The Availability of Raw Materials for the Production of Biofuels in Germany and in the EU-25

Professor Dr. Juergen Zeddies

University of Hohenheim

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Summary of the statements and conclusions

(1) This study deals with the effects of a Federal Parliament resolution on October 26, 2006 which introduced a mandatory biofuel blend ratio for the mineral oil sector. Starting on January 1, 2007 4.4 % of diesel sales must be biodiesel and 1.2 % (to be increased to 2.0% in 2008, 2.8% in 2009, and 3.6 % in 2010) of the gasoline sales must be from biofuels. The entire biofuels ratio is to rise to 6.25% in 2009 with further stages bringing the ratio to 8% in 2015). With the current above average grain prices in 2006 the question is raised whether or not these regulations can be met at all.

(2) The report analyzes the current situation and the developments in the fuel market as well as in the markets for agrarian raw materials used to produce biofuels. In addition, the availability of oil crops and grain for the production of biofuels for the years 2006, 2010, and 2020 is projected in consideration of land competition from biogas production. From the results statements and conclusions are drawn about the effects on agricultural commodity markets due to the new mandatory biofuel blend ratios act.[1]

[1] Bio-fuel ratios are based on an energy equivalence basis.

(3) The supply of biodiesel – the capacities of RME plants and oil mills are completed so far – outreaches the 2007 biofuel quota of Germany. To the year 2010, with the blend ratio being increased to 6 % and up to 2020 to 8 %, the biodiesel ratio appears attainable.

(4) With bioethanol the present plant capacity is sufficient for less than 2 % of the current gasoline consumption only.

(5) At present, in many member states of the EU a clear trend is observed to increase ethanol production capacity. Contrary to this, an investment restraint is observed in Germany. When the current ethanol production capacities are doubled in Germany until 2010 as is reliably investigated, domestic production can supply a biofuel share of the gasoline consumption not exceed 3 %. However, the momentary investment restraint is not because of raw material supply for bioethanol plants.

(6) The extremely low grain price in 2005 and the extremely high grain price in 2006 are both due to singular events. The current price high is particularly caused by the fact that the grain harvest in the EU-25 was approximately 14 million t smaller. Essentially, the liberalization of the grain market perpetuated by the Luxembourg resolutions leads to stronger price fluctuations in the EU.

(7) On the world market for grain and oil crops a rising demand and an increase of the net trade as well as a moderate rise of the prices is anticipated in medium-term due to the world's food consumption situation. However, a noticeable structural shortage is not to be expected, at least not in the next two decades.

(8) The effects of the mandatory biofuel blend ratios on the supply with grain and oil crops are primarily driven by the market situation in the EU. The potential for satisfying the increasing demand for biofuels are set-aside areas as well as structural surpluses, in particular of grain, which are intervened in parts and a substantial part of which are given export subsidies. In future these subsidies will no longer be permitted. In recent years the FRG was a net exporter of grain with the average amounting to more than 8 million tons. On mandatorily set aside land approximately 5-6 million tons of grain could have been produced. With this amount of grain approximately 3.6 million tons of bioethanol could have been produced, on an energy

basis equivalent to 2.4 million tons of gasoline. Thus, approximately 10% of the total gasoline consumption would have been substituted.

(9) In future the potential for agrarian raw materials for feeding bioethanol production in Germany and in the EU-25 will increase. This is due to stagnating food consumption and increasing yields, particularly of potential energy crops. By 2010 Germany will set free more than 2.5 million hectares and by 2020 more than 5 million hectares of agricultural area hitherto used for food production. With an ongoing propagation of biogas facilities up to 1.8 million hectares of this land can be committed of biogas. Realistically a maximum of 800,000 hectares of arable land and in addition approximately 1.75 million hectares of released grassland can be expected to be committed for bio gas production. Under these conditions the calculations show that the biofuels quota for biodiesel and bioethanol can be fulfilled at the same time.

(10) By 2010, in Germany, 15 % bioethanol quota alongside a 5 % biodiesel quota could be achieved; by 2020 even 9 % biodiesel quota as well as more than 40 % bioethanol quota. A precondition for this is that sufficient investment security facilitates the extension of ethanol production capacities. In the EU-25 biodiesel will not exceed 2 % by 2010 and 3 % by 2020; in contrast to this the production potential of the EU-25 for bioethanol by the year 2010 is sufficient for a quota fulfillment of approximately 15 % and by the year 2020 of even 40 %.

(11) In the market for biofuels exists a strong dependency on policy. In Germany this is seen when potential raw materials are used with higher priority for biogas facilities due to the Renewable Energy Sources Act (EEG). Following the expected deregulation as to combustion of grain it can be expected that only small amounts of grain will be burned in small on-farm heating plants, which will not reduce the supply noticeably. A stronger subsidization of grain combustion in larger firing plants would seriously shift the use of available potential. New plant capacities for BtL do not compete directly with biodiesel and bioethanol, because BtL production prioritizes remainder straw and remainder wood for cost reasons. Ambitious nature protection programs can also limit supply, but would probably not seriously reduce the supply situation in regard to raw materials.

(12) Germany takes a pioneer role in introducing new energy sources (EEG amongst other). Building of plants for biodiesel and bioethanol is also raised in the neighboring European Union member states. An exclusive view of the supply situation with agrarian raw materials and bio sources of energy of only the German market is a shortsighted view. The duty-free import quotas must be considered as well, in particular for ethanol from Mercosur States. With 1 million tons of ethanol waiting for the trade negotiations to be exported, preferable conditions would lead to fuel imports mainly to Germany and theoretically increase the biofuel blend ratio in gasoline consumption here by the year 2010 up to 3 % and by 2020 up to 4 %.

(13) Recapitulating it can be stated that a higher share of biofuels can be achieved neither with biodiesel nor with BtL which does not mean to stop the development proceedings of BtL. Raw material feedstock of a large availability are grain and sugar beets besides moist biomass for biogas plants. If a higher share of biofuels is to be aimed at this has to be achieved in the first instance only with bioethanol as ETBE, blending, or pure fuel.

(14) Ethanol is not like pure vegetable oil and RME which can be produced in small and middle production facilities. In order to exploit economies of scale to a large degree, Ethanol can only be manufactured in large-scale installations. It is essential for the future of the biofuels that the sector is promoted by providing incentives ethanol plants. Here large deficits are seen at present. The current tax exemption expires in 2008. After this taxation will be in accordance with over compensation until 2012, thereafter gross uncertainty concerning the fiscal regulation. The situation is insufficient and shortsighted as it fails to take into account the extremely high investment needs of a bioethanol plant. Also the development of the crude oil price is not easy to estimate. If the crude oil price adjusts itself on a long-term basis at 40 USD/Barrel, ethanol producers without national promotion cannot achieve a secured profitability. The WTO negotiations with the Mercosur States are disconcerting for investors as well, as the risk to the biofuels industry would be great if the import protection for bioethanol is waived or watered down to the rate for denatured alcohol.

(15) The potential for biodiesels is limited and in few years it will reach the capacity limit. BtL will be industrially extendable only in the next decade. The development

remains limited because current technology is focused on remainder wood and remainder straw. On this base by the year 2020 about10 % of the diesel and gasoline consumption in Germany could be substituted.

(16) The biofuel portion of BtL and biodiesel would remain below 18 % in Germany. In the next 10 years comparatively low biodiesel portions would remain. Bioethanol is at present the only available biofuel technology that could be developed fast and offer a substantial potential. Therefore, the USA, China and other countries promote ethanol to a much greater extent than Germany and various EU member states do.

(17) Addressing to policy the question is raised whether bioethanol production is to be promoted or subsidized equally as e.g. the production of biodiesel or fermentation gas, solar, or other renewable energies. Since the bio energy chains based on agrarian raw materials there will experience strong competition now and in future for the raw materials, the strong support of fermentation gas with long-term price guarantees is directing investments into this sector, while the comparatively large potential of biofuels is not sufficiently used for lack of investments in production facilities.

The Availability of Raw Materials for the Production of Biofuels in Germany and in the EU-25

1 Introduction

Bioethanol has been produced in Germany in the fuel sector since 2005 in significant and, since that time, increasing quantities. In Germany, production has been accomplished to date primarily from grains and to a minor extent, from sugar beets. Bioethanol is exempted from taxation until the amendment to the **Energy Tax Law** passed on August 1, 2006 becomes effective in January 2007. Bioethanol used to fulfill the obligatory quota is subject to the full tax rate for gasoline (65.45 ct./l). From 2007 to 2015, bioethanol in the form of E 85 will continue to appreciate tax advantages (Table 1), when not used for fulfillment of the obligatory quota. Here, bioethanol E 85 can be taxed partially or fully in the basis of cost calculations in the event of so-called overcompensation.

Biodiesel fuel used to fulfill the obligatory quota is subject to the full tax rate for diesel fuel (47.04 ct./l). By contrast, biofuel or vegetable oil not used to satisfy the obligatory quota is subject to decreasing tax reduction rates on the energy tax from 38.04 ct./l or 47.40 ct./l to 2.04 ct./l beginning in 2012.

On October 26, 2006 the German legislator passed a **Biofuel Quota Law**. According to this, the mineral oil industry is obligated, as of January 1, 2007 to provide 4.4 % of its turnover for diesel in the form of biodiesel. The quota for bioethanol in gasoline is 1.2 % (2 % as of 2008, 2.8 % as of 2009 and 3.6 % as of 2010). Both quotas are based on the energy content in each case. As of 2009, the mineral oil industry must provide a total quota of 6.25 % as the percentage for all biofuels, in the year 2010 this figure will increase to 6.75 % and is to continue to increase in stages of 0.25 % each year to 8 % by 2015. Failure to maintain the target values will result in sanctions for biodiesel in the amount of 50 cents/l and for Ethanol, in the amount of 80 cents/l. The sanctions are anticipated to have a prohibitive effect.

Table 1 Taxation of Biofuels in Germany

Taxation of biofuels [Euro/hl, Euro-Ct/l]

year	until 7/2006	from 8/2006	from 2007	2008	2009	2010	2011	2012
Diesel	47,40	47,40	47,40	47,40	47,40	47,40	47,40	47,40
Biodiesel B 100 (beyond obligatory quota)	-	9,0	9,0	15,0	21,0	27,0	33,0	45,0
Biodiesel B 5 / vegetable oil (obligatory quota)	-	15,0	47,4	47,4	47,4	47,4	47,4	47,4
Vegetable oil (beyond obligatory quota)	-	-	-	10,0	18,0	26,0	33,0	45,0
Gasoline	65,5	65,5	65,5	65,5	65,5	65,5	65,5	65,5
Bioethanol (obligatory quota)	-	-	65,5	65,5	65,5	65,5	65,5	65,5
Bioethanol – E 85 (beyond obligatory quota)	-	-	-	depending on over compensation				

Source: according to FO Licht (2006) and BMF

While the existing production capacities for biodiesel in Germany of approximately 3.5 million tons are significantly higher than the percentage of biodiesel prescribed by law (4.4%) of approximately 1.5 million tons presently, the production capacities for bioethanol in Germany are not capable of satisfying the requirement for the bio percentage of fuel in gasoline of approximately 0.65 million tons in the year 2006. Assuming full utilization of the present capacities for production of ethanol in Germany, 0.5 million tons could be produced in 2007 by the country's own capacities and the rest would have to be imported from EU member countries and from overseas.

By 2010 numerous ethanol production facilities presently under construction in other EU member countries will be in production. German companies will approximately double their production capacity by that time, so that assuming adequate demand and attractive prices, production and provision of bioethanol will not be subject to any shortages even if higher obligatory quotas for admixture are passed and sanctioned.

