and
b) The trade-distorting measure itself is actually related to the conservation of these resources;
c) The measures restrict not only imports, but have a similar impact on domestic consumption or production.

In the context of biofuel certification, it is possible to draw some important conclusions. Due to the potential impact climate change might have on human, animal and plant life or health, national policy objectives addressing these issues are considered more important under trade law than a possible discrimination of imports. Certification of ethanol aimed at the protection of human, animal and plant life is therefore *necessary* to achieve the policy objectives. Compared to other possible measures, e.g. import bans, certification can also be considered to be "least trade restrictive", because other countries can still implement rules to comply with the certification scheme (UNCTAD, 2008). If imports of ethanol are made conditional on a certificate requiring minimum GHG-savings, one can argue that clean air is a natural resource that needs to be protected. Thus, discriminating potentially unsustainable ethanol can be justified under GATT article XX (Howse et al, 2006). In order not to endanger animal and plant life or health, certification schemes may also include rules concerning:

- the preservation of carbon sinks, i.e. all kinds of forests;
- the protection of biodiversity (high conservation forests, wildlife habits, etc.)
- the protection of local environment (soil and water protection, limited use of agro-chemicals, etc.);

Hence, policies aimed at counteracting climate change are very likely to be compliant with WTO rules. However, a definite answer to this question can only be determined on a case-by-case basis, and international standards and recognized methodologies are required to provide a clear idea of the potential depletion (Vis et al., 2008).

6.2.2.3. Implications for the Image of Sustainable Free Trade

Before summarizing the main results of the preceding subchapters, it is important to note that there are no other relevant WTO rules affecting certification schemes for biofuels. Although all the authors cited above analyze possible implications of the WTO agreement on Technical Barriers to Trade (TBT Agreement), they all see no relevance of this agreement for certification schemes. Bruehwiler and Hauser (2008: 29) point out that:

> "Although the TBT Agreement has far-reaching implications for technical regulations and standards, its importance or biofuel policies is limited. [...] And most importantly, the contentious sustainability standards as discussed above do not fall under the ambit of the TBT Agreement."

The relevant paragraphs of the GATT are Art. III:4 and Art. XX. According to Art. III:4 domestic and imported ethanol should be treated equally. In this context the crucial question is whether both products are *like*: if uncertified and potentially unsustainable ethanol is considered *like* certified domestic ethanol, it will be difficult to enforce sustainability rules in international trade. However, in the literature there is a broad consensus that certification can make a difference and that uncertified ethanol is *unlike* certified ethanol. In this sense discrimination by the ethanol importing country is allowed by international trade rules if measurable, objective criteria, based on international standards lead to the conclusion that both products are *unlike*. When defining certification criteria, the involvement of various stakeholders and countries is not only crucial to ensure a balanced outcome in the interest of sustainable development; at the same time a broad consensus on sustainability criteria may preclude single countries that from complaining at the WTO.

Alternatively, if non-trade policy objectives are at risk, Art. XX says that WTO rules do not apply and, thus, countries are free to ban the imported good if it has negative consequences on human, animal, or plant life and health. This is an important point in the context of the sustainability debate because the reduction of greenhouse-gases is definitely a non-trade policy, and unsustainably produced ethanol has the potential to undermine the related policy objective. Furthermore, issues of biodiversity and the protection of the local environment are likely to be seen as necessary to achieve objectives in environmental policy. Nonetheless WTO courts would have to decide on a case by case basis whether specific certification schemes are in compliance with trade law.

For the image of sustainable free trade in ethanol, the previous discussion has clearly pointed out that liberal markets for sustainably produced ethanol are actually possible. This can be considered as a major opportunity for sustainable development in the future. Although the negative undertone has suggested that sustainability criteria are useful as a market entry barrier, the fact that they reduce marketing opportunities for unsustainable ethanol and, thus, promote the production of sustainable ethanol, is encouraging. Moreover, Howse et al. (2006: 27) note that it is possible for individual countries to impose sustainability criteria in addition to core criteria, as long as "they are based upon established methodologies (such as life-cycle product analysis) and on concerns that are supported by international norms as those on sustainable development reflected in various international legal and policy instruments" (e.g. the Kyoto Protocol). This practice has already been implemented in other areas of agriculture, e.g. organic farming, fair trade products etc. (Dankers, 2003).

However, Dankers (2003) notes that attention must be given to keep costs and administrative burdens associated with certification low, as otherwise high costs outweigh the incentives of free markets. The major downside of current WTO rules is the fact that it is difficult to account for those sustainability criteria that are not quantifiable or hardly verifiable.

The following chapter looks at an example from the literature (Lewandowski/ Faaij, 2006) to analyze more concretely the opportunities and limits of sustainability certification schemes.

6.2.3. Including Sustainability Criteria in Certification Schemes for Ethanol

6.2.3.1. Relevant Sustainability Criteria

The list is based on an article by Lewandowski and Faaij (2006). According to the different dimensions of sustainability, it distinguishes economic, ecologic and social criteria. Because not all sustainability criteria can be expected to be in line with WTO-rules, it will be evaluated to which extent objective norms, criteria and methods can help to justify the general issue. The evaluation is based on WTO-cases presented in the literature (e.g. by Howse et al., 2006; Bruehwiler/ Hauser, 2008; UNCTAD, 2008) and on analysis by Vis et al. (2008) and Schmitz (2008). Three symbols will be used for the assessment:

- "+" denotes that there is a low risk that, within a certification scheme, this criterion will be declined by the WTO; this is due to the fact that objective and established methodologies or standards exist on an international level;
- "+ / -" denotes a moderate risk that, within a certification scheme, this criterion will be declined by the WTO; standards and methodologies exist, but may be considered discriminatory, depending on the concrete requirements;
- "-" means that the Criterion is *per se* incompliant with WTO-rules as it is based on very normative or hardly measurable or arbitrary criteria.

As several sustainability criteria are subject to a further investigation by the WTO the next tables present a pessimistic and an optimistic view on their inclusion in certification schemes.

Table 6.8: Possible Criteria for Social Sustainability

Area of concern	Sustainability Criteria: SOCIAL	TYPE OF CERTIFICATE	
		Pessimistic	**Optimistic**
Labor conditions	- Freedom of Association and collective bargaining - Prohibition of forced labor - Prohibition of discrimination and equal pay for equal work - Least minimum wages - No illegal overtime - Equal pay for equal work - Regulations are in place to protect the rights of pregnant women and breastfeeding mothers	-	+
Protection of human health and safety	- Protection and promotion of human health - Farmers, workers, etc. are not unnecessarily exposed to hazardous substances or risk of injury - A safe and healthy work environment, with aspects such as machine and body protection, sufficient lighting, adequate indoor temperature and fire drills - Availability of document routines and instructions on how to prevent and handle possible near-accidents and accidents - Training of all co-workers is performed and documented; training ensures that all co-workers are able to perform their tasks according to the requirements formulated on health protection and environmental benign management or resources	-	+
Rights of children, women, indigenous people and discrimination	- Elimination of child labor: a minimum age and a prohibition of the worst form of child labor - Children have access to schools, work does not jeopardize schooling	+ / -	+
	- Indigenous people's and tribe's rights have to be respected - Recognizing and strengthening the role of indigenous people and their communities - Women should not be discriminated and their rights have to be respected - Spouses have the right to search work outside the entity where the husband works	-	+ / -
Access to resources ensuring adequate quality of life	- Farmers are content with their social situation - Access to potable water, sanitary facilities, adequate housing, education and training, transportation, and health services - Promoting of education, public awareness and training - Market access for small farmers and producer	-	+ / -

	- Equitable access to forest/farm certification among all forms of forest/farm users and tenure holders - Establishment of a communication systems that facilitates the exchange of information		
Food and energy supply safety	- Enough food of sufficient quality is available - Biomass production should not lead to severe competition with food production and the shortage of local food supply - Energy supply in the region of biomass production should not suffer from biomass trading activities	-	-
Capacity building	- Local organizations, institutions or companies should be involved in the process, e.g. control and certification - Marginalized social groups should play and equitable role in certification processes - Jobs should be generated - Trade-related skills development and social justice oriented capacity building are facilitated through learning exchanges between trading partners - Building and use of local labour and skills	-	+ / -
	- The activity should contribute to poverty combatement	-	-
	- Stakeholder involvement in the decisions that concern them	-	+ / -
Land ownership	- Avoidance of land tenure conflicts - Land ownership should be equitable - Tenure and use rights shall be clearly defined, documented and legally established - Projects should not exclude poor people from the land in order to avoid leakage effects	-	+ / -
Community (institutional) well-being	- Farms must be 'good neighbors' to nearby communities and a part of the economic and social development - A basis is created for strengthening the mutual confidence between business and the society in which they are active	-	-
	- Involvement of communities into management planning, monitoring and implementation	-	+ / -
Fair trade conditions	- Transparency and accountability of negotiations - Direct and long-term trading relationships - Fair and equal remuneration—all supply chain partners are able to cover costs and receive fair remuneration for their efforts through prices that reflect the true value of the product. Risk sharing mechanisms are actively encouraged - Communication and information flow—supply chain partners communicate openly with each other showing a willingness to share information	-	+ / -
Acceptance	- Acceptance of the production methods by producer and consumer - The activities do not lead to disadvantages for the local population like losses of jobs or food shortage - The activity carries advantages for the local population	-	+ / -

Source: Lewandowski/ Faaij (2006: 92 - 94; based on a literature review).

