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gemeinnützige GmbH

Institute for Energy and Environment

Sustainable Strategies for Biomass Use in the European Context

Analysis in the charged debate on national guidelines and the competition between solid, liquid and gaseous bioenergy sources

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Executive summary

1.1 Object of investigation

The increase in the proportion of renewable energy is a key objective of many policy instruments and programmes both at the national and European level. All programmes focus on promoting the use of biomass to produce energy and on introducing new conversion technology. Introducing new technologies onto the market can only be successful over the long term, however, if doing so is beneficial to the environment and economically attractive in the context of the goal of a harmonised European energy market.

The aim of this project is thus to analyse and evaluate possible strategies for increased use of biomass in the context of the German, European and world situations, development scenarios and future markets for bioenergy sources [i]. The studies cover the EU-28 countries [ii] for the period from 2000 to 2020. The future supply of biomass and the future demand for biomass in the EU-28 countries are examined in two end point scenarios to identify significant paths of development:

- The Current Policy (CP) scenario models future development based on current policy developments promoting agriculture and renewable energies and on existing barriers and restrictions such as administrative and regulatory barriers. It also takes policy guidelines for future development that have not yet been implemented into account.

- The Environmental+ (E+) scenario models future development based on a more environmentally oriented use of land and on greater efforts in climate protection and the promotion of renewable energies. Existing instruments in these areas are expanded accordingly.

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[i] The present studies supplement the BMU (Federal Ministry for the Environment, Nature Conservation and Nuclear Safety) research project “Stoffstromanalyse zur nachhaltigen energetischen Nutzung von Biomasse” (Material Flow Analysis of Sustainable Biomass Use for Energy) concluded in May 2004 (http://www.erneuerbare-energien.de/1024/index.php?fb=/sachthemen/ee/aktuell_biomasse/&n=11894).

[ii] EU-25 countries plus Bulgaria, Romania and Turkey

1.2 General framework

The general European framework for energy, forestry and agricultural policy and the form it takes in the member states is key for biomass use as it affects the supply and demand of biomass, production costs, market trends and the like.

The following **basic energy policy conditions** shape the possibilities for biomass use and its contribution to sustainable energy production in Europe:

- National implementation and embodiment of the European Directive on renewable electricity generation regarding the generation of electricity from biomass in the form of tax exemption, feed-in tariffs, quota schemes, investment promotion or tendering systems to achieve sufficient economic incentives that can be ensured over the medium term.
- National implementation of the European Biofuels Directive in the form of tax exemption, blending obligation, quota scheme or investment promotion to achieve sufficient economic incentives that can be ensured over the medium term.
- The establishment of comparable European provisions and guidelines for the heating sector ("Heat Directive") to continue to establish this traditionally most important renewable energy source in line with the development goals.
- The introduction of the emissions trading in the European Union beginning in 2008 and establishment of the planned Clean Development Mechanism (CDM) and Joint Implementation (JI) options in the member states.
- Measures to achieve the aims of the Kyoto Protocol or EU White Paper, particularly in the EU-15 countries.
- The policy reaction to trends in fossil fuel prices.

Although numerous tools have been developed in recent years to increase biomass use, the climate protection targets of the EU on which the White Paper is based will not be able to be achieved on time according to current projections. Consequently, existing measures may be intensified or supplemented by other measures in the coming years. An extendable range of instruments has been set up for the electricity and fuels sectors, whereas there are currently no comparable aims or instruments in the heating sector at the EU or national level. As the European framework leaves concrete implementation up to the member states, development will take a different form in each member state. Development may be delayed in the acceding countries as the pressure on these countries to achieve the climate protection targets by 2010 is generally not as great.

The embodiment of the coordinated EU biomass plan could result in new incentives, which are currently being discussed.

The following conditions for increased use of biomass to produce energy could be significant for **forestry policy conditions** throughout Europe and would have a crucial effect on the possibilities for biomass production and for production costs.