Under the impression of overproportionally higher grain prices in the year 2006, the question arises whether it can be assumed that the supply of raw materials for production of bioethanol will be ensured. For a biofuel quota of 1.2 % bioethanol in gasoline consumed during the year 2007 and up to the year 2011 (3.6 % by volume on energetic basis) and a quantity of raw material in the magnitude of 3 to 4 million tons required for this, using grain exclusively, this does not appear to present any procurement or price problems whatsoever in view of the existing grain exports by Germany and the EU. In this context, it must, however, be taken into consideration that the competition for arable land is increasing due to other bioenergy chains such as energy plants for biogas, grain for combustion in small furnace systems in agricultural operations, further expansion of rapeseed cultivation for biodiesel, etc. Finally, changes in demands for foodstuff, use of areas for residential and traffic purposes as well as further increases in the yield must be taken into consideration. For the first time in nearly 30 years, the increasing demand for bioenergy has resulted in a sustained change in the trend on important markets in the agrarian economy, specifically from a surplus to import situation. To this extent, it is important to estimate the future developments, particularly in the grain market in order to provide the proper signals for production of biofuels within the scope of quotas.

2 Objective

The objective of the study is to estimate the effects of increasing demand for agricultural raw materials for bioenergy in the various chains of application, determine the effects and limits of utilization of biomasses and describe possibilities and limits for politics. Here, the focus is on the supply of raw materials for bioethanol production facilities produced locally. In this case, it is also necessary to consider procurement options of the mineral oil industry from other sources such as imports, for example. It is necessary to examine the supply scenarios for biofuel sources for bioethanol in the amount of 1.2 % in the year 2007, 3.6% in 2010 and 6 %, or even higher quotas graduated chronologically up to the year 2020. Simultaneous procurement of the biodiesel quota must also be taken into consideration.

3 Approach

First the situation and developments in the fuel market are described. From this, the required quantities of fuel are derived to satisfy the biofuel quotas for biodiesel and bioethanol. The BtL procedure is not taken into consideration because the utilization competition is comparatively low in consideration of the quotas for biodiesel and bioethanol. It can be assumed that BtL will not be available in mentionable quantities for more than 10 years and that the first generation fuels can then be supplemented or partially substituted within the biofuel quota at the earliest. In a second step, the markets for raw materials for bioenergy sources are described. This focuses primarily on the availability of grain in consideration of a percentage of sugar beets for production of ethanol from Germany and EU resources. Here, the change in the availability of areas for agricultural utilization, the change in the consumption of foodstuffs, increases in yields and other important influential parameters are also taken into consideration. Simultaneously, it is also necessary to consider developments in the import and export sectors for the most important foodstuffs in addition to raw materials for bioenergy sources in consideration of the basic economic and political conditions. Finally, supply potentials from domestic production and import for fulfillment of biofuel quotas are estimated from the facts established regarding all market developments. In a concluding chapter, the possible utilization competition for surface area is discussed and the results evaluated under the aspect of the sensitivity of the assumptions. Conclusions are then made on this basis.

4 Market Situation and Market Developments

Below we initially turn to an analysis of the markets for fossil fuels and biofuels. First the supply and then the demand aspects are considered.

4.1 Fuels

4.1.1 Demand

4.1.1.1 Fossil Fuels

According to prognosis from the mineral oil society regarding consumption of mineral oil (June 27, 2006), the consumption of gasoline in Germany will be 22.6 million tons in 2006 (Table 2). It is anticipated to decrease to 20.5 million tons by 2010. The decrease in demands will lead to an estimated consumption quantity of 15.6 million tons in 2020. The diesel fuel consumption is estimated at 30.2 million tons in year 2006 increasing to 31.3 million tons in 2010 and 28.6 million tons in 2020. It is worth mentioning that the net export of gasoline and diesel fuel is presently 7.3 million tons. The prognosis anticipates that it will continue in approximately the previous magnitude. The net exports for fuels can be divided up into approximately one third gasoline and two thirds diesel fuel.

Table 2 Projection of Mineral Oil Consumption in Germany until 2025 (in million t)

Mineral oil products	2004	2005	2006	2007	2008	2009	2010	2015	2020	2025
Gasoline	25,0	23,4	22,6	22,0	21,5	21,0	20,5	17,9	15,6	13,6
Diesel	29,9	29,7	30,2	30,6	30,8	31,2	31,3	30,5	28,6	26,0

Source: Mineralölwirtschaftsverband e.V. (2006)

4.1.1.2 Biofuels

The demand for biofuels resulted up to the year 2006 from the economic advantage for use through its exemption from the mineral oil tax. Upon introduction of the energy tax law and the law for biofuel quotas in August and October 2006, the demand for biofuels is determined by the German fuel quotas and by the target figures of the EU biofuel directive. Table 3 indicates the demand quantity in the year 2005 of 0.7 million tons on the basis of the EU quantity target of 2 %. At a quantity target of 4.4 % (German biofuel quota) and diesel fuel consumption of 30.6 million tons, this results in a demand of 1.56 million tons in the year 2007. At an EU quantity

target of 5.75 % and diesel fuel consumption of 31.3 million tons, the quantity of diesel fuel demand in 2010 would be 2.09 million tons.

Table 3 Targets and Quantities of Biodiesel in Germany

	Unit	Target 2005	Target 2007	Target 2010
Quantity target	%	2,00	4,40	5,75
Diesel consumption [1)]	million t	29,70	30,60	31,30
Demand on biodiesel [2)]	million t	0,70	1,56	2,09

Source: own calculations.

[1)] MWV (2005)

[2)] energetic; Basis: fuel value diesel: 43 MJ/kg; fuel value biodiesel: 37 MJ/kg

The demand for bioethanol is also determined by the target figures in the EU biofuel directive which are stated more precisely in the law for biofuel quotas in Germany. According to this, the quantity target of 1.2 % is set for the year 2007. This results in demand for 0.39 million tons of bioethanol, assuming consumption of 22 million tons of gasoline in Germany (Table 4). In the year 2010, the quantity target specified for Germany is 3.60 %, however, this figure is 5.75 % for the EU-25 according to the EU biofuel directive. At a gasoline consumption of 20.5 million tons in Germany in 2010, 1.09 million tons of ethanol will be required to fulfill the German biofuel quota while 1.75 million tons of ethanol are necessary to fulfill the EU biofuel directive. If the entire biofuel quota in Germany, which is to be increased to 6.75 % in 2010 were fixed at 6.75 % obligatorily for biodiesel as well as for bioethanol, 2.05 million tons of ethanol will be required in year 2010.

Table 4 Targets and Quantities of Bioethanol in Germany

	Unit	Target 2005	Target 2010	Target 2010	Target 2010
Quantity target	%	1,2	3,60	5,75	6,75
Fuel consumption (gasoline)	Mio. t	22,0	20,5	20,5	20,5
Demand on ethanol [1)]	Mio. t	0,39	1,09	1,75	2,05

Source: own calculations.

[1)] energetic; fuel value ethanol 27 MJ/kg; gasoline 40 MJ/kg

4.1.2 Supply

4.1.2.1 Biodiesel

Production and sale of biodiesel has developed rapidly under the protection of tax exemption since the year 1995. At the end of 2005, the production capacity for diesel was approx. 2.3 million tons, which will increase to 3 to 4 million tons by the end of 2006 as a result of additional facilities when put into service (Bockey, 2006). The capacity of the oil mills, which presently amounts to over 5.5 million tons, is also being expanded rapidly. The raw material for production of biodiesel in Germany is almost exclusively rapeseed. The present agricultural area of 1.4 million ha (2006) for rapeseed has virtually reached its biological cultivation limit. Nevertheless, under changing basic political conditions in favor of rapeseed cultivation, a maximum rapeseed cultivation area of 2 million ha can be assumed in Germany. A valuable by-product during production of oil is rape meal or rape cake and, with the RME production, glycerin.

4.1.2.2 Bioethanol

The present production capacities for bioethanol in Germany in 2006 for three large-scale production systems was 0.6 million m^3 or 0.48 million tons, which, however, were not fully exhausted. According to research by eBIO (2006), 7 other facilities are under construction in the EU-25 and an additional 27 plants are planned. If these plans are realized, the present production capacity of 1.3 million m^3 in the EU-25 in

2006 will increase upon completion of the facilities under construction to 2.2 million m^3 and, after completion of the planned facilities to 6 million m^3 per year. Of this quantity, approximately 1 million m^3 would be produced by facilities in Germany. In this context, it should be mentioned that not all facilities for production of bioethanol are based on grain as raw materials. Alcohol from wine, sugar beets and molasses can also be used. The material remaining after production of ethanol is processed primarily to a high protein feed. It replaces soya meal in terms of the effective protein content at a ratio of approx. 1.3 (DDGS) to 1 (Soya meal).

4.2 Raw Materials for Biofuels

4.2.1 Situation on World Market

Since the grain market was subject to extreme price variations during the last two harvest years, it is necessary to briefly discuss the current and mid-term development. The current price increase for grain can be explained with singular events. Above all, the 14 million ton lower harvest in the EU-25 in 2006 and the higher liberalization of the grain market situation have lead to major price deviations in the EU and on the world market (TOEPFER, 2006). Other causes for the price situation include the lower world grain harvest and significantly reduced final stocks of grain (Agra-Europe 39/2006, September 25, 2006)

On a mid-term basis, however, the following facts can be assumed. Agricultural products will be traded to a considerable extent worldwide as well as between states of large domestic markets such as the EU and North America (see Appendix, Table A-1). The agricultural products are used to the major extent for production of foodstuff. They have been used for production of bioethanol in Brazil and the USA as well as for production of biodiesel, particularly in Germany, for only a few years. However, for a number of years, the influence of an increasing demand for the traded agricultural products for the energy sector has also had a noticeable influence on the commercial flows and prices.

A preview of the markets for agricultural products (FAPRI, 2005) shows a virtually constant development of the cultivation areas for the most important agricultural

products with the exception of soya, because a significantly increasing demand is assumed in the markets for oils and fats, as well as animal feed. The expansion of production is primarily the result of continuing increases in the yields. An over-proportional increase is expected for the net trade, particularly for wheat, corn, rice and soya. By comparison, other oil seeds play only an insignificant role in world production and trade. Remarkable is the expected increase in the real prices, particularly for various types of grains which is attributable in this prognosis, solely to the change in demand for the foodstuffs sector. All the same, this amounts to between 10 and 15 %. Newer prognoses from OECD take the effect of higher world market prices for fossil energy sources on the agricultural prices into consideration. They lead to the conclusion that the presently expected increase in production of bioenergy sources will result in a significantly higher price increase on the international markets for sugar, grain and oil seeds (VON LAMPE, M., 2006), at sustained high energy prices in the magnitude of 15 and 30 %.

Under the pressure of the price development for crude oil in the world market during the last two years, the danger exists that similar high price expectations would be assumed for crude oil in the future. By contrast, newer prognosis for the world market price for crude oil are in the magnitude of 50 US$/barrel. At this price level, the additional effect of an increase in the agricultural prices in the world market should be rather moderate (Commercial Energy Institute of the University of Cologne and Prognos AG, 2006).

4.2.2 Situation on EU Market

As a matter of principle, considerations assume that agricultural production in Germany, in the EU-25 and worldwide will have absolute priority for covering the demand for foodstuffs for the population and provision of renewable raw materials of high quality and therefore, competitive material applications. The production and use of agricultural raw material for non-subsidized expert markets with lucrative marketing chances has equivalent priority. Therefore, only the following are available as potentials for bioenergy sources:

- Previously fallow areas within the scope of obligatory abandonment (not used in contract cultivation for renewable raw materials)

- Structural surpluses, produced previously within the scope of the market structure for intervention and/or subsidized export, particularly grain and sugar.