Table 6.9: Possible Criteria for Ecological Sustainability

Area of concern	Sustainability Criteria: ECOLOGICAL	TYPE OF CERTIFICATE Mandatory	Voluntary
Protection of the atmosphere	- Reduction and minimization of greenhouse gas emissions - Efficient use of energy - Use of renewable resources - Low nitrogen emissions to the air - No use of persistent organic pollutants (POPs) and substances that deplete the ozone layer	+	+
Preservation of existing sensitive ecosystems	- Avoidance of pollution of natural ecosystems neighboring the fields - Prevention of nutrient leaching - Plantations should not replace forests - Maintenance of high conservation value forests	+	+
Conservation of biodiversity	- No use of GMOs - Careful/no use of exotic species, their monitoring and control - Prevention of spreading of diseases - Environmentally sound management of biotechnology - Consideration of the needs of nature and species protection - The development and adoption of environmentally friendly non-chemical methods of pest management should be promoted and it should be strived to avoid the use of chemical pesticides - Preservation of habitats	+ / -	+
Conservation and improvement of soil fertility — avoidance of soil erosion	- No impoverishment of the soil; nutrient balances should remain in equilibrium - Optimized utilization of the soil's organic nitrogen pool - Measures to prevent soil erosion are applied and described in a management plan - No accumulation of heavy metals in soil - No irreversible soil compaction; measures to prevent soil compaction are taken and described in a management plan - No pesticide residues in the soil	+ / -	+
Conservation of ground and surface water	- No depletion of ground and surface water resources - Protection of the quality and supply of freshwater resources - Avoidance of pollution of ground and surface water - No eutrophication of surface water by phosphorus emissions	+ / -	+

	- No pesticide residues in the water		
Combating deforestation desertification and drought	- Plantations should not replace forests - Sustainable harvest rates - harvest at the rate the forest regrows - Limitations for the size of the harvested areas	+ / -	+
	- No logging activities in protected forests	+	+
	- Measure to combate desertification and drought are taken and described in a management plan	+ / -	+
Landscape view	- Increase and improvement of the variation of the landscape - Conservation of typical landscape elements	-	-
Conservation of non-renewable resources	- Efficiency in the use of natural resources, including energy - Positive energy balance - Minimization of the use of raw material, resources and land - Focus on increased efficiency by increasing filling rates, decreasing fuel consumption and by using transport modes that release less greenhouse gases - Minimization of phosphorus extraction from non-renewable deposits	+ / -	+ / -
Waste management	- Minimization of wastes - Sorting of wastes - Proper handling and disposal of waste - Recycling of waste where possible - Recycling of ashes from biomass combustion - Environmental training of employees, to facilitate waste sorting and initiate energy saving - Environmental checklist on waste management, training of employees, etc	-	+ / -
Environmental additionality	- Projects have to be environmental additional by improving the environmental situation against a baseline status quo scenario	+	+

Source: Lewandowski/ Faaij (2006: 92 - 94; based on a literature review).

Table 6.10: Possible criteria for economic sustainability

Area of concern	Sustainability Criteria: ECONOMIC	TYPE OF CERTIFICATE Mandatory	Voluntary
Viability of the business	- The business has to be economically viable - Minimization of costs to ensure competitiveness - There is sustained and adequate funding for running the operation, i.e. the liquidity of cash flow to support - infrastructure development, acquisition of machines and to meet day-to-day running of the operation	-	+/-
	- Long-term commitments, contracts and management plans	-	+/-
Strength and diversification of local economy	- The activity should contribute to strengthening and diversifying the local economy - Local labor and skills should be usable - Professional and dedicated human resources are enhanced	-	+/-
Reliability of resources	- Minimization of supply disruptions - Supply security for the biomass consumer - No over-dependencies on a limited set of suppliers should be created	-	+/-
Yields	- Sustainable rate of harvesting—Forests should only be harvested at the rate that they regrow - Agricultural yields should be maintained on an economically viable and stable level	+/-	+/-
	- A management plan that describes the operational details of production is in place - A comprehensive development and research program for new technologies and production processes is in place	-	+/-
	- The activity should not block other desirable developments	-	-

Source: Lewandowski/ Faaij (2006: 92 - 94; based on a literature review).

Table 6.11: Possible criteria concerning sustainability in general

Area of concern	Sustainability Criteria: GENERAL	TYPE OF CERTIFICATE Mandatory	Voluntary
Compliance with laws and international agreements	- Activities have to comply with national laws and international agreements - All applicable and legally prescribed fees, royalties, taxes and other charges shall be paid - In signatory countries, the provisions of all binding agreements such as CITES, ILO Conventions, .. (others) shall be respected	+	+
Traceability	- Biomass has to be traceable - Biomass from non-certified resources cannot enter the trade chain - A chain-of-custody control system is in place	+	+
Avoidance of leakage effects	- (Negative) leakage effects should be avoided - People should not involuntarily be driven from their land - The biotrade activity provides local people with income opportunities that are at least equivalent in quality and quantity to the baseline situation (i.e. situation without biomass trade activity) - The role of non-governmental organizations should be strengthened	-	+ / -
Improvement of conditions at local level	- Generation of jobs - Generation of education opportunities - Capacity building - Support of infrastructure development - Enhancement of democratic development - Increase of (farmers) income - Improvement of environmental management at local level	-	+ / -

Source: Lewandowski/ Faaij (2006: 92 - 94; based on a literature review).

The following table summarizes to what extent sustainability criteria can be included in certification schemes under the optimistic and the pessimistic scenario.

Table 6.12: Summary of sustainability criteria that may be included in certification schemes

	Pessimistic view			Optimistic view			Total areas of concern
	+	+/-	-	+	+/-	-	
Social sustainability	0	1	13	3	7	4	14
Economic sustainability	0	1	6	0	6	1	7
Ecological sustainability	4	6	2	9	2	1	12
General sustainability	2	0	2	2	2	0	4
Total	6	8	23	14	17	6	37
in %	16%	22%	62%	38%	46%	16%	100%

Source: own illustration based on Lewandowski/ Faaij (2006).

Several ecological criteria can be expected to comply with WTO-rules when these are interpreted in a very strict sense ("pessimistic view"), while social and economic issues are unlikely to be enforceable. The ecological criteria refer to the protection of the atmosphere and the preservation of sensitive ecosystems (incl. no logging in protected forests) as well as to the criterion of "environmental additionality". If these criteria are not included in sustainability schemes for ethanol, EU policy objectives and international sustainability rules may be undermined (GATT article XX); for each of these criteria it is also possible to use the life-cycle idea as a basis for reasoning (GATT article III:4). Furthermore six issues related to ecological sustainability may be included once objective measures are defined or appropriate standards are formulated in WTO-compatible manner ("optimistic view"). Issues concerning waste management and landscape view can be considered non-compliant with WTO-rules, with landscape view being the most normative aspect of ecological sustainability.

Regarding social sustainability, only one area of concern may be included in sustainability certification scheme, namely child labour or forced labour ("pessimistic view"). These issues may not be challenged as they deal with essential human rights (UNCTAD, 2008). All other criteria are either normative, i.e. their definition depends on the local context, or are impossible to measure. The same is true for issues dealing with economic sustainability. The ideas behind the sustainability issues may all be justified and desirable from a sustainability point of view, e.g. viability of the business, long-term supply contracts, or rural development, but it is impossible to *enforce* them in a certification framework. Hence they cannot be included in a *mandatory* certification framework.

In general the pessimistic view is based on a very strict interpretation of WTO-rules. If countries envisage making sustainability certificates mandatory for ethanol imports, then it is advisable to concentrate on these core criteria. Including further criteria in mandatory certification schemes bears a certain "WTO-risk": the scheme may be challenged at the WTO, thus requiring adjustments. The number of stakeholders involved in current negotiations on sustainability criteria for ethanol suggests that numerous certification schemes will exist in the future. Non-governmental organizations that aim at improving social, economic and ecological conditions in third countries will include respective criteria in certification schemes. As long as these criteria are not made mandatory on national level, which would be prohibited by WTO-rules, these voluntary certification schemes represent a good instrument to embrace sustainable development even more. Additional certification costs may be the major obstacle for these schemes. Therefore policies in importing countries would have to address the fact that some fuels contribute more to sustainable development in third countries than others (Vis et al., 2008; UNCTAD, 2008). Chapter 6.4.2 analyzes in more detail how the EU can take these considerations into account.

Meanwhile it is worth to look at those areas of concern that can neither be addressed by voluntary nor by mandatory sustainability certificates. Even when taking an optimistic perspective on WTO-jurisprudence, six areas of concern cannot be addressed. They include:

- Rights of indigenous people;
- Food and energy supply safety;
- Reduction of poverty (in rural areas of developing countries);
- Community and institutional well-being;
- Improvement of landscape view;

Furthermore, it is demanded that ethanol production should not block other desirable developments. In the light of the public debate about sustainable biofuels, "food versus fuel" issues and the reduction of poverty in respective countries require special analysis, in particular if the market for ethanol (and biodiesel) shall be liberalized. The other issues are too general or too unrelated to EU policy objectives and the desirable future image so that they are not part of further discussions.

6.2.4. Ethanol Production in Liberalized Markets and Sustainability Issues

6.2.4.1. The Framework for Analysis

The goal of this chapter is to analyze the implications of free trade on prices for food and feedstock, on the area potentially available for both purposes, and on issues related to rural development, which is a broader view on the subject of "poverty in rural areas of developing countries" mentioned above.

Common micro-economic theory suggests that supply and demand are balanced at all times because there is *inter alia* no time-lag in the adjustment process (Fritsch et al., 2007). In practice, however, farmers were not able to cope with additional demand from both, fuel and food markets in the last years. This led to higher prices particularly for cereals, and had a detrimental effect on availability and access to food due to highly volatile prices. All this happened in distorted markets for agriculture in general and biofuels in particular. In order to assess the vulnerability of countries under liberalized conditions, it is important to analyze

a) the current situation in relation to trade in biofuel feedstocks and energy imports, to derive the extent to which countries are exposed to price movements;

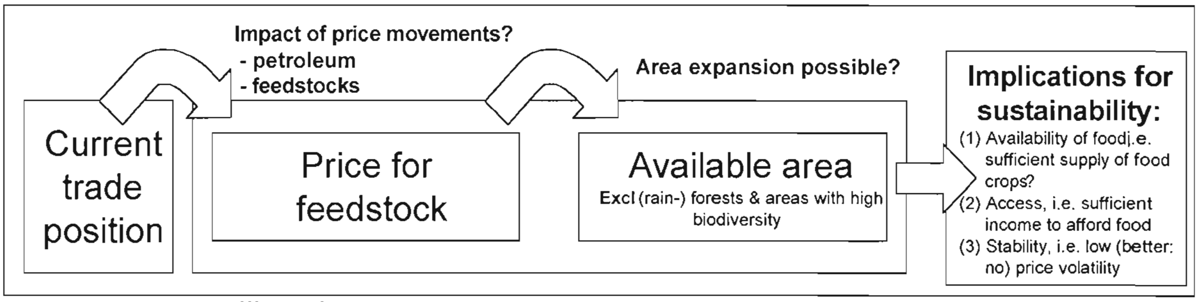
The major issues in the case of liberalization concern

b) price developments for feedstock and prices for energy commodities, notably petroleum; and

c) available land to expand production to areas that are suitable and consider ecological issues mentioned in the previous chapter.