- Continuing development of strategies and concepts in sustainable forest management
- Continuing technical advances in the form of mechanisation and rationalisation in forestry production of raw materials (including agro-forestry systems)
- The scope and type of demand for roundwood for use as a material, which is difficult to estimate in acceding countries
- Incorporation of forestry into a comprehensive European environmental and agricultural policy and its effects on basic forestry policy conditions
- European agreement on sustainable forest management and mechanisms for preventing illegal felling in non-EU countries (FLEGT)

An isolated assessment of forestry policy action with regard to the development of forest biomass potentials makes little sense, neither on the EU level, nor on the member state level. Due to the fact that there is no coordinated and coherent forestry policy on the EU level, it is currently the decisions on energy policy, economic policy, environmental policy, and agricultural policy which have the strongest influence on the mobilisation of forestry potentials.

In contrast, due to the Common Agricultural Policy (CAP), the **agricultural policy framework** is relatively similar in each of the individual member states, but is, on the whole, difficult to predict for the period after 2012. Fundamental changes to the current pricing policy, though, are rather unlikely.

Europe-wide, the possibilities of biomass production and the production costs are decisively affected by the following framework:

- Ongoing technical progress in the form of increased yields in the production of agricultural raw materials.
- Ongoing technical progress in the conversion of raw materials, for example feed conversion in breed improvement.
- WTO commitments to reduce subsidised exports of surplus agricultural products from the European Union.
- Decoupling of the existing product-related price equalisation payments for cereals, oleaginous fruits and animal products which will lead to an increased release of land for set-asides or cultivation of renewable raw materials.
- Eastern enlargement of the EU, which will lead to production increases, especially of cereals and oleaginous fruits, which are difficult to estimate.

The development of agricultural policy to date has been decisively determined by the agreements of the GATT Uruguay Round, WTO I and the awaited, yet somewhat uncertain, results of WTO II. It has been orientated towards reduction of domestic support and export subsidies, and towards opening the market to other countries. The EU and other industrial countries with high levels of agricultural support have reformed their national policies accordingly. This means it can be expected that this process will be accelerated upon conclusion of WTO II, and in a further WTO round, will lead to a far-reaching reduction of all support elements in agricultural policy which should be achieved by 2013.

In this process, it is already evident that to an increasing extent in the EU, land which is no longer needed for food production becomes non-productive land. Only part of this land has as yet been used for the production of biomass because the economic and legal framework has only recently been significantly improved in this area of production. Multiple additional resources will be available for biomass production in the future. This is primarily accounted for by the agricultural land set aside in accordance with the Common Agricultural Policy. Land used to cultivate sugar beets, whose yields were previously exported, also shows potential for biomass. Limiting milk and beef production by removing product-related payments beginning in 2006 will also make land available for biomass production. The negotiated accession criteria provide for particular promotion of rural areas in the new member states, and the introduction of direct payments to farmers. This will generally improve the competitiveness of agricultural production and consequently also of energy crops in the acceding countries.

1.3 Biomass supply

The supply of biomass refers to the share of total available biomass that can be used under given technical restrictions (the "technical potential of biomass"). It takes into account the available utilisation technologies, their efficiency, availability of sites also in terms of competing uses, as well as "insurmountable" structural, ecological (e.g. nature conservation areas) and other non-technical restrictions. The supply of biomass is calculated from the forestry potentials, potentials of agricultural areas or the energy crop potentials derived from those areas, and the potentials of residues.

Forest potentials include felling products that are not used as material (firewood and logging residues), referred to in the following as the **"technical potential of raw wood from felling"**, and the annual growth that is not felled, referred to as the **"technical potential of raw wood from growth"** in the following. This differentiation reveals the amount of wood that would be available for energy production if logging residues were used and how much additional wood could be used if annual growth were utilised to capacity. The potentials for 2000 are derived based on the situation as reported in the FAO Statistical Database (FAOSTAT[iii]), the European Forest Sector Outlook Study conducted by the UNECE and the FAO (EFSOS[iv]), and the Temperate and Boreal Forest Resources Assessment (TBFRA-2000[v]). The forest

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[iii] Food and Agricultural Organization (FAO) Statistical Database www.faostat.fao.org

[iv] European Forest Sector Outlook Study, www.unece.org/trade/timber/efsos

[v] Temperate and boreal forest resource assessment by UNECE and FAO, www.unece.org/trade/timber/fra/welcome.htm

potentials for 2010 and 2020 are derived based on model assumptions according to the EFSOS on the forecast of future trends in demand for wood products in the individual European countries and modelling of forest resources derived from this demand by the large-scale matrix European Forest Information Scenario Model (EFISCEN[vi]). Again a distinction is made between potential from felling and potential from growth.