In principle, milk, milk products and beef should also be included. However, it cannot be assumed that the corresponding EU market structures will be liberalized to such an extent that these surpluses will no longer be produced in the future.

A balance of the fallow areas still available and areas presently used for production of subsided export surpluses for sugar and grain allows calculation of the theoretically usable potential area for bioenergy sources. This can be used either exclusively for certain energy plants such as grain and sugar beets for production of ethanol, rapeseed for biodiesel or silo corn for biogas plants. However, since the structure of use is not known or can only be speculated, it is assumed below that the potentially usable areas will be utilized for the cultural mixture presently used for crop rotation. This procedure is intended to prevent over-estimating energy plant potentials by neglecting crop rotation limits and obligations for sustainability. In each case, the potential is estimated for the year 2010 and 2020 using a average for a number of past years as the basis. It is necessary to estimate the future foodstuffs consumption to make a prognosis regarding the future.

4.2.2.1 Export Surpluses for Grain

During the years 2000-2003 (4-year average), Germany exported an average of nearly 12 million tons of grain, primarily wheat, barley and rye (see Appendix, Table A-2). This was offset by imports of approximately 3.5 million tons, so that on the balance, more than 8 million tons of grain were exported on a net basis (FAOSTAT). France even had a net export in the basis of 15 million tons of grain (see Appendix, Table A3). Germany and France were the primary exporters of grain. The export surplus of the EU-15, however, was only 11 million tons, the surplus for the EU-25, 13 million tons of grain (see Appendix, Tables A-4 and A-5).

4.2.2.2 Potential from Uncultivated Areas

In addition to this, 5 to 6 million tons of grain could have been produced on the obligatorily uncultivated areas in Germany with the existing cultivation mixture; in France, this would have amounted to approximately 7 million tons of grain (see Appendix, Table A-6) (EUROSTAT).

4.2.2.3 Future Supply Situation for Agrarian Raw Materials

In Germany and in the EU-25, highly increasing expansion of the potentials for bioenergy result in the estimate for availability of agrarian raw materials for the future periods of 2010 and 2020. The population is increasing only slightly and the consumption per person is also increasingly slightly in most member countries as well as in Germany (see Appendix, Table A-7). By contrast, the yields are increasing in all countries at a magnitude of 1.5 % per year and, particularly for the potential energy crops even higher increase figures have been realized to date, which are also expected in the future (see Appendix, Table A-8). The balance of all developments results in an additional area potential of 2.1 million ha, in comparison to the basis for Germany, which will increase again by 2.7 million ha during the period from 2010 to 2020 (see Appendix, Table A9). However, of this figure, approximately 1 million ha was reserved as grassland and in the year 2010 and in the year 2020 approximately 1.75 million ha, which cannot be taken into further consideration here for biofuels (THRÄN et al., 2006).

Assuming the cultivation mixture for the previous cultivation situation, this results in a potential area on arable farmland totaling 420,000 ha in 2010 for moist biomass and approximately 2.2 million ha for dry biomass (Table 5). In the year 2020, approximately 800,000 ha will be available for moist biomass and approximately 4.4 million ha for dry biomass including approximately 3.5 million ha for grain (see Appendix, Table A10).

Table 5 Theoretical (additional) Production Potential in Germany and in the EU-25 (in ha)

	Moist biomass 1000 ha			Total 1000 ha	Dry Biomass 1000 ha							Total 1000 ha	Quantity 1000 ha
Year	Silage maize	Lucerne	Sugar beets		Sun-flowers	Rape-seed	Wheat	Triticale	Rye	Barley	Grain maize		
Germany													
Basis 2000-2004	116	3	47	**166**	3	111	307	51	85	218	39	**814**	**980**
2010	316	7	97	**420**	22	335	896	138	316	399	122	**2228**	**2648**
2020	628	14	168	**810**	36	611	1842	274	647	760	253	**4423**	**5233**
EU 25													
Basis 2000-2004	538	139	240	**917**	259	540	2534	240	396	1422	699	**6090**	**7007**
2010	1224	457	480	**2161**	759	1120	5928	587	1175	5672	2384	**17625**	**19786**
2020	2875	1312	1084	**5271**	1097	2715	12996	1251	2753	9473	5714	**35999**	**41270**

Source: own calculations.

The percentage of the area used for moist and dry biomass is virtually interchangeable depending on the demand situation. Initial prognosis estimate the extent of silo corn area in Germany to be up to an area of 1.8 million ha assuming continuous expansion of biogas plants (GÖMANN et al., 2006). Since, according to the calculations for moist biomass, a total of only 640,000 ha would be available without changing the cultivation mixture, the additional 1.2 million ha would come from released grassland or be at the expense of rapeseed and grain cultivation.

On the basis of the yield per area and the growth rates up to 2006, the theoretically available potential for biofuels can be calculated at least for dry biomass. Again, a considerable production surplus of 1.8 million ha or 14 million tons results particularly for the grain products in the year 2010 with overproportional growth up to the year 2020 (Table 6).

Table 6 Theoretical (additional) Production Potential of Raw Materials for Biofuel Production [1)]

Raw material	Unit	Germany			EU 25		
		2000	2010	2020	2000	2010	2020
Available land							
Moist biomass	1000 ha	119	323	642	677	1681	4187
Rapeseed	1000 ha	111	335	611	540	1120	2715
Sunflowers	1000 ha	3	22	36	259	759	1097
Cereals	1000 ha	700	1871	3776	5291	15746	32187
Sugar beets	1000 ha	47	97	168	240	480	1084
Theoretical production potential for biofuels							
Rape seed	million t	0,37	1,29	2,73	1,50	3,60	10,14
Sunflower seed	million t	0,01	0,06	0,11	0,45	1,53	2,55
Cereals	million t	4,61	14,31	33,61	25,45	87,86	208,54
Sugar beets	million t	2,75	6,57	13,22	9,25	21,45	56,26

Source: own calculations.

[1)] yield increase 1,5 %/year

In the EU-25, a similar production development can be expected with relative magnitudes equivalent to those in Germany. The average figures are based on overproportional growth in France, Poland, the Czech Republic, Hungary and Spain, while other member countries have no potential or below-average growth (Denmark,

Latvia, Lithuania, etc.). The new member countries Rumania and Bulgaria are potential surplus countries for agricultural products, which offer an additional potential.

5 Potentials for Biofuels

Further calculations estimate the production potential for biofuels (Table 7). Initially, competition for utilization of the areas, for example, production of biogas on potential areas or use of grain in agricultural small furnace systems or as co-ferment in biogas plants, are not taken into consideration. Further competition for utilization could result from increased dedication of FFH and conservation areas as well as flood protection areas. The maximum potentials for biofuels are therefore reflected below. Since biodiesel and bioethanol have a common quantity target, the balances for both biofuels are determined separately.

5.1 Biodiesel

A consumption quantity of 1.8 million tons of biodiesel is assumed for the year 2005. A portion of this is provided through imports. Since the imports result on the basis of comparative cost advantages, the actual use of this import quantity is used as a basis. This leads to a percentage of biodiesel of 5.2 % of the total diesel fuel consumption in the year 2005. The estimate for 2010 assumes an increase for rapeseed of 335,000 ha on presently uncultivated areas and arable land no longer used for production of foodstuffs. In consideration of the yield increase, this results in a quantity potential of 1.29 million tons of rapeseed for Germany in the year 2010 (Table 6). This quantity would allow production of approx. 0.516 million tons of biodiesel. In consideration of the fuel value, this results in an energy equivalent quantity of 2.00 million tons of diesel mineral oil substitution in consideration of the contribution of sunflower seeds (considering the previously already available quantity of biodiesel). Biodiesel could therefore cover an energetic percentage of 6 % in the year 2010. In the year 2020, the overall diesel consumption is expected to decrease lightly: Rapeseed production can be accomplished on an additional area (of

611,000 ha). The calculations lead to an energetic equivalent share of 2.50 million tons of biodiesel corresponding to 8.75 %.

Table 7 Theoretical (additional) Potential for Biofuels

	Unit	Germany			EU 25		
		2005	2010	2020	2005	2010	2020
Diesel							
Diesel consumption	million t	29,70	31,30	28,60	158,60	165,00 [5)]	178,20 [5)]
Biodiesel potential out of	million t	1,80 [1)]	-	-	2,00	-	-
Rape seed [8)]	million t	-	2,316	2,892	-	3,44	6,06
Sunflower seed[9)]	million t	-	0,011	0,017	-	0,73	1,22
Total	million t	1,80	2,327	2,91	2,00	4,17	7,28
	Energy equivalent [3)] million t	1,55	2,00	2,50	1,72	3,59	6,26
Possible share of diesel	%	5,20	6,40	8,75	1,10	2,18	3,52
Gasoline							
Gasoline consumption	million t	23,40	20,50	15,60	124,80	113,60	98,00 [6)]
Bioethanol potential out of	million t	0,48	-	-	1,03	-	-
Cereals [7)]	million t	-	3,79	8,89	-	23,24	55,17
Sugar beets	million t	-	0,54	1,05	-	1,70	4,47
Total	million t	0,48	4,81	10,72	1,03	25,97	60,67
	Energy equivalent [4)] million t	0,32	3,25	7,03	0,70	17,53	40,95
Possible share of Gasoline	%	2,05	15,85	45,1	0,56	15,43	41,8

Source: own calculations.

[1)] Incl. Import
[2)] 1 t Ethanol = 1,26 m^3; 1 m^3 Ethanol = 790 kg
[3)] Fuel value diesel 43 MJ/kg; fuel value biodiesel 37 MJ/kg
[4)] Fuel value gasoline 40 MJ/kg; fuel value bioethanol 27 MJ/kg
[5)] Assumption: Increase of diesel consumption 2005-2010 +4 %, 2010-2020 +8 %
[6)] Assumption: decrease of gasoline consumption 2005-2010 -9 %, 2010-2020 -16 %
[7)] Assumption: 3,78 t Cereals yield 1 t Ethanol
[8)] Rape seed 40% yield of oil
[9)] Sunflower seed 48% yield of oil

In the EU-25, a diesel fuel consumption of nearly 160 million tons is assumed, using approximately 2 million tons of biodiesel presently. The theoretical potentials for additional expansion of the rapeseed cultivation areas are comparatively low based on Germany; those for sunflower seeds significantly higher. Nevertheless, rapeseed dominates in the EU-25 in the production of oil bearing plants. Using the

corresponding calculation process, the percentage of biodiesel in the total diesel consumption will be 1 % in 2005 and could increase to 2.18 % in the year 2010 and to a maximum of 3.52 % in 2020. The comparatively low potential for biodiesel in the EU-25 results, on the one hand, from the fact that, in addition to Germany, only France, Poland, the Czech Republic and Hungary will release large arable areas for rapeseed. On the other hand, it is assumed that only the grain cultivation mixture can be produced on the release areas for reasons of crop rotation. This means that, in the event of a significant shift in the competition situation in favor of rapeseed (and sunflower seeds), a higher potential can develop for biodiesel, however, a lower potential remains for bioethanol. Even assuming that cultivation of rapeseed and sunflower seeds could be expanded, for example, at the expense of grain and, in some areas also at the expense of sugar beets (with declining sugar beet cultivation area), clear limits exist for provision of biodiesel in the total diesel consumption in the EU-25.