(UN Energy, 2007; Fargione et al., 2008). The underlying rationale is that countries are less vulnerable to rising agricultural commodity prices if they can cultivate them by themselves, i.e. if sufficient area is available to cope with rising demand (Fargione, et al., 2008). In this way they can also benefit from the cultivation of biofuel feedstocks. Finally, some general remarks from studies on trade liberalization are important for cross-checking and enhancing the analysis.

Figure 6.6: Framework for analyzing liberalized markets for biofuels and sustainability



Source: own illustration.

Although it is crucial to assess the exact impact of biofuel production on food, feed and energy markets on country- and even on local level, these analyses are too extensive to be included in this master thesis. Instead the overall impact of free trade will be discussed.

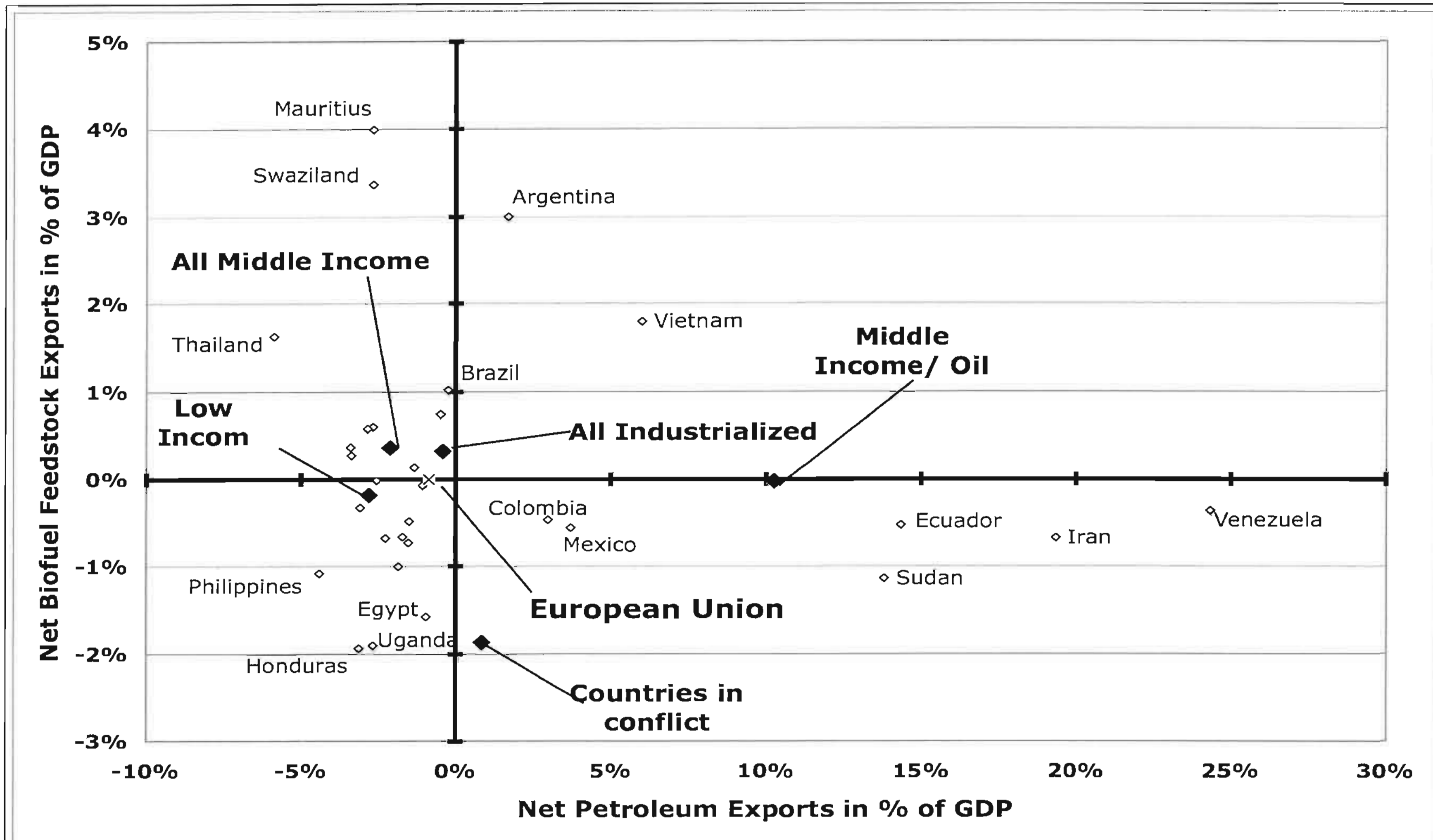
6.2.4.2. Biofuels and Petroleum: The Current Trade Position of Sample Countries

According to the UN (UN Energy, 2007), a country's status has to be analyzed in terms of (a) food imports and exports, (b) energy imports and exports, and (c) general economic development. In this way, the following figure presents the outcome of such an analysis. It captures

a) the trade balance for all biofuel feedstocks, i.e. cereals and preparations, oilseeds and sugar (raw); these were plotted for each country against
b) petroleum import bills, represented by all imports of crude oil and road transport fuels (gasoline and diesel). Finally both import ratios have been related to
c) the current GDP in USD to consider the overall economic impact price changes might eventually have.

As numerous sources had to be considered to analyze the current trade position of the countries included in the sample, complete data is only available until 2005. For a more general picture, data from 2004 has been included. Figure illustrates position of middle and low-income countries from sample that are considered most vulnerable towards price changes in energy and food markets. Positions of other countries indicated with their average values.

Figure 6.7: Trade position in biofuel feedstocks and petroleum products in % of GDP (current USD); 2004-05 avg.



Source: own illustration based on FAOstat, 2008; MWV, 2008; ECB, 2008; IMF, 2008. (No data on import bills of (road) transport fuels was available for Malawi, Mauritius, Swaziland and Uganda; assumption: average trade balance of other petroleum-importing African countries (in relation to total merchandise imports).

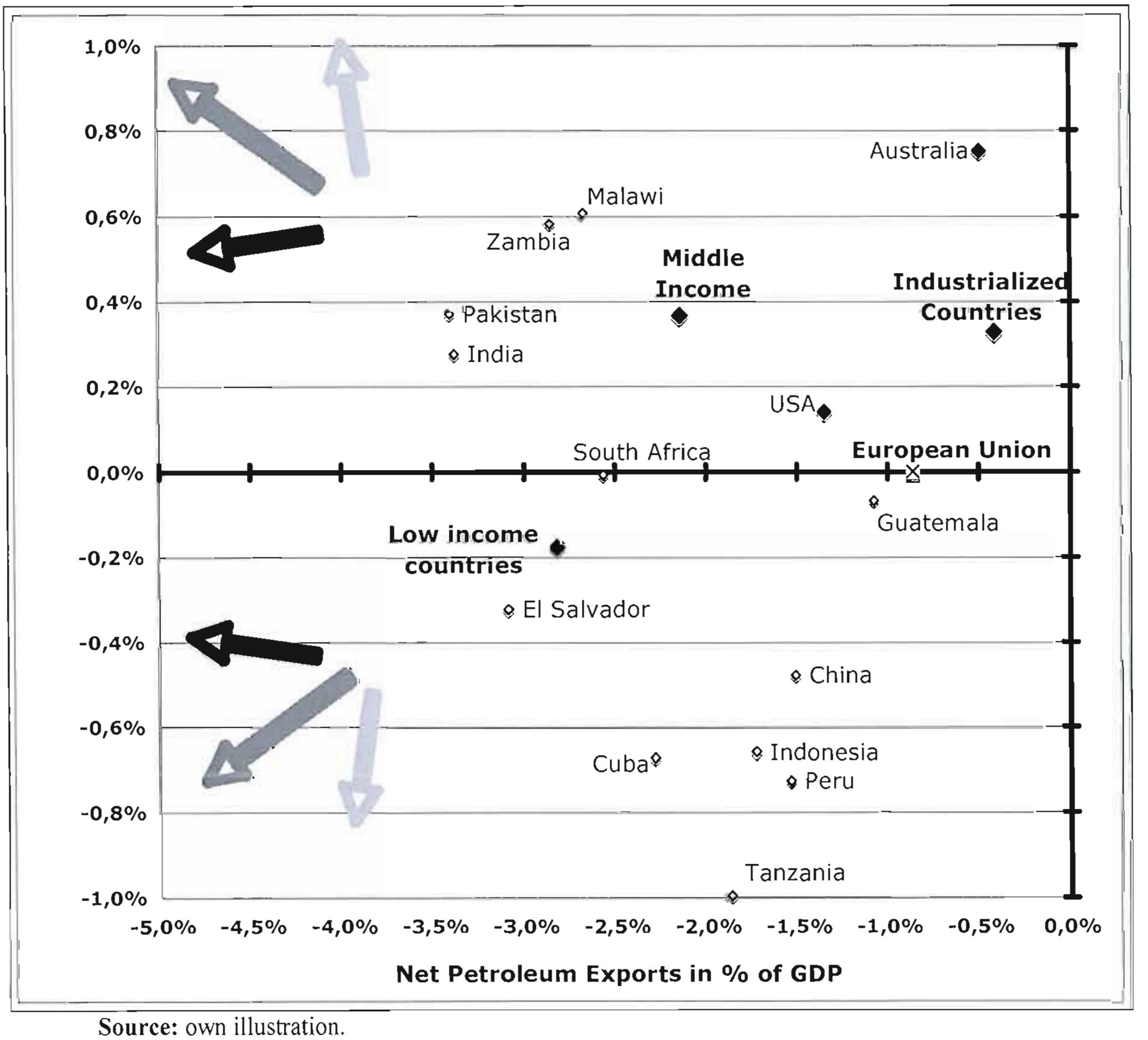
The analysis shall start with those countries in the upper right square where those countries can be found that export petroleum and biofuel feedstocks. Of the countries included in the sample only are in the strongest position as they benefit from price increases in both markets. These countries should not be affected by the competition between food and fuel. Amid the surplus in petroleum production security of supply is not an issue for these countries.