In all, the technical potentials of raw wood in the EU-28 countries amount to almost 165 million bdt or 3,046 PJ in 2000. They consist of 66% unused growth and 34% firewood and logging residues. Especially in the ten new member states, an increased demand for roundwood and thus felling is expected by 2020. As felling will not increase as strongly as the demand for roundwood, the technical potential of raw wood is expected to drop by around 17% to approximately 137 million bdt p.a. or 2,535 PJ p.a. by 2020.

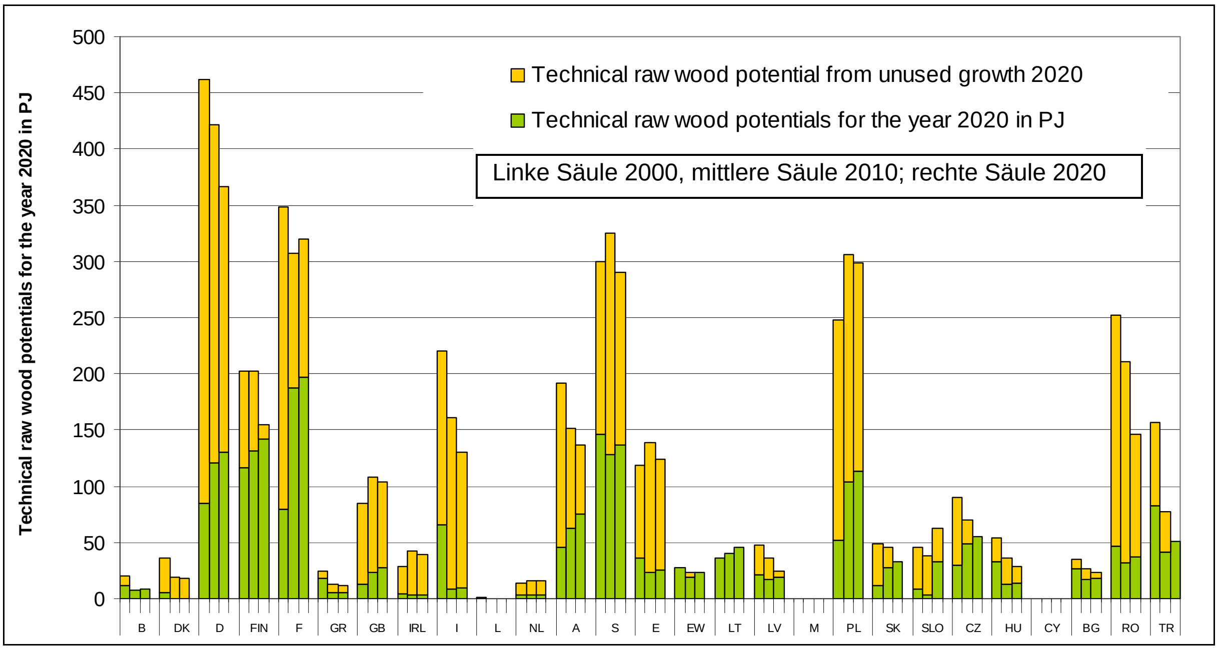

Figure I: **Technical fuel potential from forestry in the EU-28 countries (2000 – 2010 – 2020)**

Figure I shows the technical fuel potentials of the EU-28 countries for the period from 2000 to 2020 broken down into firewood, forest wood (logging residues) and unused growth. Germany offers the greatest potentials, followed by France, Sweden, Poland, Romania, Italy, Finland and Austria. Felling is expected to exceed the theoretical potential of raw wood in Belgium, Latvia, Portugal, the Czech Republic and Turkey. It is therefore likely that, in 2020,

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[vi] European Forest Information Scenario Model, www.efi.fi/projects/eefr/

these countries will not dispose of any reserves from unused growth useable for energy production.

Agricultural potentials include energy crops produced on agricultural land that is taken out of food production.