5.2 Bioethanol

The situation in the gasoline sector differs fundamentally. In Germany, as well as the EU-25, consumption will decrease significantly. The present percentage of bioethanol in gasoline is at a very low level in Germany as well as in the EU-25. In the year 2010, approximately 14 million tons of grain and approximately 6.5 million tons of sugar beets will be available theoretically for production of bioethanol, in addition to the figures for 2005 (Table 6). This results in an additional potential of 4.33 million tons of ethanol in comparison to the year 2005. If the present production figures for ethanol of 0.48 million tons are added to this, 4.81 million tons will be available theoretically in the year 2010. Converted to an energy basis, 3.25 million tons of the 20.5 million tons of gasoline consumption then expected could be replaced. Therefore, a maximum of 15 % of the gasoline could be substituted in energy terms by bioethanol. By the year 2020, this percentage would even increase to 45 %, if all available resources for production of grain and sugar beets were used for production of ethanol. The capacity of the ethanol plants in Germany would then have to be approximately 11 million tons. This would mean that approximately

50 new ethanol plants would have to be constructed each with a capacity of 200,000 ethanol/year.

The percentage of bioethanol in gasoline in the EU-25 could not be increased quite as drastically. However, nearly 90 million tons of grain and 20 million tons of sugar beets will be available in addition theoretically in the year 2010. This would allow production of 26 million tons of ethanol with a calorific equivalent value of approx. 18 million tons of gasoline. This would make possible substitution of 15 % biofuel in the gasoline consumption. This could even be increased to 40 % by the year 2020 in the EU-25 in the face of highly decreasing gasoline consumption. This, however, would require construction of approx. 125 new ethanol plants with a capacity of 200,000 t/year. This would put the EU-25 on approximately the same level as Brazil and the USA in terms of their extension plans.

6 Evaluation of Results

In comparison to other estimates presented previously, higher theoretical potentials for biofuels are calculated with the methods used here. This results particularly from the fact that previously presented calculations are an estimate only for the year 2005, however, some for the year 2010 as well. Although they also conclude the theoretical potentials from the uncultivated areas still available and surpluses of agrarian raw materials for "dry biomass", they do not consider the continuing trends in the population growth, per person consumption of foodstuffs, yield increases in agriculture, new use of areas at the cost of agricultural areas and release potentials from improvement of feed stock utilization in animal husbandry.

The results presented using this calculation method do, however, require interpretation in regard to the background of increasing competition for utilization for the arable areas no longer required for production of foodstuffs in addition to the production of biofuels. The construction of **biogas plants** will continue, particularly in Germany, due to the extremely attractive energy savings law. These investments could even continue on an accelerated basis through use of biogas in natural gas networks after appropriate treatment. In addition to moist biomass, biogas plants could also use grain, which would then no longer be available for biofuels.

Expansion of the area available for cultivation of corn as an energy source from approximately 150,000 ha to 1.8 million ha in Germany by the year 2020 does not, however, appear to exhaust the economic potential. In addition, 1 million ha of released grassland will be available for biogas in the year 2010 and approximately 1.75 million ha by the year 2020.

In Germany, a portion of the self-produced grain could be utilized directly for heat in small heating plants for agricultural operations in Germany if **combustion of grain** is approved, however, this quantity would be relatively low (approximately 50,000 plants for 15 tons would required only 100.000 ha).

Finally, the government could reserve increasing numbers of areas for **conservation** or restrict their utilization.

Assuming that approximately 0.9 million ha is reserved for the purposes mentioned above by 2010 and approx. 1.8 million ha by 2020 in Germany, and therefore not be available for biofuels, it would still be possible to cover approximately 10% of the gasoline consumption in 2010 and approximately 20 % in 2020 with bioethanol. As long as the obligation exists to not cultivate areas, no competition exists for utilization for procurement of the raw material when the ethanol producers conclude **cultivation contracts for non-cultivated areas**. This is being used to an increasing extent.

Utilization competition with a negative effect on the results through production of facilities for **BtL** is presently not planned and hardly expected for 2020. Cost calculations on BtL assume cheap raw materials such as remnant straw and remnant wood. Grain, with only a slightly higher energy content than straw, would increase the cost for BtL to such an extent that it would not longer be economical. This also applies for grain grass plants. The use of perennial energy plants such as miscanthus and fast growing plantations would be more economical. Competition will occur on the market only when BtL has established itself; specifically when BtL is clearly preferred to bioethanol by fuel consumers. The production capacity for BtL from residue wood and residue straw (30 million tons of biofuel in Germany) is estimated by DINJUS to be 5 million tons/year for Germany (2006). This would

presently allow substitution of 10 % of the diesel and gasoline consumption. This would require approximately 30 BtL plants by the year 2020.

The following quantities and shares of biofuels could be produced in Germany in the year 2020 without any significant competition occurring for utilization of the raw materials:

- Biodiesel 2.91 million tons: 8.75 % of diesel consumption
- Bioethanol 10.72 million tons. 45.1 % of gasoline consumption
- BtL 5 million tons.: 11.3 % of total consumption of diesel and gasoline
- Percentage of biofuels on total consumption 33 % (breakdown: Biodiesel 5.6 %, bioethanol 16 %, BtL 11.3 %)

Such elements are not recognizable in other EU member countries or only in a highly reduced form. Therefore, an additional potential from the adjacent EU member countries would be available in Germany for supply of raw materials for biofuels with which, a very considerable international trade already exists, particularly for rapeseed and grain. Simultaneously, it would be taken into consideration that the final biofuels, biodiesels and bioethanol are also products requiring a great deal of transport. To this extent, reservations regarding investments in biodiesel and bioethanol plants in Germany, even in the face of existing demand resulting from biofuel quotas in Germany, could be compensated by supplies from adjacent countries. Finally, all considerations must include the fact that international trade will also occur to an increasing extent. Expected import contingence for bioethanol, grain, sugar and other products within the scope of the Mercosur negotiations will probably flow preferably in the direction of Germany in view of the present basic conditions. This would make an additional quantity of bioethanol of up to 1 million tons available by the year 2010. This would cover the fuel quota for gasoline in Germany of up to 3.3 % by the year 2010 and up to 4.3 % by the year 2020.

The potential for biodiesel are limited and will reach their capacity limits within a few years. BtL will be available on a major commercial basis only in the course of the next decade. Expansion remains limited to remnant wood and remnant straw according to the present state of knowledge. This would allow substitution of a maximum of 10 % of the diesel and gasoline consumption in the year 2020.

The biofuel percentage from BtL and biodiesel would therefore remain less than 18 % in Germany. During the next 10 years it would then remain at comparatively low percentages of biodiesel. Bioethanol is presently the only biofuel technology available which could be expanded quickly and would offer significant potentials: For this reason, ethanol is supported in the USA, China and other countries to a much greater extent than in Germany and several EU member countries.

7 Conclusion

(1) The supply of biodiesel and the capacities of the RME plants and oil mills are present to such an extent that the biofuel quota for diesel in Germany could already be fulfilled in the year 2007. By 2010, up to 6 % would be achievable and by the year 2020 up to 8 %. BtL will be available on a large scale commercial basis only in the next decade. The use of raw materials remains limited to remnant wood and remnant straw primarily, according to present knowledge: The plant capacities for bioethanol presently are sufficient only to cover less than 2 % of the gasoline consumption. If a higher percentage of biofuels is targeted, this can be achieved initially only using bioethanol as ETBE, admixture or as pure fuel.

(2) Potentials for biofuels, particularly bioethanol, consist to date of uncultivated areas and structural surpluses; these would presently allow substitution of approximately 2.4 million tons of the gasoline consumption corresponding to approximately 10 %.

(3) In the future, the potential of agrarian raw materials for biofuels in Germany and in the EU-25 will increase (stagnating consumption of foodstuffs with strong increases in yields). Up to the year 2010, more than 2.5 million ha and up to the year 2020,

more than 5 million ha of arable land will be released from the present production of foodstuffs in Germany.

(4) In addition to a biodiesel quota of approx. 5 %, a 15 % bioethanol quota could be achieved by the year 2010 and by the year 2020, this could even increase to 8 % biodiesel quota and over 40 % bioethanol quota. Beyond this, 10 % BtL could also easily be provided from remnant materials.

(5) This assumes that sufficient investment security will allow expansion of the ethanol production capacities. Presently, great deficits are visible here. The tax exemption until only 2008, then taxation according to overcompensation until 2012, with great insecurity regarding the subsequent tax regulation is insufficient in view of the extremely high investments required for a bioethanol plant. Moreover, the development of the crude oil price is difficult to estimate. Also significant is the risk that the import protection for bioethanol would be rescinded or reduced to one half the rate for denatured alcohol.

(6) Bioethanol is presently the only available biofuel technology which could be expanded quickly and would offer significant potentials. This is the reason why the USA, China and other countries support ethanol to a much greater extent than Germany and a number of EU member countries.

Bibliography

Mineralölwirtschaftsverband Hamburg e.V.:MWV- Prognose 2025 für die Bundesrepublik Deutschland, June 27, 2006

Bockey. D. (2006): Biodiesel und pflanzliche Öle als Kraftstoffe – aus der Nische in den Kraftstoffmarkt. In: Biogene Kraftstoffe – Kraftstoffe der Zukunft? Forschungszentrum Karlsruhe Nr. 1, 15. Jahrgang-2006.

eBIO (2006): Bioethanol for fuel in the EU. Written notification.

Toepfer (2006): Marktbericht September 2006. Alfred C. Toepfer International GmbH, Hamburg.

FAPRI, Agricultural Outlook (2005)

Lampe, M. von (2006): Agricultural market impact of future growth in the production of biofuels. OECD, Paris

Richtlinie 2003/30/EG des Europäischen Parlaments und des Rates zur Förderung von Biokraftstoffen oder anderen erneuerbaren Kraftstoffen im Verkehrsektor von 08.06.2003, Amtsblatt der Europäischen Gemeinschaften, 17.05.2003, L/123/42FF.

Energiewirtschaftliches Institut an der Universität Köln/Prognos AG, 2006: Auswirkungen höherer Ölpreise auf Energieangebot und -nachfrage

FAOSTAT: Statistics from the Food and Agriculture Organisation of the United Nations.

EUROSTAT: Annuals Statistics

Thrän, D., W. Weber, A. Scheuermann, N. Fröhlich, J. Zeddies, A. Henze, C. Thoroe, J. Schweinle, U. Fritzsche, W. Jenseit, L. Rausch and K. Schmid (2006): Sustainable strategies for biomass use in the European context. IE- Report, Edition 1/2006, Institut für Energetik und Umwelt.

Gömann, H., P. Kreins and T. Breuer (2006): Deutschland- Energie-Corn-Belt Europas? FAL Braunschweig und Universität Bonn. In print.

Dinjus, D. (2006): Zukunftsvision “Biomass to liquid”, Landwirtschaftlicher Hochschultag der Universität Hohenheim (June 26, 2006). In: Landinfo, issue 6/2006, in print.

APPENDICES

Data Sources for the Potential Estimation (including comments)

Appendix 1: World Market for Grain, Oilseeds and Sugar

The preview for worldwide production and trade of grain, oil seed and sugar was completed before the drastic increase in the world oil price in 2004. A strong increase in wheat and corn production, and a strong increase in sugar production were determined while the production increase will rise and oil plants was more modest. A mentionable expansion of the cultivated areas is expected only for Soya. The net trade will increase overproportionally for all products. The prognosis indicates real increasing prices for all types of grain, stagnating prices for oil plants and decreasing prices for sugar.

Newer prognosis from the OECD indicate similar price increases for grain, however, increasing prices for oil plants and sugar by including a higher world market price for crude oil.

Regarding the availability of raw materials for biofuels, it can be assumed that the demand for grain and oil seed initially concentrated in the USA and EU can be supplied by the world market, without problems, even if the import demand is high.