The same is true for countries in the lower right square. Export surpluses in petroleum make these countries independent from others, while they benefit from rising energy prices in the future. As they are endowed with favorable resources to grow either sugarcane or maize, political decisions determine whether ethanol plays a more important role in the future. Countries from Latin America, i.e. Mexico, Ecuador, Colombia and Venezuela may consider higher levels of ethanol production to seize export opportunities (F.O. Licht, 2007). In Iran and Sudan similar intentions do not exist due to political circumstances.

Despite high revenues from petroleum exports, food shortages may nonetheless be relevant as prices for foodstuffs in free markets transmit more directly across borders than it is currently the case. Income distribution by governments is crucial in this case as the design of ... policy can help to buffer the effects of high prices for the poor in the country. These distribution policies are even more important as both, food *and* energy prices rise (FAO, 2008b; FAO, 2003). Another crucial issue is whether it is possible to increase the area of arable land: constraints in human and capital resources might eventually hamper the development. The following chapter will scrutinize this issue for all countries in the sample in more detail.

Countries with export surpluses in biofuel feedstock, but negative petroleum import bills are located in the upper left square in Figure 6.7. Particularly countries with high export surpluses are already actively promoting ethanol production (e.g. Mauritius, Swaziland, Thailand) to become more independent from crude oil imports. Rising prices for energy may increase the pressure on available area in the coming years. Countries in the lower left corner suffer from high import bills for petroleum and from rising prices for food imports. The analysis suggests that especially Honduras and Uganda, but also the Philippines and eventually Egypt face a double problem as both, prices for energy and foodstuffs rise. Regardless of the trade balance in biofuel feedstocks, the analysis suggests that high import bills for petroleum and appropriate endowment of resources - as it can be assumed for all countries in the sample - result in high pressure to increase arable land, where possible, or to displace other crops, where land is a scarce production factor. Limited foreign currency reserves to pay the import bills may aggravate this tendency, especially in low income countries. They are even more exposed to higher prices for imported goods as their economies are generally weaker. This fact is illustrated in Figure 6.8; it presents in more detail the trade position in feedstocks and petroleum imports for those countries that have not such a prominent position as the other countries in the sample. The arrows indicate how the position of each country may change if - *ceteris paribus* - prices in petroleum products (black arrow), agricultural products (grey) or both commodities (dark grey) rise. As mentioned above, it can be expected that the movement in relation to the GDP is more pronounced in low income countries like Malawi, Zambia, Pakistan, or Tanzania, than for middle income countries, like South Africa, Guatemala or Peru.

Figure 6.8: Trade position in feedstocks and petroleum imports in % of GDP (current USD)



Source: own illustration.

Finally, it is worth to note that the situation of countries with low income where severe crises or wars are taking place, have (Kenya, Ethiopia, Sudan, and Zimbabwe) are in a more difficult position than other countries of the same income category. Particularly for cereals, their import bill is extremely high, and, leaving aside the petroleum surplus from Sudan, their import bills for transport fuels are amongst the highest across the sample.

6.2.4.3. Feedstock prices in Liberalized Markets and Land-Use Considerations

This chapter analyzes how feedstock prices may rise if markets are liberalized. Three studies are considered to provide an idea about price and associated land use changes. The study by Bouët (2008) looks at trade liberalization in general, while the study on "Global Food Projections to 2020" (Rosegrant et al., 2001) deals with various policy scenarios until 2020. Both studies are published by the International Food and Policy Research Institute (IF-PRI). Finally, the study by the OECD (2008b) will, again, be considered; although it is limited by the fact that it only regards trade liberalization in biofuels it is a useful reference. The following table summarizes the impacts on world prices for the most important biofuel feedstocks.

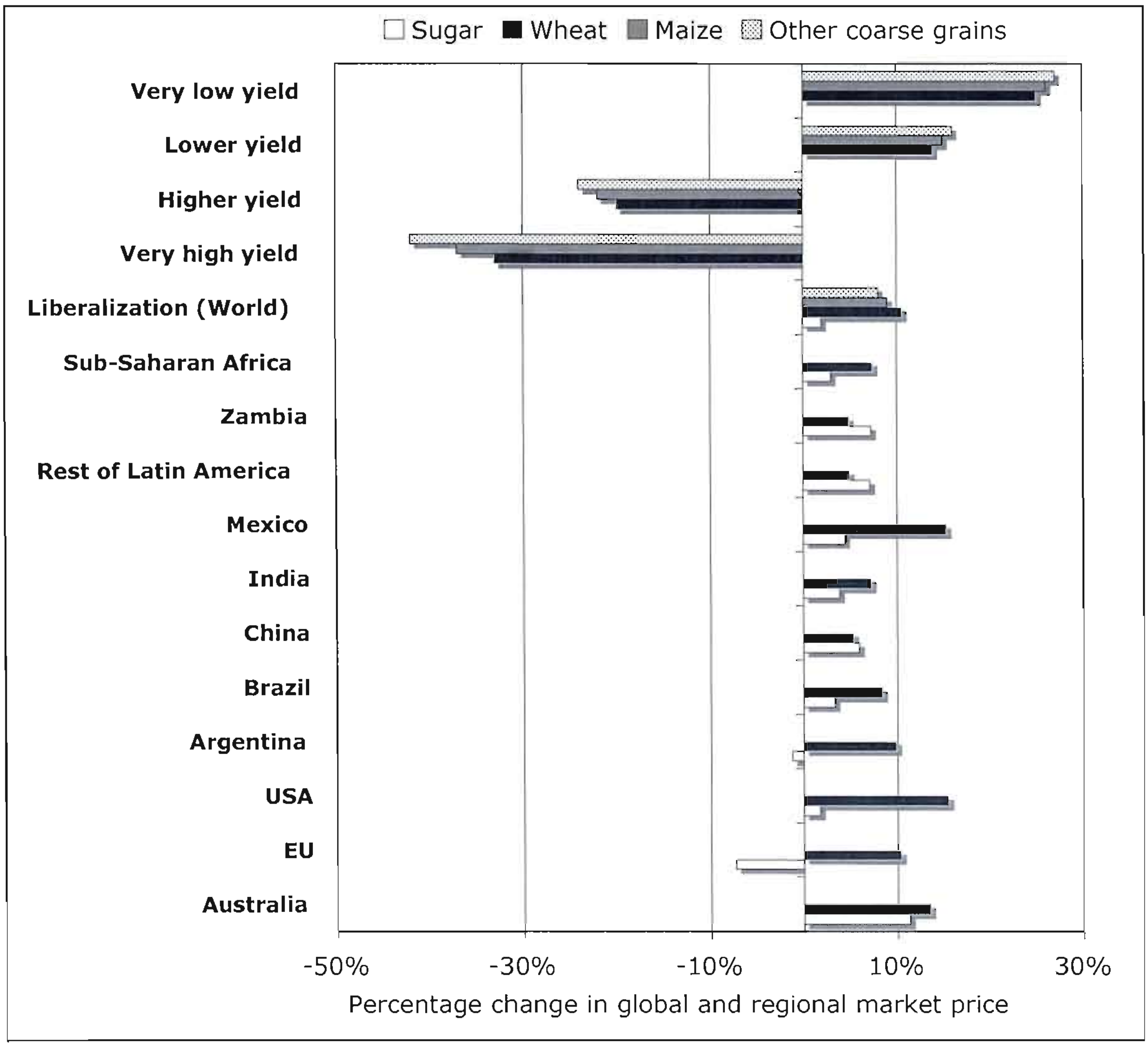
Table 6.13: Impact of free trade on prices for ethanol feedstocks

	Sugar (raw)	Maize	Wheat
Rosegrant et al., 2001	N.A.	+8.8%	+8.1%
Bouët, 2008	+2.0%	N.A.	+10.6%
OECD, 2008b	+3.0%	-1.5%	-2.5%

Source: see references in table.

Overall moderate changes in world prices can be expected. Depending on current bilateral trade agreements, however, price changes on regional level show significant variations. Bouët (2008) provides a more precise picture on this topic. The following figure summarizes the impact of trade liberalization on sugar prices in various regions. Major price increase for wheat occur in Australia, Mexico and the United States. Price increases in sugar are more moderate, with major changes occurring in Australia, Latin America (excluding Argentina and Brazil), and China. EU prices for sugar fall by 7%. The most important message of the figure relates not to prices chances on regional level, but to underlying assumptions used in the models. Rosegrant et al. (2001) have tested the impact of various yield levels on market prices for cereals. The result sheds a different light on price increases under agricultural trade liberalization as it suggests that there are much stronger forces, which have an even more important impact on regional and world prices. For this reason it is an important task to understand the drivers of recent price surges, which were much stronger than the impacts of either liberalization or yields.