The estimate of land potentials for 2000 is based on the country data provided by EUROSTAT and FAO. It takes into account fallow land (land that has been set aside) and land that could potentially be released as a result of reduced surpluses of market products. The estimates of potentials for bioenergy sources for 2010 and 2020 also include the following changes:

- Food consumption due to the demographic development and changes in per capita consumption. Higher consumption decreases and lower consumption increases the available potentials for bioenergy sources.
- The expected redesignation of previously agricultural land for residential building, traffic and other purposes. This redesignation of land reduces the potential for bioenergy sources.
- Increases in the yield and performance of crop and animal production. These increases make potentials from agricultural land and grassland available for bioenergy sources.

Table I: Assumptions used in the scenarios concerning basic conditions for agriculture in the future

Current Policy Scenario (CP)	Environmental Scenario (E+)
100% of fallow land is available for energy crop cultivation.	Only 70% of fallow land is cultivated.
Deficits in the production of rapeseed and sunflower reduce the technical potential.	Deficits in the production of rapeseed and sunflower are covered by imports.
Surplus production of market regulation products is reduced and areas are released for energy crop cultivation (except pork and poultry).	Surplus production of market regulation products is reduced and areas are released for energy crop cultivation (except pork and poultry).
Redesignation of land: residential building, traffic, nature conservation according to the current trend.	Additional redesignation of arable land (2.5% in 2010 and 5% in 2020) for purposes of nature conservation (without any yields).
Increased yields in crop and animal production.	Yield increase for grassland is 50% less compared to the CP scenario.

Table I shows the assumptions that define the two scenarios through 2020. Balancing the individual variables results in an aggregated land potential for the production of bioenergy.

The results indicate that trends in the individual member states vary considerably:

- Land potentials in France and Germany are increasing considerably due to the large amount of agricultural areas with a high yield level and as a result of food consumption, further increases in yield and moderate increases in population.
- The results for Great Britain do not indicate any potential for bioenergy sources for the period under consideration given the overall deficit self-sufficiency and assuming that the population will continue to grow and that considerable amounts of land will be redesignated despite substantial increases in yield.
- Italy, the Netherlands, Belgium-Luxembourg and Greece are less important for biomass potential.
- Spain is a particular case with especially high potentials for land to be made available in the future. This is due to a stagnating population development and sharply increased yield expectations. It is also assumed that a considerable portion of the especially large amount of fallow land in 2000 can technically be used for bioenergy sources if all reasonable alternatives of extensive use are considered.
- Denmark also has a comparatively high level of land potential for bioenergy sources, which result primarily from the reduction of surplus dairy production.
- Extremely high potentials are also expected for Ireland, the country with the highest agricultural surpluses per inhabitant and, which is important, subsidised animal products.
- The potentials for land to be made available for bioenergy sources are increasing considerably in the Baltic countries and Hungary, which show high rates of yield growth and a low absolute yield level, a decreasing population as well as a comparatively large amount of agricultural land.
- There is also a large amount of land available for bioenergy sources in Poland. This can be attributed to the large areas that have been left fallow in the transformation process and the comparatively high advances in yield in the final phase of the transformation process.

- Of the candidate countries Turkey does not have any important potential for bioenergy sources given its strong population growth and the expected increase in per capita consumption over the long term. As agricultural countries with decreasing populations, Bulgaria and Romania show greater potentials for bioenergy sources, especially for the period following their accession to the EU.

Figure II shows the potential of agricultural areas in the CP scenario. In 2020, just less than 60 million ha of land will be available for bioenergy sources. The proportion of land made available accounted for by grassland increases from 8% in 2000 to 25% in 2020.