Table A-1: Global Production and Trade of Cereals

		2004/05		2014/15	
Wheat					
Cultivated area	Million ha	217.9		219.1	
Production	Million t	619.0	(621)	658.6	(688)
Net trade	Million t	89.9		108.4	
Price U.S.FOB Gulf	US dollars t	152.0	(152)	164.3	(162)
Maize					
Cultivated area	Million ha	143.3		144.9	
Production	Million t	700.8		767.1	
Net trade	Million t	76.6		95.2	
Price U.S. FOB Gulf	US dollars t	96.0	(101)	114.0	(121)
Barley					
Cultivated area	Million ha	58.2		56.3	
Production	Million t	151.3		148.8	
Net trade	Million t	13.8		17.5	
Price Canada Feed	US dollars t	84.0		94.0	
Rice					
Cultivated area	Million ha	149.7		149.6	
Production	Million t	400.0	(408)	447.5	(466)
Net trade	Million t	22.9		32.9	
Price Thai 100% Grade B	US dollars t	309.0	(256)	341.0	(322)
Soya					
Cultivated area	Million ha	93.1		103.6	
Production	Million t	230.8	(283)[1)]	272.9	(342) [1)]
Net trade in seed	Million t	57.2		84.9	
Net trade in meal	Million t	45.0		60.2	
Net trade in oil	Million t	9.0		13.4	
Price of seed Illinois Processor	US dollars	202.0		213.0	
Price of seed CIF Rotterdam	US dollars t	233.0	(235) [1)]	243.0	(264) [1)]

Source: FAPRI Agricultural Outlook 2005, 2004/05 actual values; figures in brackets acc. to OECD-FAO Agricultural Outlook: 2005-2014, 2004/05 estimated

Table A-1 (continuation): Global Production and Trade of Oilseeds and Sugar

		2004/05		2014/15	
Rapeseed					
Cultivated area	Million ha	26.5		26.5	
Production	Million t	43.0		46.1	
Net trade in seed	Million t	5.7		6.9	
Net trade in meal	Million t	2.2		2.7	
Net trade in oil	Million t	1.3		1.2	
Price of seed Cash Vancouver	US dollars	250.0		243.0	
Price of seed CIF Hamburg	US dollars t	245.0		246.0	
Sunflower					
Cultivated area	Million ha	21.8		22.3	
Production	Million t	25.3		30.2	
Net trade in seed	Million t	1.3		2.1	
Net trade in meal	Million t	2.3		2.9	
Net trade in oil	Million t	1.6		2.1	
Price of seed CIF Niederrhein	US dollars t	275.0		275.0	
Sugar					
Cultivated area sugar cane	Million ha	20.4		22.2	
Cultivated area sugar beet	Million ha	5.8		6.1	
Sugar production	Million t	141.7	(148)[2)]	170.9	(178)[2)]
Net trade	Million t	33.2		38.7	
Price FOB Caribbean	US dollars t	178.0		233.0	
Price crude sugar New York	US dollars t		(219)		(165)
Price white sugar FOB London	US dollars t		(252)		(198)

1) Total oilseeds or weighted oilseed price at European harbour
2) Crude sugar
Source: FAPRI Agricultural Outlook 2005, 2004/05 actual values; figures in brackets acc. to OECD-FAO Agricultural Outlook: 2005-2014, 2004/05 estimated

Appendix 2: Imports, Exports and Surpluses in the EU

The FAO offers consistent statistics for all EU member countries for description of the present surplus situation for the most important agricultural products. Since the import/export quantities vary highly from year to year, depending on the harvest results and other basic conditions, an average was calculated for the years 2000-2003 for the study. Net exports are preceded by a negative sign. The two largest agrarian exporters in the EU, Germany and France, as well as the net export figures for the EU-15 and EU-25 are illustrated as examples.

Table A-2 till Table A-5: Imports and Exports in t

Import/Export in t

Germany	2000	2001	2002	2003	2000 - 2003
Milk Fresh					
Import	931.785	680.966	933.855	1.404.341	987.736,75
Export	2.270.169	1.905.654	1.892.897	2.117.560	2.046.570,00
Difference	-1.338.384	-1.224.688	-959.042	-713.219	-1.058.833,25
Butter of Cow Milk					
Import	131.121	113.194	137.730	153.851	133.974,00
Export	52.492	48.167	46.617	84.079	57.838,75
Difference	78.629	65.027	91.113	69.772	76.135,25
Cheese (Skim Cow Milk)					
Import	554	541	693	566	588,50
Export	30	423	11	16	120,00
Difference	524	118	682	550	468,50
Cheese (Whole Cow Milk)					
Import	405.966	423.310	427.443	477.935	433.663,50
Export	519.611	540.675	502.012	647.258	552.389,00
Difference	-113.645	-117.365	-74.569	-169.323	-118.725,50
Meat Bovine Fresh					
Import	147.285	82.067	122.765	137.354	122.367,75
Export	350.624	485.915	430.629	374.759	410.481,75
Difference	-203.339	-403.848	-307.864	-237.405	-288.114,00
Meat of Swine					
Import	712.806	612.955	729.255	808.470	715.871,50
Export	325.996	393.842	464.666	553.711	434.553,75
Difference	386.810	219.113	264.589	254.759	281.317,75
Meat Poultry Fresh					
Import	339.235	397.983	374.725	368.579	370.130,50
Export	134.453	144.123	201.883	234.658	178.779,25
Difference	204.782	253.860	172.842	133.921	191.351,25
Cereals					
Import	3.446.125	2.883.894	3.631.290	4.021.188	3.495.624,25
Export	14.391.914	11.384.414	10.959.319	10.536.774	11.818.105,25
Difference	-10.945.789	-8.500.520	-7.328.029	-6.515.586	-8.322.481,00
Wheat					
Import	1.291.134	967.752	1.393.430	1.540.799	1.298.278,75
Export	4.569.373	5.710.406	5.872.406	4.473.168	5.156.338,25
Difference	-3.278.239	-4.742.654	-4.478.976	-2.932.369	-3.858.059,50
Rye					
Import	16.970	14.406	17.077	79.123	31.894,00
Export	1.993.222	1.001.084	1.003.053	953.848	1.237.801,75
Difference	-1.976.252	-986.678	-985.976	-874.725	-1.205.907,75
Barley					
Import	654.588	704.757	798.814	783.867	735.506,50
Export	6.146.482	2.888.541	2.251.565	3.179.001	3.616.397,25
Difference	-5.491.894	-2.183.784	-1.452.751	-2.395.134	-2.880.890,75
Oats					
Import	111.250	86.616	96.532	101.055	98.863,25
Export	26.103	28.207	38.058	30.397	30.691,25
Difference	85.147	58.409	58.474	70.658	68.172,00
Triticale					
Import	1.712	2.099	2.273	1.488	1.893,00
Export	68.532	164.398	220.350	169.936	155.804,00
Difference	-66.820	-162.299	-218.077	-168.448	-153.911,00
Maize					
Import	975.668	705.459	888.235	1.059.672	907.258,50
Export	553.373	595.657	664.692	856.604	667.581,50
Difference	422.295	109.802	223.543	203.068	239.677,00
Rapeseed					
Import	1.362.502	1.257.504	1.221.154	1.210.585	1.262.936,25
Export	621.546	682.506	775.211	389.142	617.101,25
Difference	740.956	574.998	445.943	821.443	645.835,00
Sunflower					
Import	354.325	330.913	239.996	283.625	302.214,75
Export	45.394	99.900	17.732	18.325	45.337,75
Difference	308.931	231.013	222.264	265.300	256.877,00
Sugar Total (Raw Equiv.)					
Import	284.148	288.065	324.404	415.571	328.047,00
Export	1.538.129	1.724.362	1.155.114	1.223.869	1.410.368,50
Difference	-1.253.981	-1.436.297	-830.710	-808.298	-1.082.321,50
Soybeans					
Import	3.840.424	4.574.084	4.345.729	4.515.526	4.318.940,75
Export	8.391	11.458	25.798	25.731	17.844,50
Difference	3.832.033	4.562.626	4.319.931	4.489.795	4.301.096,25

Source: FAOSTAT http://faostat.fao.org/faostat/collections

Import/Export in t

France	2000	2001	2002	2003	2000 - 2003
Milk Fresh					
Import	964.431	953.397	795.904	740.960	863.673,00
Export	908.603	993.921	829.293	856.077	896.973,50
Difference	55.828	-40.524	-33.389	-115.117	-33.300,50
Butter of Cow Milk					
Import	148.302	138.611	123.957	126.624	134.373,50
Export	71.381	69.282	73.128	74.694	72.121,25
Difference	76.921	69.329	50.829	51.930	62.252,25
Cheese (Skim Cow Milk)					
Import	85	308	82	38	128,25
Export	11	253	406	115	196,25
Difference	74	55	-324	-77	-68,00
Cheese (Whole Cow Milk)					
Import	209.644	203.309	195.020	202.070	202.510,75
Export	526.005	510.307	497.040	523.610	514.240,50
Difference	-316.361	-306.998	-302.020	-321.540	-311.729,75
Meat Bovine Fresh					
Import	279.019	206.782	233.337	223.153	235.572,75
Export	254.625	143.864	198.201	257.975	213.666,25
Difference	24.394	62.918	35.136	-34.822	21.906,50
Meat of Swine					
Import	319.909	300.565	280.487	298.992	299.988,25
Export	403.408	363.760	400.417	406.605	393.547,50
Difference	-83.499	-63.195	-119.930	-107.613	-93.559,25
Meat Poultry Fresh					
Import	134.009	149.183	150.056	163.434	149.170,50
Export	718.826	658.286	654.227	607.341	659.670,00
Difference	-584.817	-509.103	-504.171	-443.907	-510.499,50
Cereals					
Import	1.664.242	1.767.984	1.563.953	1.253.129	1.562.327,00
Export	32.746.384	28.363.250	27.936.918	30.583.815	29.907.591,75
Difference	-31.082.142	-26.595.266	-26.372.965	-29.330.686	-28.345.264,75
Wheat					
Import	454.147	533.187	478.214	223.471	422.254,75
Export	18.034.060	15.621.317	13.678.411	16.366.886	15.925.168,50
Difference	-17.579.913	-15.088.130	-13.200.197	-16.143.415	-15.502.913,75
Rye					
Import	2.501	2.474	6.362	15.681	6.754,50
Export	25.004	16.577	10.113	18.776	17.617,50
Difference	-22.503	-14.103	-3.751	-3.095	-10.863,00
Barley					
Import	98.933	46.718	24.598	27.016	49.316,25
Export	4.766.376	4.105.761	4.273.806	5.470.450	4.654.098,25
Difference	-4.667.443	-4.006.828	-4.227.088	-5.445.852	-4.586.802,75
Oats					
Import	9.118	13.218	1.461	1.570	6.341,75
Export	73.393	25.256	47.240	66.799	53.172,00
Difference	-64.275	-12.038	-45.779	-65.229	-46.830,25
Triticale					
Import	2.281	8.937	1.973	1.427	3.654,50
Export	4.348	8.611	6.986	14.457	8.600,50
Difference	-2.067	326	-5.013	-13.030	-4.946,00
Maize					
Import	281.458	293.257	234.729	216.805	256.562,25
Export	7.947.828	7.046.438	8.378.135	7.079.809	7.613.052,50
Difference	-7.666.370	-6.753.181	-8.143.406	-6.863.004	-7.356.490,25
Rapeseed					
Import	28.076	28.207	11.218	11.364	19.716,25
Export	2.244.967	1.418.319	1.638.157	1.717.428	1.754.717,75
Difference	-2.216.891	-1.390.112	-1.626.939	-1.706.064	-1.735.001,50
Sunflower					
Import	93.088	116.701	77.680	296.463	145.983,00
Export	526.592	555.643	372.620	283.754	434.652,25
Difference	-433.504	-438.942	-294.940	12.709	-288.669,25
Sugar Total (Raw Equiv.)					
Import	343.593	305.307	417.284	280.586	336.692,50
Export	3.208.705	3.011.609	2.951.083	2.762.302	2.983.424,75
Difference	-2.865.112	-2.706.302	-2.533.799	-2.481.716	-2.646.732,25
Soybeans					
Import	440.851	968.466	1.016.832	799.633	806.445,50
Export	20.308	5.412	21.473	28.378	18.892,75
Difference	420.543	963.054	995.359	771.255	787.552,75