Figure 6.9: Price impact of liberalization compared to changes in yields



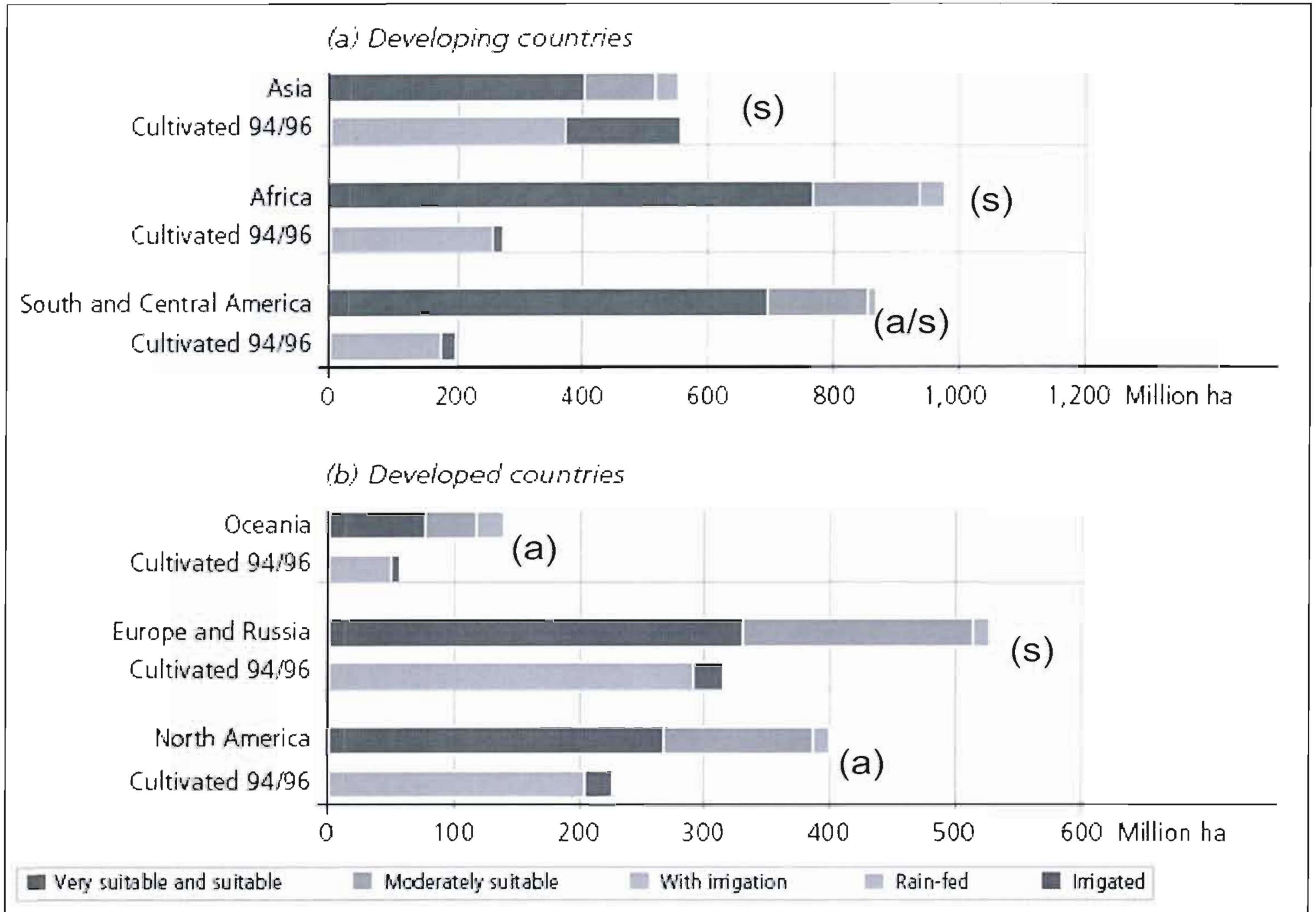
Source: Yield scenarios and global price change for coarse grains and maize: Rosegrant et al., 2001; regional and global price changes for wheat and sugar: Bouët (2008). It is important to note that Rosegrant et al. based their analyses on the 2001 price levels while the calculations from Bouët (2008) were made against the background of much higher prices. Nonetheless the figures shall be related to each other because the percentage change in prices can be considered to be independent from the actual price level.

The major message regarding ethanol production is that even in the case of trade liberalization in all agricultural goods, no significant changes in production patterns may be observed as prices for all inputs rise. The underlying supply and demand figures in different regions do not vary substantially (Rosegrant et al., 2001). In the EU the production of cereals is expected to decline by -4%, while production is 1% lower. The United States and Australia may see their exports rise, while EU countries export less. In Latin America supply and demand are relatively balanced, while other regions remain importers; though it should be mentioned that the demand for cereals relative to production is much higher in Africa than in Asia. An exemption here is Sub-Saharan Africa, where demand and production rises stronger than in other regions. The OECD study is the only one that (2008b) considers land use change in the light of trade liberalization for biofuels. Although the report does not analyze the impact for single biofuel feedstocks, area for biofuel feedstock in relation to total crop area is expected to increase in by Latin America and Australia by +0.5% and 0.3% respectively, and to decline in North America and Africa by -0.3%. In Asia there is literally no change. No studies are available on the impact of liberalized sugar markets on total area.

It is reasonable to argue that all studies come to similar conclusions, as they see production in the "South" increase, mainly at the expense of the "North", i.e. industrialized countries. To what extent prices increase or decrease remains uncertain because much depends on dynamic market effects, like the adoption of new technologies or the optimal variation of factor inputs (both influencing yields), available area and accompanying policies (Fischer et al., 2001; FAO, 2003). In either case the price increases due to liberalization are a far cry from recent price surges.

Considering available area for crop production, the perspectives of economists and agronomists differ. Bouët (2008) for instance regards land as a scarce input factor in Africa, Latin America (excl. Argentina and Brazil), Asia and Europe. Regions considered land abundant include North America, Oceania (mainly due to Australia), Brazil and Argentina. This perspective - from an economist - can be contrasted to resource assessments presented by de Vries et al. (2007), cited in Chapter 3, and a study by the FAO (Fischer et al., 2001) in which global agro-ecological resources have been assessed. The results from Fischer et al. (2001) present a different view on the question whether land is an abundant or scarce input factor. Area that is very to moderately suitable for cultivating crops (upper bar chart) is contrasted to the cultivated area below.

Figure 6.10: Comparison of land with crop production potential and land used for cultivation (1994-96 avg.)



Source: Fischer et al., 2001: 13; (a) denotes abundant, (s) denotes scarce land resources according to Bouët (2008).

The figure shows that there is still significant potential of cultivable land in Africa and Latin America; more than 70% of *additional* cultivable, i.e. very suitable, suitable or moderately suitable land is located in these two regions. It is noteworthy that half of this land is located in just seven countries: Angola, Democratic Republic of Congo, Sudan, Argentina, Brazil, Colombia and Bolivia. Furthermore, Fischer et al. (2001: 13) note that in Asia land resources are indeed scarce while the agricultural potential in Europe and Russia, North America, and Oceania is unlikely to be used in the future. Nonetheless intensification of agriculture rather than area expansion will be the principle means to increase production in the future. According to Fischer et al., (2001) there is considerable scope for increased yields, especially in developing countries. Hence the surplus area in Africa or Latin America may remain vastly untapped.

There are, however, two other circumstances limiting the potential growth in arable land. From an ecological perspective, soil degradation or ecological fragility are the most important constraints. From an economic perspective, the lack of agricultural infrastructure and limited financial resources, especially in Africa, may hamper area expansion (Fischer et al., 2001). The latter point is most likely to be accountable for the different potential estimates by economists and agronomists. The lack of infrastructure and the level of political risk associated with investments in Africa or in some Asian or Latin American countries is an important, well-known constraint. In economic analyses, e.g. Bouët (2008), this fact is likely to be the most important limit to area expansion.

6.2.4.4. Concluding Remarks and Implications for Sustainability

So far it can be summarized that free trade results in higher prices on global level, with substantial differences across regions, depending on whether countries benefited from preferential market access in the past or not. The most substantial price increases can be expected for cereals (5 to 10%). Prices for sugar increase just slightly. For the economics of ethanol production this outcome is important as it can be concluded that current comparative advantages remain the same in a free trade scenario. At the same time ethanol production in the US is affected by liberalization, but due to better economics not as severe as EU-production (OECD, 2008b).

The fact that corn-to-ethanol remains competitive under liberalization may be negative from a sustainability point of view, because many developing and least-developed countries are traditional importers of cereals. This situation does not change after agricultural markets have been liberalized. Consequently, food and fuels will keep on competing for areas in North

America. In Europe the competition between food and ethanol production will not be relevant as ethanol from wheat and sugar beet is not competitive.

Compared to the surge in prices for agricultural commodities from 2005 to 2008, the impact of trade liberalization in agricultural commodities is relatively low. Also it should be noted that price increases and free market access for developing and least developed countries may eventually lead to higher yields for food and feedstock crops in currently disadvantaged areas, e.g. Africa. Still it is difficult to estimate to which extent higher yields or area expansion may contribute to growth in production for food and ethanol crops. In this context the comparison of agronomic and economic studies has revealed at an important aspect: the assessment of land abundance differs with the perspective of the researcher. A country may be considered land abundant from an agronomic point of view, while land is considered scarce from the economic perspective. As outlined in Chapter 3 policies are the crucial factor as they can enable countries to tap their agricultural potential. In this context developing countries, or middle-income countries as they have been classified in Chapter 6.2.4.2, should be in a better position as infrastructural issues and policy risks have a lower importance. Less or least-developed countries, i.e. low-income countries as they have been classified in Chapter 6.2.4.2, are in a less favorable position and they would need more assistance in tapping their resources in a sustainable manner.

6.3. Sustainable Free Trade and the Impact on EU Policy Objectives

6.3.1. The Outline of an Alternative Policy Strategy for Ethanol

The following table summarizes a policy strategy that is designed to reach the EU policy objectives in a free trade scenario considering the most important sustainability principles. In order to facilitate the analysis the proposal will directly refer to the seven axes of the Biofuels Strategy of the EU, as passed by the European Commission in 2006. In this way there will be a direct link to the respective policy objective and the current strategies. Regarding the strategy proposal, it is important to analyze the impact on the other policy objectives to avoid or minimize significant trade-offs from the beginning. The proposals are based on the rationale of dynamic efficiency. For evaluating the policy strategies the symbols from earlier analyses will be used. Furthermore, a question mark symbol denotes an uncertain impact on the policy objective as eventually measures in other policy areas have a strong influence on the actual outcome. The last row of each table indicate what broader measures in the same policy area may eventually be required in liberalized markets for sustainable ethanol.