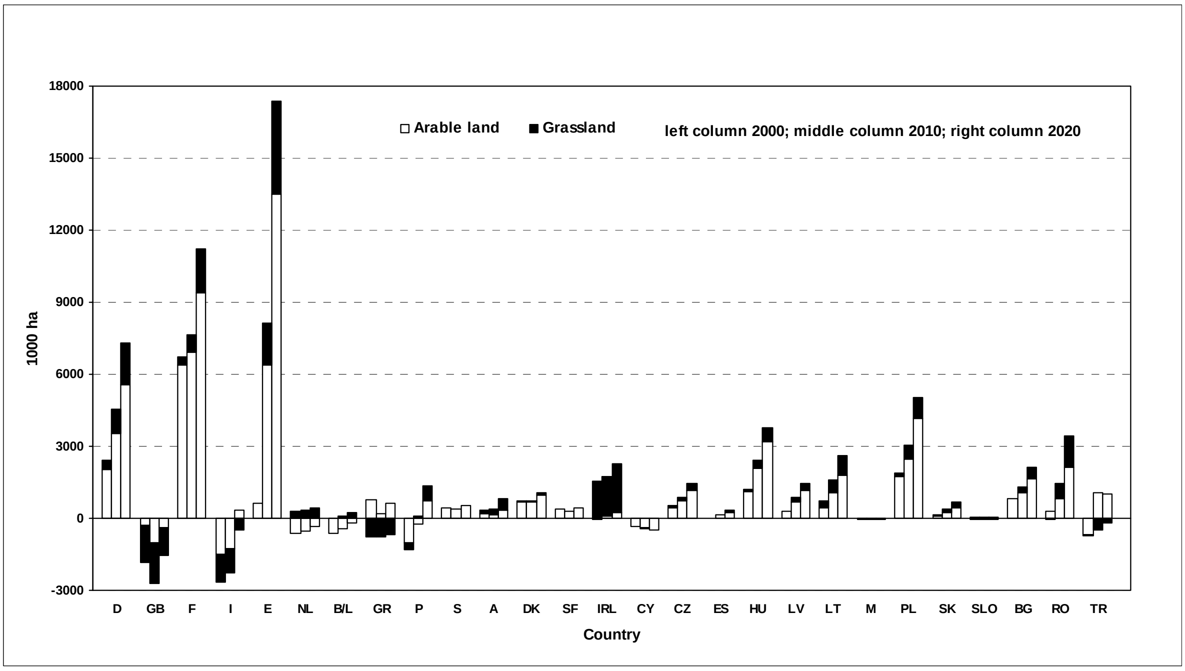

Figure II: **Potential of agricultural areas in the EU-28 countries in the CP scenario (2000 – 2010 – 2020)**

In the E+ scenario, factors which reduce the potential prevail, especially as a result of a reduced increase in grassland yield and the additional redesignation of arable land for extensive agriculture and for nature conservation areas. The results show that under these assumptions, considerable potential for bioenergy sources can still be expected – almost 30 million ha in the EU-28 countries – through 2020, although at 12%, grassland will account for a considerably smaller proportion of that land.

The totals for land potential in the CP scenario are twice as great as those in the E+ scenario.

Figure III shows the energy crop potentials calculated from the potential area. The potential is based on the mix of the main established cultivated crops used in the respective countries (i.e. cultivable land and yields according to EUROSTAT).

The potential for energy crops for 2000 is 690 PJ p.a. in the E+ scenario and 1,180 PJ p.a. in the CP scenario. By 2020 the potentials increase to 2,614 PJ p.a. in the E+ scenario and 7,792 PJ p.a. in the CP scenario due to additional land being released. The potential for energy sources is three times as great in the CP scenario because the CP scenario assumes that more land can be expected to be released, especially in countries with high yields.

Provided that cultivation structures are retained, the greatest potential is accounted for by the cultivation of cereal and lignocellulose crops. The potential of oil energy crops is of less importance. Cultivation structures could shift, however, due to increasing demand for oil energy crops. Such a shift would only be slight due to strict crop rotation limits for rapeseed.