Source: FAOSTAT http://faostat.fao.org/faostat/collections

Import/Export in t

EU-15	2000	2001	2002	2003	2000 - 2003
Milk Fresh					
Import	6.497.767	5.914.747	6.034.488	6.732.710	6.294.928,00
Export	5.942.093	5.460.399	5.276.619	5.873.963	5.638.268,50
Difference	555.674	454.348	757.869	858.747	656.659,50
Butter of Cow Milk					
Import	698.404	664.243	654.356	754.012	692.753,75
Export	660.345	688.399	673.532	839.572	715.462,00
Difference	38.059	-24.156	-19.176	-85.560	-22.708,25
Cheese (Skim Cow Milk)					
Import	1.662	1.918	1.791	1.619	1.747,50
Export	2.416	2.926	3.235	1.050	2.406,75
Difference	-754	-1.008	-1.444	569	-659,25
Cheese (Whole Cow Milk)					
Import	1.877.149	1.944.692	2.005.276	2.195.870	2.005.746,75
Export	2.254.103	2.322.464	2.324.725	2.576.431	2.369.430,75
Difference	-376.954	-377.772	-319.449	-380.561	-363.684,00
Meat Bovine Fresh					
Import	1.768.488	1.264.549	1.534.738	1.717.299	1.571.268,50
Export	1.759.969	1.489.390	1.687.900	1.790.765	1.682.006,00
Difference	8.519	-224.841	-153.162	-73.466	-110.737,50
Meat of Swine					
Import	2.713.025	2.717.377	2.733.753	3.004.158	2.792.078,25
Export	3.579.830	3.473.683	3.699.116	3.969.374	3.680.500,75
Difference	-866.805	-756.306	-965.363	-965.216	-888.422,50
Meat Poultry Fresh					
Import	1.347.399	1.453.421	1.430.848	1.595.985	1.456.913,25
Export	2.320.464	2.319.961	2.461.717	2.381.057	2.370.799,75
Difference	-973.065	-866.540	-1.030.869	-785.072	-913.886,50
Cereals					
Import	40.491.151	44.701.012	53.632.811	49.253.835	47.019.702,25
Export	65.425.708	55.159.176	54.879.690	58.712.602	58.544.294,00
Difference	-24.934.557	-10.458.164	-1.246.879	-9.458.767	-11.524.591,75
Wheat					
Import	21.062.402	23.842.415	28.964.477	23.797.654	24.416.737,00
Export	30.004.903	27.222.444	25.987.371	29.173.612	28.097.082,50
Difference	-8.942.501	-3.380.029	2.977.106	-5.375.958	-3.680.345,50
Rye					
Import	191.305	308.348	879.842	616.069	498.891,00
Export	2.102.377	1.265.638	1.257.002	1.065.073	1.422.522,50
Difference	-1.911.072	-957.290	-377.160	-449.004	-923.631,50
Barley					
Import	4.177.960	5.402.092	6.770.402	5.919.649	5.567.525,75
Export	15.198.410	9.876.701	9.216.013	11.656.871	0,00
Difference	-11.020.450	-4.474.609	-2.445.611	-5.737.222	-5.919.473,00
Oats					
Import	352.811	326.323	353.351	450.429	370.728,50
Export	941.018	1.150.857	1.192.611	1.035.917	1.080.100,75
Difference	-588.207	-824.534	-839.260	-585.488	-709.372,25
Triticale					
Import	57.110	151.196	204.732	321.377	183.603,75
Export	84.492	178.164	240.651	194.054	174.340,25
Difference	-27.382	-26.968	-35.919	127.323	9.263,50
Maize					
Import	10.253.756	10.251.805	11.965.255	12.541.901	11.253.179,25
Export	9.065.548	8.388.479	9.848.618	8.740.029	9.010.668,50
Difference	1.188.208	1.863.326	2.116.637	3.801.872	2.242.510,75
Rapeseed					
Import	2.996.081	3.351.234	2.774.239	2.510.034	2.907.897,00
Export	2.993.585	2.373.496	2.756.955	2.603.710	2.681.936,50
Difference	2.496	977.738	17.284	-93.676	225.960,50
Sunflower					
Import	2.575.505	2.258.202	1.712.747	2.119.256	2.166.427,50
Export	692.068	785.599	525.922	456.888	615.119,25
Difference	1.883.437	1.472.603	1.186.825	1.662.368	1.551.308,25
Sugar Total (Raw Equiv.)					
Import	3.901.797	4.727.569	4.779.852	4.663.627	4.518.211,25
Export	8.857.566	8.467.151	7.443.737	7.437.283	8.051.434,25
Difference	-4.955.769	-3.739.582	-2.663.885	-2.773.656	-3.533.223,00
Soybeans					
Import	16.116.339	19.964.284	20.199.168	19.400.005	18.919.949,00
Export	1.158.854	1.589.951	1.940.653	1.736.478	1.606.484,00
Difference	14.957.485	18.374.333	18.258.515	17.663.527	17.313.465,00

Source: FAOSTAT http://faostat.fao.org/faostat/collections

Import/Export in t

EU-25	2000	2001	2002	2003	2000 - 2003
Milk Fresh					
Import					
Export					
Difference					-544.679,75
Butter of Cow Milk					
Import					
Export					
Difference					60.426,00
Cheese (Skim Cow Milk)					
Import					
Export					
Difference					
Cheese (Whole Cow Milk)					
Import					
Export					
Difference					456.608,75
Meat Bovine Fresh					
Import					
Export					
Difference					-152.224,75
Meat of Swine					
Import					
Export					
Difference					-935.250,75
Meat Poultry Fresh					
Import					
Export					
Difference					-971.971,75
Cereals					0,00
Import					
Export					
Difference					-13.053.361,50
Wheat					
Import					
Export					
Difference					
Rye					
Import					
Export					
Difference					
Barley					
Import					
Export					
Difference					
Oats					
Import					
Export					
Difference					
Triticale					
Import					
Export					
Difference					
Maize					
Import					
Export					
Difference					
Rapeseed					
Import					
Export					
Difference					-364.308,75
Sunflower					
Import					
Export					
Difference					1.171.648,50
Sugar Total (Raw Equiv.)					
Import					
Export					
Difference					-3.694.146,75
Soybeans					
Import					
Export					
Difference					

no data available

Source: FAOSTAT http://faostat.fao.org/faostat/collections

Appendix 3: Change of Agricultural Land Uses

Data from EUROSTAT and FAOSTAT were used to determine the development of agriculturally used land, the cultivation ratio and fallow areas. The acknowledged fallow areas include only the areas actually not under cultivation, i.e. not used for production. A part of the obligatorily uncultivated land is used for cultivation of energy plants. These areas are assigned to the specific types of cultivation. Again, a four-year average was used as the basis for estimating the potential in this study for compensation of annual variations.

Table A-6: Cultivation Area of Agricultural Crops, Germany

Cultivated land in ha

Germany	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	**2000 - 2003**
Agricultural land	17.308.000	17.343.000	17.337.000	17.327.000	17.373.000	17.152.000	17.068.000	17.033.000	16.967.000		**17.022.667**
Cereals	6.235.246	6.526.735	6.707.515	7.024.879	7.031.633	6.638.210	7.015.663	7.045.731	6.940.982	6.866.977	**6.967.338**
Wheat	2.445.800	2.578.800	2.594.418	2.727.898	2.802.455	2.601.122	2.968.940	2.897.202	3.014.620	2.967.379	**2.962.035**
Rye	722.500	861.370	809.100	844.642	926.395	748.170	842.658	836.981	728.388	531.107	**734.784**
Barley	2.069.500	2.108.700	2.208.408	2.273.950	2.180.849	2.212.880	2.067.590	2.111.822	1.970.335	2.087.100	**2.059.212**
Oats	391.900	309.200	301.900	312.388	264.143	267.754	237.020	233.324	233.148	260.851	**241.086**
Triticale	208.000	288.600	364.224	437.814	468.546	386.458	499.475	533.492	560.466	504.840	**524.568**
Maize	345.546	325.065	372.200	369.600	341.029	370.735	360.841	396.544	398.745	472.700	**407.208**
Rapeseed	1.057.600	973.886	853.600	913.971	1.007.225	1.198.038	1.078.010	1.137.962	1.296.648	1.268.000	**1.195.155**
Sunflower	188.900	52.160	43.758	34.445	33.704	33.354	25.729	24.905	26.100	38.000	**28.684**
Sugar beet	502.722	523.599	515.500	504.147	503.376	489.164	452.000	447.697	459.400	444.900	**450.999**
Forage land[1)]	7.087.059	7.402.466	7.450.210	7.420.870	7.346.551	6.822.638	6.670.740	6.593.508	6.509.829	6.557.604	**6.582.920**
Field forage[1)]	1.816.309	2.120.457	2.176.772	2.152.454	2.081.137	1.708.851	1.623.097	1.580.904	1.540.208	1.589.324	**1.583.383**
Green maize [1)]	1.205.038	1.251.788	1.326.462	1.294.484	1.235.130	1.202.844	1.154.474	1.132.476	1.119.164	1.172.930	**1.144.761**
Permanent grassland [1)]	5.270.750	5.282.009	5.273.438	5.268.416	5.265.414	5.113.787	5.047.643	5.012.604	4.969.621	4.968.280	**4.999.537**
Fallow land[1)]	1.438.650	1.281.846	1.085.115	749.191	695.957	845.754	823.188	850.199	834.569	938.670	**861.657**

1) Source: EUROSTAT http://epp.eurostat.cec.eu.int/portal
Source: FAOSTAT http://faostat.fao.org/faostat/collections

Appendix 4: Initial Data for Prognosis of Foodstuff Requirement as well as Area and Yield Development

The data conglomerated in Table A-7 was used to estimate the potentials for biofuels and other renewable raw materials. The future consumption of foodstuffs and feed stocks was based on the population figures and the consumption per-capita. Applicable statistics and preliminary estimates were used for the development of the population. The consumption per-capita was determined from a current series for all important foodstuffs and estimated for 2010 and 2020 by means of regression analysis and plausibility considerations. For Germany, this resulted in per-capita consumption of 1,104.5 grain units in the year 2000 (as average over a number of years). This consumption will increase by 2.11 % in the period 2000-2010 (within 10 years) and will stagnate beginning in 2010. The change in the agriculturally utilized land was determined by regression calculation. For Germany, the reduction amounting to 0.509 % in 10 years is slight. The area used during the last few years was higher. In the past, the area was increased by recultivation of brown coal areas and new use of other areas. States with negative changes in the utilized areas have gained area by new use as agricultural areas (irrigation, land reclamation, etc.). The rates of change for the yields were determined by regression calculation for the past 10 years. The weighed increase in yield for all cultivated land was 15.16 % in Germany. It will continue to increase up to 2010 and 2020. The change rates for the yields are defined negatively, because these results in a release of area from production of foodstuffs for energy plants.