Figure 6.11: Proposal for achieving energy policy objectives under the Alternative Ethanol Strategy

Policy axis	Keyword	ENERGY POLICY Policy proposal	Policy effectiveness: impact on...			
			COM	DOM	DIV	SUST
I	Blending mandates	Flexible mandates: define a corridor for blending target while aiming at an average (volumetric) displacement of gasoline:				
		1st generation ethanol: imports only; define the mandate in terms of a "corridor" to allow for flexibility in times of high feedstock prices.	+ +	- -	-	+
		2nd generation ethanol: introduction of blending mandates to create the respective industry; gradual increase of blending target.	+	+ +	0	+
	Tax exemptions	Only to promote ethanol that is produced in a particularly sustainable manner	?	0	?	+ +
VII	Research & development	Concentrate R&D efforts exclusively on 2nd generation ethanol; Intensify research and development of biorefinery concepts; eventually design a special "feed-in tariff" for ethanol from biorefineries. Concentrate on research on most eco-efficient feedstocks.	+	+	0	+
A	Fuel efficiency	Set stricter targets for fuel efficiency that consider alternative means for GHG-abatement in the transport sector and eventually in the overall economy; Consider alternative options for engines or transport modes to lower fuel demand and to foster diversification of energy sources (by type).	0	(+)	0	(+)

Legend - contribution to policy objective: COM = Competitive supply of ethanol, exploiting the maximum potential of GHG-savings; DOM = domestic supply; DIV = geographical diversification of resources; SUST = general sustainability aspects other than GHG-savings.

** Key policy measure for all objectives; ++ measure of vital importance for single policy objective; + positive contribution to policy objective; 0 neutral, i.e. neither positive nor negative contribution to policy objective; – inconsistent with, or contradictory to policy objective; – – measure having significantly negative impact on policy objective; ? uncertain impact.*

(BRACKETS) are used for accompanying measures only and indicate their potential impact on the policy objectives.

Policy axis	Keyword	ENVIRONMENT POLICY => OBJECTIVE: max. GHG-savings at given cost Policy proposal	Policy effectiveness: impact on... COM	DOM	DIV	SUST
II	GHG-savings	Introduce a EU-wide mandatory certification scheme that is in compliance with WTO rules and includes expected GHG-savings from 2nd generation feedstock in the EU (no less favourable treatment).	++	+	0	+
	Tax exemptions	Reward higher certified GHG-savings by tax exemptions; the extent of tax concessions should consider average prices for GHG-emission rights, but should at the same time represent an incentive for blenders and consumers.	+	0	0	+
A	Kyoto-obligations	Full carbon trading should be envisaged and no sectors should be excluded, as it is currently the case.	-	0	0	++

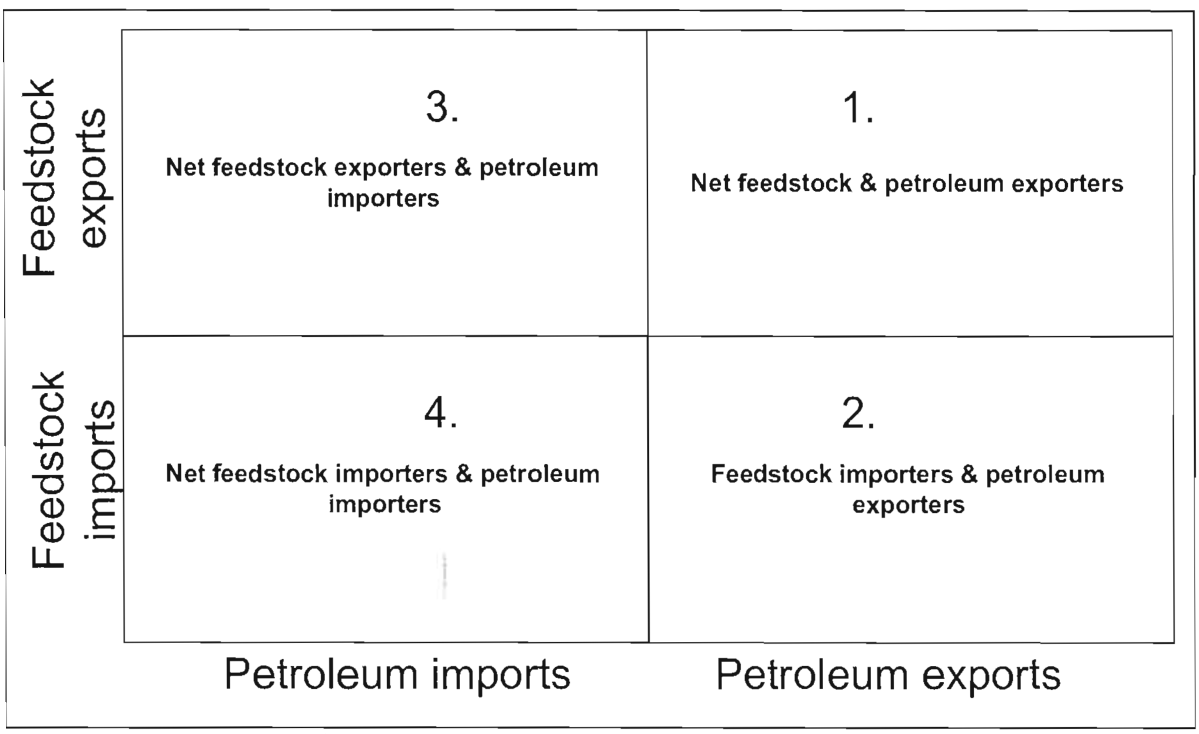
Policy axis	Keyword	EU AGRICULTURAL POLICY => OBJECTIVE: economic development and income creation in rural areas of the EU Policy proposal	Policy effectiveness: impact on... COM	DOM	DIV	SUST
III	Developing the production (of bioenergy in general)	Conduct studies on member state and regional level to assess the opportunities of biomass-based energy; compare the results to other alternatives of renewable energy generation; Within this framework, the most suitable locations for ethanol production should be identified and supported in an adequate manner.	+	+	0	+
IV	Feedstock production	Create an incentive scheme for energy crop growers that is in accordance with WTO-rules; this means that payments should be granted on a per hectare basis, like the energy crop scheme. Intervention stocks are eventually required for providing food aid if prices surge and least developed countries face significant troubles.	+	0	0	+
A	Direct payments decoupled from production	In particularly disadvantaged rural areas, direct payments for farmers should be considered to maintain landscape and recreational benefits; these should not be coupled to any production.	0	0	0	(+)

Source: own illustration.

The policy axes V and VI of the current EU Biofuels Strategy deal with tariffs and preferential market access. Both may be replaced by one axis that focuses on adequate policies to promote third countries to develop their biofuel industry, and by another axis that deals with issues in relation to sustainability certification.

The fifth policy axis of an Alternative Strategy for ethanol should solely focuses on the promotion of third countries and should be designed to make them future EU suppliers. There are, however, justified doubts about the capacity of some countries to develop their industries further or to promote ethanol production due to the competition between food and fuel. The following figure serves as a reference for the final discussion on this topic.

Figure 6.12: Conceptual framework (food-vs-fuel) for policy analysis



Source: own illustration.

1. In these countries there are the best opportunities for establishing long-term trade relationships as the country is independent from energy imports and the trade balance in feedstocks suggests sufficient factor endowment; as most typical petroleum exporters have not been identified as potential ethanol producers, this leads even to a better geographical diversification of energy imports.
2. In these countries there is in general no pressure to develop a domestic ethanol sector as the country exports petroleum and the feedstock trade balance suggests relatively scarce resources; the propensity to develop the ethanol sector

should be low; if resource endowment (area or potential yield increases) suggests the development of an ethanol sector, attention must be given that the country slowly develops its industry to avoid severe land-use competition;

3. Countries that have an export surplus of ethanol feedstocks and import petroleum should have a strong interest in developing their market. They are also in a position to supply the other countries with ethanol. However, the EU should take into account that pressure on land may become unsustainable; therefore countries that are land-abundant are in the best position to establish a long term supply relations with EU member states.
4. If a country imports both, biofuel feedstock and energy, and if the economic structure is rather weak, there are more important issues to address than ethanol production; only in exceptional cases should the EU help to establish respective biofuel capacities in the country. Otherwise it is more adequate to address issues in relation to improvements in agricultural production.

In all cases the capacity of a national economy to enact policies that avoid food shortages or that transfer income to the poor is crucial. Furthermore, the structure of the economy may lead to the conclusion that biofuel development is not appropriate, e.g. if not sufficient resources are given, or if the economy is not sufficiently diversified and depends too much on price movements of single commodities (FAO, 2003; UN Energy, 2007; FAO 2008b). EU intervention stocks as mentioned under the fourth policy axis of the Biofuels Strategy should solely act as food aid in case of severe food shortages in one or the other country (compare proposed strategy). Amid the fact that corn-to-ethanol production remains a viable option for US producers, even under liberalization and, thus, may continue to compete with other cereals for land in exporting nations wheat stocks should by no means be processed into ethanol in the EU.

The sixth policy axis should focus on sustainability certificates for domestic and imported ethanol. Referring to the criteria from (Lewandowski/ Faaij, 2006) the following table outlines the possible impact of certification on the different EU policy objectives.