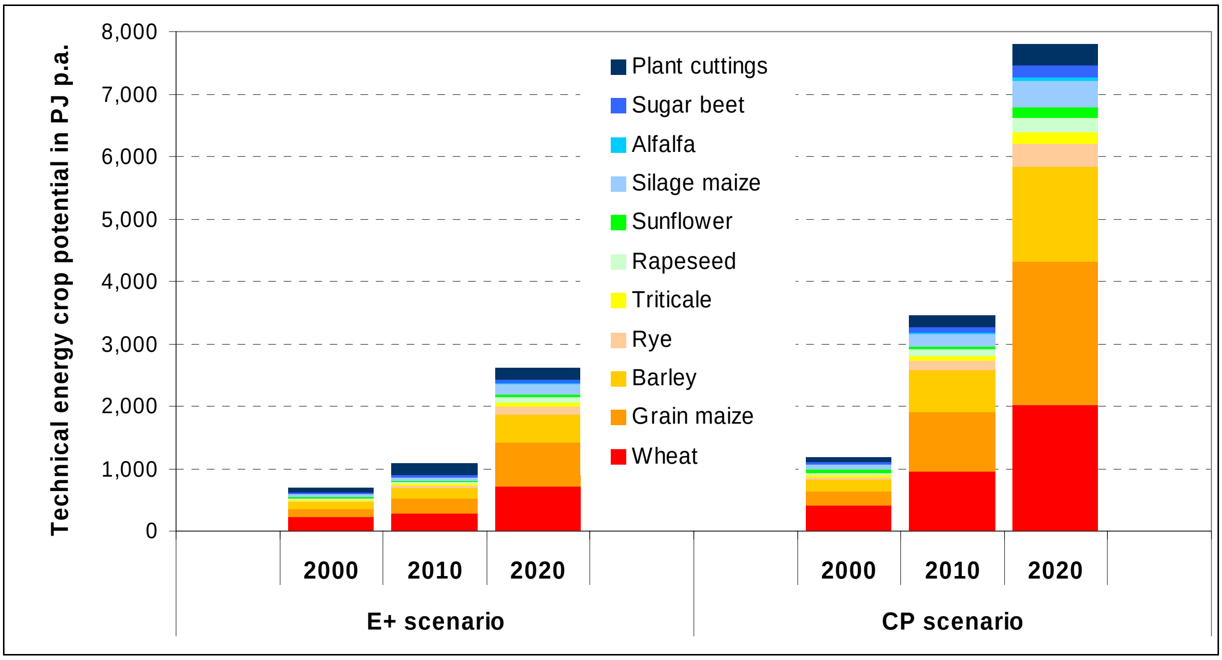

Figure III: **Potential for energy sources from energy crops in PJ p.a. for the EU-28 countries in the E+ and CP scenarios**

Potential of residues include residues, by-products and waste resulting from agriculture, wood and food processing and the end of the production chain. The available biomass is that which is not intended for use as a material and/or biomass resulting as waste from use as a material. Figure IV shows the energy source potentials from residues for each of the EU-28 countries. Thus, changes in the demand for wood and food also affect the potentials of residues. A distinction is made between woody residues, herbaceous residues (straw) and other residues:

- The potential of woody residues in the EU-28 amounted to 1,550 PJ p.a. in 2000. The extrapolation of potentials for 2010 and 2020 for by-products and residues from the wood processing industry and black liquor is based on estimates of the future demand for roundwood and increases slightly through 2020. The potential for waste wood and prunings is assumed to remain constant from 2000 to 2020. Distribution across Europe is characterised by a prominent wood processing industry in Scandinavia, considerable waste wood potentials in populous nations and selective relevant amounts of prunings in the southern countries.
- The available straw potential in the EU-28 countries in 2000 is 470 PJ p.a. for fermentation and 870 PJ p.a. for thermo-chemical conversion[vii].
- The potential decreases by around 6% by 2020, principally due to increases in yield and the resulting shift in the grain to straw ratio to the detriment of straw. The agricultural countries France and Germany have the greatest straw potentials. Other residues include excrements, other agricultural residues (harvest residues, cereals that are not suitable for food or feed), industrial substrates, sewage sludge and organic waste. In 2000, the energy source potential from other residues for the EU-28 countries ranges from around 1,350 to 1,710 PJ p.a. As a result of the expected slight increase in the demand for food, the potential is expected to increase slightly by 2020. Throughout Europe, excrements are the most important among the other residues.

- The total amount of residues is determined primarily by the EU-15 countries, whereas acceding and candidate countries (except Poland and Turkey) show comparatively low potentials. Altogether, the potentials of residues change only slightly through 2020.

The total potential for residues in the EU-28 countries is 3,742 PJ p.a. for 2000 and will change only slightly (3,987 PJ p.a.) by 2020.