Table A-7: Development of Important Variables for Bioenergy Potential According to Countries

Country	Population			Per capita consumption			Agricultural used land			Change rates of yields in % (weighted average)		Area potential in ha and %					
	2000 (in 1000)	Change in % until		2000 (GE)	Change in % until		2000[2] (in 1000 ha)	Change in % until		2000 - 2010	2010 - 2020	2000	%	2010	%	2020	%
		2010	2020		2.010	2020		2010	2020								
Germany	82.188	1,07	-0,29	1.104,5	2,11	0,00	17.023	0,509	0,509	-15,16	-15,16	2.409.302	14,15	4.543.325	26,69	7.300.886	42,89
United Kingdom	59.623	3,56	3,49	998,2	7,00	0,00	16.954	5,708	5,708	-10,00	-15,00	-1.841.626	-10,86	-2.703.560	-15,95	-1.568.179	-9,25
France	58.749	3,17	1,10	1.328,9	3,29	0,00	29.631	2,465	2,465	-11,08	-15,00	6.722.083	22,69	7.629.654	25,75	11.214.504	37,85
Italy	57.680	1,53	-0,75	1.180,9	4,36	0,00	15.527	2,698	2,698	-10,00	-15,00	-2.652.431	-17,08	-2.280.070	-14,68	-132.652	-0,85
Spain	39.733	0,17	-1,18	1.223,4	5,48	0,00	29.914	1,132	1,132	-30,00	-30,00	652.192	2,18	8.145.458	27,23	17.363.878	58,05
Netherlands	15.864	6,30	3,72	1.087,8	-1,43	0,00	1.945	2,137	2,137	-10,00	-15,00	-308.240	-15,85	-198.557	-10,21	70.630	3,63
Belgium/Lux	10.675	2,75	2,22	1.203,1	1,43	0,00	1.518	-3,146	-3,146	-19,43	-19,43	-620.472	-40,87	-307.198	-20,24	54.895	3,62
Greece	10.554	1,50	-0,65	1.149,0	7,09	0,00	8.492	9,113	9,113	-10,00	-15,00	-26.126	-0,31	-604.295	-7,12	-37.576	-0,44
Portugal	10.198	1,09	2,10	1.018,3	8,04	0,00	4.142	-5,436	-5,436	-30,00	-30,00	-1.312.674	-31,69	-112.259	-2,71	1.335.635	32,25
Sweden	8.861	3,63	3,51	1.120,3	5,71	0,00	3.143	7,516	7,516	-14,00	-15,00	389.115	12,38	346.555	11,03	508.645	16,18
Austria	8.103	1,47	1,17	1.175,9	4,76	0,00	3.392	3,129	3,129	-10,00	-15,00	347.843	10,25	409.372	12,07	817.048	24,09
Denmark	5.330	3,28	2,49	1.195,2	6,05	0,00	2.663	3,851	3,851	-10,00	-15,00	737.888	27,71	726.583	27,28	1.063.183	39,92
Finland	5.171	1,80	1,10	1.057,5	3,38	0,00	2.220	9,467	9,467	-10,00	-15,00	388.344	17,50	306.668	13,82	429.084	19,33
Ireland	3.777	8,63	4,36	1.087,8	2,00	0,00	4.410	0,027	0,027	-14,92	-15,00	1.492.239	33,84	1.747.281	39,62	2.253.293	51,10
EU 15[1]	**376.482**	**1,83**	**0,65**	**1.154,8**	**5,37**	**0,00**	**140.974**	**2,643**	**2,643**	**-16,03**	**-18,69**	**10.737.522**	**7,62**	**21.943.932**	**15,57**	**45.027.911**	**31,94**
Cyprus	786	12,09	10,33	1.098,6	9,28	5,00	127	26,403	26,403	25,40	25,40	-329.446	-259,41	-411.437	-323,97	-481.882	-379,43
Czech Republic	10.267	-1,06	-2,22	1.006,1	3,20	5,51	4.277	0,095	0,095	-10,00	-15,00	528.230	12,35	890.254	20,82	1.446.831	33,83
Estonia	1.367	-4,24	-2,83	930,4	5,43	5,00	858	10,000	10,000	-30,00	-30,00	-1.094	-0,13	164.797	19,21	326.307	38,03
Hungary	10.266	-2,97	-3,34	895,6	7,27	5,31	5.862	6,275	6,275	-30,00	-30,00	1.187.649	20,26	2.406.215	41,05	3.751.584	64,00
Latvia	2.373	-5,27	-5,29	786,3	5,68	5,66	2.480	2,658	2,658	-26,62	-26,62	152.965	6,17	745.455	30,06	1.337.538	53,94
Lithuania	3.500	-4,06	-4,29	889,2	8,12	5,00	3.488	0,891	0,891	-30,00	-30,00	703.491	20,17	1.614.814	46,30	2.621.052	75,15
Malta	392	4,85	3,65	1.051,0	5,57	3,70	10	41,596	41,596	-10,00	-15,00	-46.590	-481,97	-50.028	-517,53	-52.200	-540,00
Poland	38.649	-0,75	-1,69	984,4	6,60	5,43	18.383	2,221	2,221	-12,97	-15,00	1.898.375	10,33	3.050.733	16,60	5.054.230	27,49
Slovakia	5.400	0,00	-0,93	862,0	0,00	5,59	2.441	0,295	0,295	-10,00	-15,00	132.973	5,45	380.209	15,57	659.883	27,03
Slovenia	1.967	-0,41	-2,14	1.063,0	6,50	3,86	511	12,436	12,436	-13,69	-15,00	-14.623	-2,86	-32.570	-6,37	-21.122	-4,13
Total (10)	74.967			1.063,0			38.436					4.211.930		8.758.442		14.642.222	
Bulgaria	7.997	-6,89	-7,88	786,8	6,86	7,01	5.468	1,457	1,457	-10,00	-15,00	817.886	14,96	1.304.019	23,85	2.120.113	38,77
Romania	22.117	-3,75	-4,19	811,7	6,87	7,00	14.849	-0,286	-0,286	-10,00	-15,00	285.104	1,92	1.434.611	9,66	3.424.658	23,06
Turkey	68.234	14,43	11,13	721,9	0,00	7,00	40.543	-1,271	-1,271	-14,51	-15,00	-742.840	-1,83	570.522	1,41	823.172	2,03
Candidate Countries	98.348						60.860					360.150		3.309.152		6.367.943	
EU 25	**451.449**	**1,32**	**0,22**	**1.132,8**	**5,20**	**0,90**	**179.410**	**2,604**	**2,604**	**-16,39**	**-18,89**	**14.445.153**	**8,05**	**30.009.163**	**16,73**	**59.249.232**	**33,02**
EU 28	549.797						240.270					15.309.601		34.011.526		66.038.076	

1) do not correspond with balance fo all countries due to imprecise data and data sources; 2) Average of 3 years

Source: own calculations

Appendix 5: Regression Coefficients

A primary data for the regression calculation is shown in Table A-8 as absolute yield increases, absolute regression coefficients and relevant regression coefficients. The year 2003 was not taken into consideration here because extreme crop failures occurred all over Europe. In Germany, the decrease in the land area amounted to 8,666 ha/year. The yield on grain increased by 0.85 dt/ha and year, or 1.3 % in relation to the average yield for the years 2000-2002 of 65.85 dt/ha. The regression coefficients obtained with the scope of cultivation for the primary cultures illustrated resulted in a relative increase in the yield for arable land cultivation in the amount of 1.52 %.

Table A-8: Agricultural Land, Yields and Regression Factors

Agricultural Area in 1000 ha

Germany	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	REG	REG in % per year
Agricultural Area	17.136	16.951	17.162	17.308	17.343	17.337	17.327	17.373	17.152	17.068	17.033	16.967	**-8,6678**	**-0,05**

Yield in dt/ha

Germany	1994	1995	1996	1997	1998	1999	2000	2001	2002	REG	weighting factor	weighted REG	REG in % per year
Cereals total	58,28	61,08	62,82	64,75	63,39	66,98	64,53	70,52	62,52	0,85	0,80	0,68	1,03
Rapeseed	27,38	31,87	23,08	31,36	33,64	35,76	33,26	36,56	29,68	0,80	0,15	0,12	0,36
Sunflowers	16,46	21,30	23,59	24,67	25,34	25,15	24,75	21,68	19,92	0,30	0,00	0,00	0,00
Sugar beets	481,60	497,50	505,61	511,14	532,15	563,78	616,60	552,38	583,25	14,10	0,05	0,74	0,13
Total											1,00	**1,54**	**1,52**

Table A-8 (continuation): Agricultural Land, Yields and Regression Factors

Agricultural area in 1000 ha

EU-15	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	REG	REG in % per year
Agricultural Area	145.197	144.525	143.770	143.608	142.456	142.721	142.365	142.328	142.091	141.103	140.831	140.987	**-372,5524**	**-0,26**

Yield in dt/ha

EU-15	1994	1995	1996	1997	1998	1999	2000	2001	2002	REG	weighting factor	weighted REG	REG in % per year
Cereals total	50,11	49,90	55,90	54,01	56,41	55,50	57,32	55,03	56,62	0,76	0,85	0,65	1,15
Rapeseed	25,23	28,79	27,21	31,09	30,91	32,19	29,88	29,70	30,36	0,49	0,07	0,03	0,11
Sunflowers	13,71	13,34	16,13	17,54	16,25	15,99	17,78	16,12	16,86	0,38	0,04	0,01	0,08
Sugar beets	515,43	523,69	543,32	570,10	554,83	602,82	610,53	558,66	620,77	11,56	0,04	0,49	0,08
Total											1,00	**1,19**	**1,43**

Agricultural area in 1000 ha

EU-25	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	REG	REG in % per year
Agricultural Area	170.584	177.558	183.423	183.016	181.874	181.842	181.426	181.366	181.076	179.724	179.310	179.196	**-467,2303**	**-0,26**

Yield in dt/ha

EU-25	1994	1995	1996	1997	1998	1999	2000	2001	2002	REG	weighting factor	weighted REG	REG in % per year
Cereals total	42,84	43,77	47,66	46,72	49,29	48,44	47,41	47,94	48,96	0,64	0,85	0,54	1,12
Rapeseed	24,15	27,04	25,14	28,61	29,03	29,12	27,49	28,06	27,59	0,37	0,07	0,02	0,09
Sunflowers	14,13	13,96	16,70	16,82	16,57	16,01	17,79	16,87	17,46	0,39	0,03	0,01	0,07
Sugar beets	338,56	352,12	390,35	359,62	396,19	387,99	393,43	356,71	405,69	5,28	0,05	0,27	0,07
Total											1,00	**0,85**	**1,36**

Appendix 6: Calculation of Areas Released for Bioenergy

Table A-9 shows the basic data for calculation of the areas released for energy plant potentials for the basis and the years 2010 and 2020 as examples for Germany. The change in the population figures and the change in the consumption per capita results in an aggregated rate of change for foodstuffs consumption. In the year 2010, the consumption of foodstuffs in Germany will increase by 2.76 %. During the period 2010-2020, it was decreased by 0.255 %. The use of the land area during the period in question has a positive sign, i.e. this area is not available for renewable raw materials. The increase in yield has a negative sign because it releases land area for energy plants. Changes in the consumption of foodstuffs, in the available area and in the yield increases are agglomerated to obtain a relative change coefficient. For Germany, this means that up to the year 2010, 11.9 % of the area available during the basis period will no longer be required for production of foodstuffs. During the next period, this figure even increases to 14.9 %. In the subsequent part of the table, the change rates for the areas, foodstuff consumption and yield increases are based on the area available for agricultural utilization and expressed in ha. Also areas had been added which will be released as a result of improvement of the utilization of feed stocks, particularly in pork and fowl production. In the balance, this results in an additional potential for cultivation of bioenergy sources of 2.1 million ha by the year 2010 and 2.76 million ha by the year 2020. Therefore, approximately 4.5 million ha of land in 2010 and approx. 7.3 million ha in 2020 or approximately 40 % of the area utilized for agricultural purposes will be available for production of energy sources or for utilization for other purposes.