Figure 6.13: The impact of social sustainability criteria on EU policy objectives

Area of concern	Sustainability Criteria: SOCIAL	Contribution to policy objective		
		EU-DIV	EU-COM	EU-DOM
Labor conditions	- Freedom of Association and collective bargaining - Prohibition of forced labor - Prohibition of discrimination and equal pay for equal work - Least minimum wages - No illegal overtime - Equal pay for equal work - Regulations are in place to protect the rights of pregnant women and breastfeeding mothers	-	-	+
Protection of human health and safety	- Protection and promotion of human health - Farmers, workers, etc. are not unnecessarily exposed to hazardous substances or risk of injury - A safe and healthy work environment, with aspects such as machine and body protection, sufficient - lighting, adequate indoor temperature and fire drills - Availability of document routines and instructions on how to prevent and handle possible near-accidents and accidents - Training of all co-workers is performed and documented; training ensures that all co-workers are able to perform their tasks according to the requirements formulated on health protection and environmental benign management or resources	0	0	+
Rights of children, women, indigenous people and discrimination	- Elimination of child labor: a minimum age and a prohibition of the worst form of child labor - Children have access to schools, work does not jeopardize schooling	0	0	0
	- Indigenous people's and tribe's rights have to be respected - Recognizing and strengthening the role of indigenous people and their communities - Women should not be discriminated and their rights have to be respected - Spouses have the right to search work outside the entity where the husband works	0	0	0
Access to resources ensuring adequate quality of life	- Farmers are content with their social situation - Access to potable water, sanitary facilities, adequate housing, education and training, transportation, and health services - Promoting of education, public awareness and training - Market access for small farmers and producer - Equitable access to forest/farm certification among all forms of forest/farm users and tenure holders - Establishment of a communication systems that facilitates the exchange of information	0	0	0

Food and energy supply safety	- Enough food of sufficient quality is available - Biomass production should not lead to severe competition with food production and the shortage of local food supply - Energy supply in the region of biomass production should not suffer from biomass trading activities	-	0	0
Capacity building	- Local organizations, institutions or companies should be involved in the process, e.g. control and certification - Marginalized social groups should play and equitable role in certification processes - Jobs should be generated - Trade-related skills development and social justice oriented capacity building are facilitated through - learning exchanges between trading partners - Building and use of local labour and skills	+	0	0
	- The activity should contribute to poverty combatement	0	0	0
	- Stakeholder involvement in the decisions that concern them	-	0	0
Land ownership	- Avoidance of land tenure conflicts - Land ownership should be equitable - Tenure and use rights shall be clearly defined, documented and legally established - Projects should not exclude poor people from the land in order to avoid leakage effects	-	-	0
Community (institutional) well-being	- Farms must be 'good neighbors' to nearby communities and a part of the economic and social development - A basis is created for strengthening the mutual confidence between business and the society in which they are active	0	0	0
	- Involvement of communities into management planning, monitoring and implementation	+	+	0
Fair trade conditions	- Transparency and accountability of negotiations - Direct and long-term trading relationships - Fair and equal remuneration—all supply chain partners are able to cover costs and receive fair remuneration for their efforts through prices that reflect the true value of the product. Risk sharing mechanisms are actively encouraged - Communication and information flow—supply chain partners communicate openly with each other showing a willingness to share information	+	0	0
Acceptance	- Acceptance of the production methods by producer and consumer - The activities do not lead to disadvantages for the local population like losses of jobs or food shortage - The activity carries advantages for the local population	0	0	0

Source: own illustration; criteria based on Lewandowski/ Faaij (2006).

Figure 6.14: The impact of economic sustainability criteria on EU policy objectives

Area of concern	Sustainability Criteria: ECONOMIC	Contribution to policy objective		
		EU-DIV	EU-COM	EU-DOM
Viability of the business	- The business has to be economically viable - Minimization of costs to ensure competitiveness - There is sustained and adequate funding for running the operation, i.e. the liquidity of cash flow to support infrastructure development, acquisition of machines and to meet day-to-day running of the operation	0	+	0
	- Long-term commitments, contracts and management plans	+	0	0
Strength and diversification of local economy	- The activity should contribute to strengthening and diversifying the local economy - Local labor and skills should be usable - Professional and dedicated human resources are enhanced	0	0	0
Reliability of resources	- Minimization of supply disruptions - Supply security for the biomass consumer - No overdependencies on a limited set of suppliers should be created	++	+	0
Yields	- Sustainable rate of harvesting—Forests should only be harvested at the rate that they regrow - Agricultural yields should be maintained on an economically viable and stable level	+	+	0
	- A management plan that describes the operational details of production is in place - A comprehensive development and research program for new technologies and production processes is in place	+	+	0
	- The activity should not block other desirable developments	0	0	0

Source: own illustration; criteria based on Lewandowski/ Faaij (2006).

Figure 6.15: The impact of ecological sustainability criteria on EU policy objectives

Area of concern	Sustainability Criteria: ECOLOGICAL	Contribution to policy objective		
		EU-DIV	EU-COM	EU-DOM
Protection of the atmosphere	- Reduction and minimization of greenhouse gas emissions - Efficient use of energy - Use of renewable resources - Low nitrogen emissions to the air - No use of persistent organic pollutants (POPs) and substances that deplete the ozone layer	0	0	0
Preservation of existing sensitive ecosystems	- Avoidance of pollution of natural ecosystems neighboring the fields - Prevention of nutrient leaching - Plantations should not replace forests - Maintenance of high conservation value forests	-	0	0
Conservation of biodiversity	- No use of GMOs - Careful/no use of exotic species, their monitoring and control - Prevention of spreading of diseases - Environmentally sound management of biotechnology - Consideration of the needs of nature and species protection - The development and adoption of environmentally friendly non-chemical methods of pest management - should be promoted and it should be strived to avoid the use of chemical pesticides - Preservation of habitats	-	0	0
Conservation and improvement of soil fertility — avoidance of soil erosion	- No impoverishment of the soil; nutrient balances should remain in equilibrium - Optimized utilization of the soil's organic nitrogen pool - Measures to prevent soil erosion are applied and described in a management plan - No accumulation of heavy metals in soil - No irreversible soil compaction; measures to prevent soil compaction are taken and described in a management plan - No pesticide residues in the soil	+	+	0
Conservation of ground and surface water	- No depletion of ground and surface water resources - Protection of the quality and supply of freshwater resources - Avoidance of pollution of ground and surface water	0	0	0

	- No eutrophication of surface water by phosphorus emissions - No pesticide residues in the water			
Combating deforestation desertification and drought	- Plantations should not replace forests - Sustainable harvest rates - harvest at the rate the forest regrows - Limitations for the size of the harvested areas	-	0	0
	- No logging activities in protected forests	-	0	0
	- Measure to combate desertification and drought are taken and described in a management plan	0	0	0
Landscape view	- Increase and improvement of the variation of the landscape - Conservation of typical landscape elements	0	0	0
Conservation of non-renewable resources	- Efficiency in the use of natural resources, including energy - Positive energy balance - Minimization of the use of raw material, resources and land - Focus on increased efficiency by increasing filling rates, decreasing fuel consumption and by using transport modes that release less greenhouse gases - Minimization of phosphorus extraction from non-renewable deposits	0	0	0
Waste management	- Minimization of wastes - Sorting of wastes - Proper handling and disposal of waste - Recycling of waste where possible - Recycling of ashes from biomass combustion - Environmental training of employees, to facilitate waste sorting and initiate energy saving - Environmental checklist on waste management, training of employees, etc	0	0	0
Environmental additionality	- Projects have to be environmental additional by improving the environmental situation against a baseline status quo scenario	0	0	0
Legend - contribution to policy objective: COM = Competitive supply of ethanol, exploiting the maximum potential of GHG-savings; DOM = domestic supply; DIV = geographical diversification of resources; SUST = general sustainability aspects other than GHG-savings. ** Key policy measure for all objectives; ++ measure of vital importance for single policy objective; + positive contribution to policy objective; 0 neutral, i.e. neither positive nor negative contribution to policy objective; – inconsistent with, or contradictory to policy objective; – – measure having significantly negative impact on policy objective.*				

Source: own illustration; criteria based on Lewandowski/ Faaij (2006).

Again the evaluation criteria are the same as above. General sustainability criteria as mentioned by Lewandowski and Faaij (2006) are not found to have an impact on EU policy objectives and, thus the respective table has not been presented here. The following overview summarizes the outcome of the evaluation.

Figure 6.16: Impact of sustainability criteria on EU policy objectives

	Contribution to policy objective			Total criteria
	EU-DIV	EU-COM	EU-DOM	
Social sustainability	-0,5	-0,5	1,0	14
Economic sustainability	2,5	2,0	0,0	7
Ecological sustainability	-1,5	0,5	0,0	12
Total	0,5	2,0	1,0	33
in %	2%	6%	3%	9%
	The overall effectiveness summarizes the combined effect of policy measures by adding up the single evaluations: "+" => 0.5; "–" => -0.5; "0" => 0, and so forth. Each sustainability criterion is equally weighted.			

Source: own illustration.

Overall certification has a relatively low impact on the policy objectives. Social sustainability criteria have a slightly negative impact on the energy policy objectives "Diversification of Supply" and "Competitive GHG-abatement costs". This is due to the fact that certification may be costly and may exclude some countries that would have otherwise exported ethanol to the EU. It is, however, reasonable to argue that this is the price to pay for sustainability. EU domestic supply may eventually benefit from the certification as there are already strict criteria for sustainability for EU farmers that might be an obstacle for foreign producers. The most important impact may come from additional economic sustainability criteria in certification schemes, as they are oriented towards security of supply and long-term, competitive supply, including the reliability of resources, sound management practices or sustainable yield improvements. The ecological criteria may negatively impact geographical diversification of ethanol imports as ethanol from certified origin does not involve area expansion in viable, but protected areas. Again, this "price" is reasonable compared to the potential damage that may occur due to the logging of forests.

It is important to note that attention should be given to the proper drafting of economic and social sustainability criteria and definitions. Only issues related to ecological sustainability can be expected to be compliant with WTO-rules. Social sustainability criteria may eventually find their way into sustainability certificates via voluntary labelling; in this area relatively objective standards may be applied, like those from the International Labour Organization (ILO). When it comes to economic issues, however, criteria are arbitrary and highly normative (e.g. "What is a long-term relationship and how can it be defined?"; "How can the viability of the business be defined?", and so on). So while criteria in terms of economic sustainability are positive for energy policy objectives of the EU, they cannot be included in certification schemes.

For the sixth axis of an Alternative Strategy for ethanol, it is advisable to define criteria that can be very much expected to be in line with WTO rules. Certificates by other organizations may also be allowed, although it should be noted that costs would occur for achieving a higher level of sustainable development. To make these schemes WTO-compliant, the EU should collaborate on international level to define relatively objective sustainability standards. These may then be included in certification schemes and rewarded according to the fulfilment of criteria (compare policy axis I of the Alternative Strategy). The following, last chapter concludes the discussion.

6.3.2. The Impact on EU Policy Objectives

6.3.2.1. The Feasibility of Domestic Supply

The main idea for ensuring domestic supply in a liberalized market for sustainable ethanol is to introduce blending targets for ethanol made from cellulosic biomass. Due to the fact that there are currently few plants in the EU and none that produces ethanol from cellulosic feedstocks on a commercial basis, it might take up to 5 to 10 years to produce 2nd generation ethanol in quantities that are comparable to today's level of domestic ethanol production from conventional feedstocks (Worldwatch, 2007). Those who define blending targets would have to take this into account. Support measures may be similar to those that currently exist for 1st generation ethanol, i.e. capital grants, guarantees, or low-interest loans. These measures should accompany the development of the industry during the period mentioned above. In this context it may be possible to define a range for the blending mandate and a EU-wide target that has to be achieved on average during this time. Thereby it is possible to account for shortages in feedstock supply or other problems that an infant industry may experience. Certainly more significant R&D measures than currently in place would be required to promote ethanol. An integrated assessment by all relevant stakeholders, i.e. ethanol industry, farm sector, petroleum companies would be required to define a blending target against this background. If the domestic share of total ethanol consumption can be 50% as envisaged by the EU cannot be assessed. However, due to the lack of infrastructure this target is definitely ambitious.

The non-discriminatory certification scheme should promote ethanol that is produced in a particularly sustainable manner. In this context one approach would be to count ethanol with particular sustainability benefits proportionally stronger towards the blending target. This, however, would neglect the fact that it is the objective to displace gasoline by ethanol to achieve higher independence from crude-oil imports. Instead, another approach would be to grant tax exemptions for ethanol that is even more sustainable - due to objective criteria - than ethanol for which minimum sustainability principles have been respected. This approach might be more favourable when considering that all policy objectives have the same importance. In general the idea is to make consumers bear the cost for additional costs of 2nd generation ethanol. The differential is expected to decrease by 2020, although it is unlikely that it will vanish.

6.3.2.2. The Feasibility of Geographical Diversification

Shortly after liberalization, there will be a high dependency on ethanol from Brazil. This is certainly undesirable from the perspective of energy policy, but inevitable as other producers would have to expand their industries. The analysis in the preceding chapters has, however, revealed that there are literally no policy measures to bring about supply diversification. On the other hand market liberalization can be considered to provide sufficient incentives for other more competitive countries to export the fuel to the EU. One may argue that it should be in the self-interest of petroleum companies and distributors to diversify supply in order to minimize their supply risk, even if there is a relatively reliable producer like Brazil. Nonetheless, there is no policy measure available to control the origin of ethanol supply. Whether the EU can achieve its objective of geographical diversification is therefore very uncertain.

Targeted policy measures, i.e. transfer of knowledge or capital aid, may provide incentives for ethanol producers to expand their production in countries where abundant land resources exist that can be used in a sustainable manner. In this way it would also be possible to improve the current infrastructure in many developing and less developed countries so that they can also tap yet unexplored potential for agricultural production. Whether it is possible to include some criteria of sustainable economic development in certification schemes is unlikely. The analysis suggests that this might be impossible as long as no commonly acknowledged sustainability principles exist on a global level.

In order to avoid extreme effects of land-use competition, flexible blending targets may be the best policy measure. In this way demand for ethanol increases if prices for feedstock are low; In times of high energy prices petroleum companies are free to lower the blending ratio This is in their own interest as they can thus make more profits. At the same time the lower blending ratio and somewhat lower demand for gasoline would buffer the demand for ethanol feedstock, and slow down a possible increase in feedstock and foodstuff. Further econometric analysis (eventually on a country level) are required to confirm or falsify this policy proposal. Although such a proposal is at the expense of geographical diversification of overall energy supply, it is a necessary concession to warrant sustainable development.

6.3.2.3. The Feasibility of Rural Development and Income Creation

As mentioned earlier, the EU cannot achieve the objective in terms of rural development and income creation by using first generation feedstocks for ethanol. In a free trade environment it is crucial to conduct studies on member state and regional level to assess the opportunities of biomass-based energy. In particular the studies should consider other alternatives of renewable energy generation from biomass that are eventually more viable. Within this framework, the most suitable locations for ethanol production should be identified and supported in an adequate manner.

Whether it is possible to pay non-production related subsidies to farmers under free trade rules remains an open issue as Bruehwiler and Hauser (2008) note. If this is in compliance with WTO rules then the EU should envisage to maintain an energy crop scheme that is designed for more advanced or competitive feedstocks. In either case in the future European farmers should focus either on large-scale or organic production methods that respect basic sustainability principles (EC DG-AGRI, 2006). This tendency, however, could already be observed in recent years and is expected to continue under liberalized and even under more distorted markets (Schrader, 2004).

Final Conclusion

The objective of this master thesis was to evaluate whether the European Union can achieve its policy objectives in terms of ethanol by 2020 in a scenario of sustainable free trade. This scenario is quite far away from the current situation, as trade distortions limit market access to the European Union and the concept of sustainable development is only embraced on a regional level, not globally. Within this setting the development of ethanol markets is problematic for two reasons. First, it is not possible to use the comparative advantage of many countries from the South - that could play a much bigger role in these markets - and, secondly, it is incompatible with the concept of sustainable development.

The European Union has the highest production costs for ethanol - produced from sugar beet and wheat - and would have to cease the production once markets are liberalized. The first research question of the thesis focused on the concrete definition of policy objectives and looked at the EU Biofuels Strategy that was enacted in 2006 to achieve these objectives. The overall aim of the European Union is to balance objectives in the areas of energy policy, environment and sustainability policy and agricultural and rural development policy. Looking at the trade-offs reveals that there is currently a strong bias towards support of farm income and rural development. In the short-term one may argue that domestic supply and rural development and farm income support have to be traded off against cheaper, imported fuels, and higher greenhouse-gas savings. In the long term, however, technology may allow to produce the fuel from cellulosic biomass. This option is not only cheaper, once technology matures, it would also provide a new domestic source of renewable energy that shows similar greenhouse-gas benefits as ethanol from sugarcane. Hence the EU trades off more competitive, domestic supply, higher greenhouse-gas benefits against the support of rural income.

Building on a technologically more advanced production of ethanol rather than on the conventional manufacturing of the product is also in line with common trade theory. If there are countries that have advantages in the production of a certain good due to better endowment with natural resources, other, less competitive countries can balance this difference by using more advanced technologies.

Sustainable development is the second factor that is important in the context of biofuel production. This is because expansion of agricultural areas should not occur on land with high conservation value or biodiversity. In this way the notion of sustainability limits purely economic reasoning and, thus, has to be an essential part of the debate about free markets for ethanol. Certification of production processes is the best way to ensure that basic sustainability principles have been respected. As some ecological problems may be considered very severe, trade law allows for establishing tariffs to block imports from those countries that do not respect these basic principles of sustainable development. When it comes to broader sustainability issues like labour conditions or issues of economic or rural development, all depends on whether the sustainability criterion concerned is objective or measurable, i.e. based on international standards and recognized methodologies. Only then it is possible to merge sustainability concerns and free trade. If there are sustainability issues that cannot be covered by certification schemes, policies on regional level have to be considered.

As the desirable future for ethanol markets combines free trade and sustainability principles, an Alternative Ethanol Strategy of the European Union should put an emphasis on second-generation ethanol made from cellulosic biomass, and on a non-discriminatory certification scheme for sustainable feedstock production in the EU and abroad. The analysis in this thesis shows, however, that the policies to promote sustainable free trade require significant efforts, which have to be subject to further analyses.

First, there is the issue of domestic production. In order to seize all the benefits from domestic production it is required to identify areas where cellulosic feedstocks and infrastructural benefits lead to the best results, from an economic, ecological and eventually social point of view. Furthermore it would be required to provide incentives for especially sustainable production of ethanol; still the criteria should be objective. The second emphasis is on sustainable production in other markets. In these countries the same, non-discriminatory sustainability principles must apply. Further research should in this context focus on the country-specific opportunities and risks to promote ethanol production in the country as other issues, especially food security, may be more important on a local level.

Overall it has been found that the EU will fail to reach its rural development objectives in relation to ethanol, when defined very strictly based on conventional ethanol production. More advanced, cellulosic ethanol may still provide many benefits in other areas, but cannot contribute as much to rural development as conventional ethanol production could. Many energy policy objectives, i.e. domestic supply and geographical diversification require ambitious strategies to be achieved. In particular the geographical diversification of imports is likely to be beyond the influence of EU policymakers. When it comes to the reduction of greenhouse-gas emissions, the policy targets can be achieved as already today there is the possibility to reach higher greenhouse-gas savings by importing ethanol from other countries. Overall the EU is likely to fail its policy objectives in terms of ethanol.

Whether ethanol production can be combined with ambitious sustainability principles is uncertain. Current trade rules do only allow to save highly valuable, ecological resources, but they do not address issues in relation to economic or social sustainable development. The possibility to include these issues in trade strongly depends on whether they can be objectively defined. As the notion of sustainability differs from one country to another, a global approach is required to tackle the question to which extent sustainability principles can be objectively defined. The crucial question is whether it is possible to consider absolute norms in global economics or whether all sustainability principles remain subject to local interpretation. If different value judgements remain the major characteristic of sustainability, then it is unlikely that trade may become a means to foster sustainable development around the world. If absolute norms exist that are free from value judgements on local level, e.g. issues in relation to ecological sustainability, the major task for governments would be to liberalize markets based on these principles so that the benefits of sustainable free trade can be seized.

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