Table A-9: Estimation of Change of Potentials for Bioenergy Sources until 2010 and 2020, Germany

	Basis 2000	2010	2020
Absolute population	82.188.000	83.066.000	82.822.000
- Change in % up to		1,0683	-0,2937
Per capita consumption (grain equivalent)	1.104,5	1.127,8	1.127,8
- Change in % up to		2,11	0,00
Consumption change in % up to		2,7596	-0,255
Abs. agricultural land in ha	17.022.667		
- Land redesignation in % up to..... [1)]		0,509	0,509
Yield increase in % up to..... [2)]		-15,157	-15,157
Balance of all changes in % up to.....		**-11,8880**	**-14,9027**
Balance of agricultural land			
- Basis available ha	17.022.667		
- Increase (+) reduction (-) due to redesignation in ha		86.678	86.678
- Increased(+) decreased(-) demand for food in ha		469.753	-43.421
- Release due to yield increase in ha (-)		-2.580.090	-2.580.090
- Release due to improved feed conversion in ha (-)		-110.364	-220.728
- Potential for biomass in ha for the year.....	**-2.409.302**	**-2.134.023**	**-2.757.561**
accumulation of the above in ha		**-4.543.325**	**-7.300.886**
- the above as % of the basis available agricultural land	**14,15**	**26,69**	**42,89**
- quantity equivalents of the above			
- Cereals [3)]	15.866.375	34.454.811	55.367.086
- Straw	12.693.100	27.563.848	44.293.669

1) according to estimated trend

2) according to estimated trend from table REG or minimum yield extrapolation of 1% or 1,5% per year respectively, max. 3%, for land redesignation max. 1%

3) grain/straw ratio 1:0,8

Source: Thrän et. al. (2006)

Appendix 7: Calculation of Production Quantities for Bioenergy from Released Land Areas

Table A-10 (with continuation) shows the areas which will become available for various cultivated plants suitable as energy plants as a result of release from production of foodstuffs during the basis period (2000), in the year 2010 and in the year 2020. They are grouped into cultivated plants for moist biomass in cultivated plants for dry biomass, whereby further differentiation into silo corn and Lucerne (due to its significance in France), oil plants and sugar beets appears practical. A comparison of the land areas in the years 2000, 2010 and 2020 shows an increase in the potential. For calculation, it was basically assumed that precisely the cultivation mixture practiced during rotation will be used on the areas released from production of foodstuffs. When the crop rotation limits were not exhausted previously, the area percentages can shift in relation to one another up to the limits for the crop rotation or other capacities, depending on the efficiency. However, this was not taken into consideration here.

The results of this potential estimation for the individual cultures form the basis for calculation of the biofuel potentials in this study by converting the areas in question in consideration of the yields in the initial situation and the yield changes in the product quantities, thereby determining the possible production of biodiesel and bioethanol.

Even in the year 2000, approximately 166,000 ha of land could have been cultivated for moist biomass and approximately 814,000 ha for dry biomass at the expense of non-cultivation and surplus production of grain and sugar.

Table A-10: Potential Agricultural Land according to Energy Crops, Year 2000

	Country	'moist' biomass			'dry' biomass						
		silage maize (in 1000 ha)	lucerne (in 1000 ha)	sugar beets (in 1000 ha)	sunflowers (in 1000 ha)	rapeseed (in 1000 ha)	wheat (in 1000 ha)	triticale (in 1000 ha)	rye (in 1000 ha)	barley (in 1000 ha)	grain maize (in 1000 ha)
1	Belgium	0	0	0	0	0	0	0	0	0	0
2	Denmark	18	1	11	0	18	113	7	12	136	0
3	**Germany**	**116**	**3**	**47**	**3**	**111**	**307**	**51**	**85**	**218**	**39**
4	Finland	0	0	7	0	12	33	0	7	123	0
5	France	330	74	96	171	278	1229	58	8	374	421
6	Greece	0	0	0	0	0	0	0	0	0	0
7	United Kingdom	0	0	0	0	0	0	0	0	0	0
8	Ireland	0	0	0	0	0	0	0	0	0	0
9	Italy	0	0	0	0	0	0	0	0	0	0
10	Luxembourg	0	0	0	0	0	0	0	0	0	0
11	Netherlands	0	0	0	0	0	0	0	0	0	0
12	Austria	6	1	4	2	5	26	3	5	20	14
13	Portugal	0	0	0	0	0	0	0	0	0	0
14	Sweden	1	1	10	0	7	74	8	6	79	0
15	Spain	3	10	5	33	2	97	1	4	127	18
	EU 15	**474**	**89**	**180**	**208**	**432**	**1879**	**127**	**125**	**1077**	**491**
16	Estonia	0	0	0	0	0	0	0	0	0	0
17	Latvia	0	0	4	0	2	54	3	17	49	0
18	Lithuania	3	1	5	0	11	72	10	24	75	1
19	Malta	0	0	0	0	0	0	0	0	0	0
20	Poland	21	16	35	0	46	278	80	216	115	19
21	Slovakia	3	2	1	2	3	12	0	1	7	4
22	Slovenia	0	0	0	0	0	0	0	0	0	0
23	Czech Republic	19	8	5	3	28	83	3	4	44	4
24	Hungary	19	24	9	46	18	157	17	8	55	180
25	Cyprus	0	0	0	0	0	0	0	0	0	0
	EU 25	**538**	**139**	**240**	**259**	**540**	**2534**	**240**	**396**	**1422**	**699**
26	Bulgaria	8	13	1	82	0	173	1	3	43	67
27	Romania	1	7	1	17	1	39	0	0	10	59
28	Turkey	0	0	0	0	0	0	0	0	0	0
31	**EU 28**	**547**	**159**	**242**	**358**	**541**	**2745**	**242**	**399**	**1474**	**825**

Table A-10 (Continuation): Potential Agricultural Land according to Energy Crops, Year 2010

	Country	'moist' biomass			'dry' biomass						
		silage maize (in 1000 ha)	lucerne (in 1000 ha)	sugar beets (in 1000 ha)	sunflowers (in 1000 ha)	rapeseed (in 1000 ha)	wheat (in 1000 ha)	triticale (in 1000 ha)	rye (in 1000 ha)	barley (in 1000 ha)	grain maize (in 1000 ha)
1	Belgium	0	0	0	0	0	0	0	0	0	0
2	Denmark	27	1	12	0	46	188	11	38	170	0
3	**Germany**	**316**	**7**	**97**	**22**	**335**	**896**	**138**	**316**	**399**	**122**
4	Finland	0	0	8	0	29	44	0	13	130	0
5	France	636	142	121	237	381	1879	111	15	979	1202
6	Greece	0	0	0	0	0	0	0	0	0	0
7	United Kingdom	0	0	0	0	0	0	0	0	0	0
8	Ireland	4	0	3	0	1	14	0	0	39	0
9	Italy	0	0	0	0	0	0	0	0	0	0
10	Luxembourg	0	0	0	0	0	0	0	0	0	0
11	Netherlands	0	0	0	0	0	0	0	0	0	0
12	Austria	8	1	4	5	3	28	3	8	25	22
13	Portugal	0	0	0	0	0	0	0	0	0	0
14	Sweden	1	2	11	0	19	113	11	35	67	0
15	Spain	54	161	62	342	2	886	21	55	2755	433
	EU 15	**1046**	**314**	**318**	**605**	**816**	**4047**	**296**	**480**	**4565**	**1779**
16	Estonia	0	3	0	0	9	22	1	8	47	0
17	Latvia	2	0	17	0	9	212	12	69	194	0
18	Lithuania	11	3	21	0	43	284	38	96	297	2
19	Malta	0	0	0	0	0	0	0	0	0	0
20	Poland	46	36	79	0	103	622	178	483	258	42
21	Slovakia	16	10	5	11	14	63	2	5	34	21
22	Slovenia	0	0	0	0	0	0	0	0	0	0
23	Czech Republic	49	20	14	7	73	218	8	11	117	11
24	Hungary	55	71	26	136	53	460	51	22	161	528
25	Cyprus	0	0	0	0	0	0	0	0	0	0
	EU 25	**1224**	**457**	**480**	**759**	**1120**	**5928**	**587**	**1175**	**5672**	**2384**
26	Bulgaria	16	27	1	170	0	359	2	6	89	138
27	Romania	4	31	4	78	6	174	0	1	44	268
28	Turkey	0	0	12	16	0	273	0	4	106	16
31	**EU 28**	**1245**	**515**	**498**	**1023**	**1126**	**6735**	**589**	**1186**	**5911**	**2806**

Table A-10 (Continuation): Potential Agricultural Land according to Energy Crops, Year 2020

	Country	'moist' biomass			'dry' biomass						
		silage maize (in 1000 ha)	lucerne (in 1000 ha)	sugar beets (in 1000 ha)	sunflowers (in 1000 ha)	rapeseed (in 1000 ha)	wheat (in 1000 ha)	triticale (in 1000 ha)	rye (in 1000 ha)	barley (in 1000 ha)	grain maize (in 1000 ha)
1	Belgium	0	0	0	0	0	0	0	0	0	0
2	Denmark	51	2	21	0	88	356	21	73	312	0
3	**Germany**	**626**	**14**	**168**	**36**	**611**	**1842**	**274**	**647**	**760**	**253**
4	Finland	0	0	12	0	52	80	0	23	230	0
5	France	983	220	164	347	634	2926	172	24	1460	1889
6	Greece	0	0	0	0	0	0	0	0	0	0
7	United Kingdom	0	0	0	0	0	0	0	0	0	0
8	Ireland	13	0	9	0	2	52	0	0	142	0
9	Italy	0	0	0	0	0	0	0	0	0	0
10	Luxembourg	0	0	0	0	0	0	0	0	0	0
11	Netherlands	0	0	0	0	0	0	0	0	0	0
12	Austria	24	3	10	13	8	86	9	25	70	66
13	Portugal	136	0	5	19	0	116	28	100	19	283
14	Sweden	2	3	16	0	35	212	20	64	126	1
15	Spain	144	428	147	856	5	2383	56	146	7384	1151
	EU 15	**2388**	**982**	**721**	**820**	**1983**	**9113**	**598**	**1170**	**7413**	**4596**
16	Estonia	0	9	0	0	24	58	4	22	127	0
17	Latvia	3	0	36	0	19	443	25	144	405	0
18	Lithuania	22	7	45	0	90	603	81	205	631	5
19	Malta	0	0	0	0	0	0	0	0	0	0
20	Poland	99	76	167	0	220	1325	379	1028	549	89
21	Slovakia	36	23	12	25	33	147	4	13	79	50
22	Slovenia	0	0	0	0	0	0	0	0	0	0
23	Czech Republic	102	41	29	14	151	453	17	23	243	24
24	Hungary	107	138	51	263	102	890	98	43	311	1022
25	Cyprus	0	0	0	0	0	0	0	0	0	0
	EU 25	**2875**	**1312**	**1084**	**1097**	**2715**	**12996**	**1251**	**2753**	**9473**	**5714**
26	Bulgaria	30	51	2	325	0	689	4	11	170	265
27	Romania	14	103	14	259	20	578	1	4	145	888
28	Turkey	0	0	22	29	0	496	0	7	193	28
31	**EU 28**	**2350**	**1276**	**1109**	**1902**	**2206**	**16936**	**1006**	**2291**	**9891**	**6652**