[vii] Energy from herbaceous biomass, sewage sludge and organic municipal waste can be generated using thermo-chemical or bio-chemical conversion. The water content of the material in particular, which can vary significantly, determines which method is used. It therefore does not make sense to assign material to one of the two categories. Bio-chemical conversion provides lower energy yield than thermo-chemical conversion due to the nature of the process.

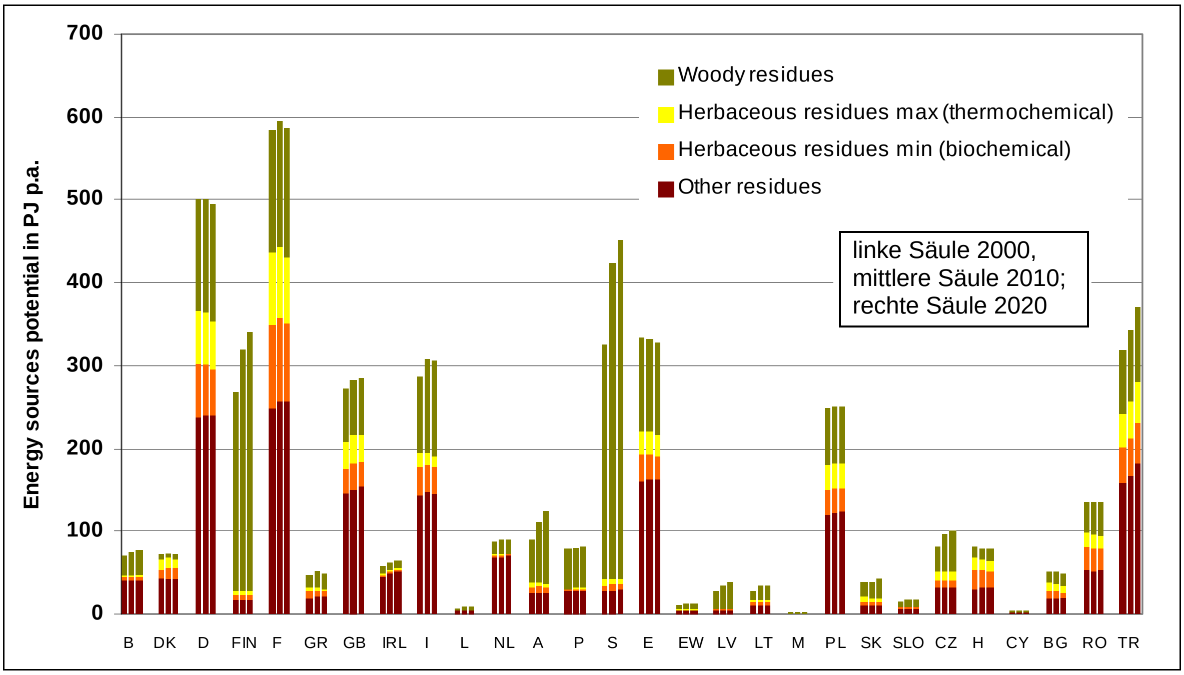

Figure IV: **Energy source potential from residues in the EU-28 countries (2000 – 2010 – 2020) (averages of industrial residues, harvest residues, other agricultural residues and sewage sludge)**

Figure V shows the **total potential** for bioenergy sources for the EU-28 countries. For the reference year 2000, the potential is approximately 8,000 PJ p.a. in the E+ scenario and approximately 8,450 PJ p.a. in the CP scenario. The potentials from residues and forest wood remain relatively stable through 2020, whereas the potentials from energy crops multiply. Thus, the energy source potential for the EU-28 countries in 2020 is approximately 9,550 PJ p.a. in the E+ scenario and approximately 14,750 PJ p.a. in the CP scenario.

In 2020, more than half of the European fuel potential can be found in France, Spain, Germany and Poland, which is particularly due to the great potentials of energy crops. The Northern European countries (Sweden and Finland) have the greatest potentials for forest wood while the populous countries in Central Europe (Germany and France) have higher potentials for residues.

In all, the potentials for bioenergy sources in the EU-28 countries in 2000 account for around 10% of gross domestic consumption, which even in the CP scenario could only be approximately doubled by 2020.

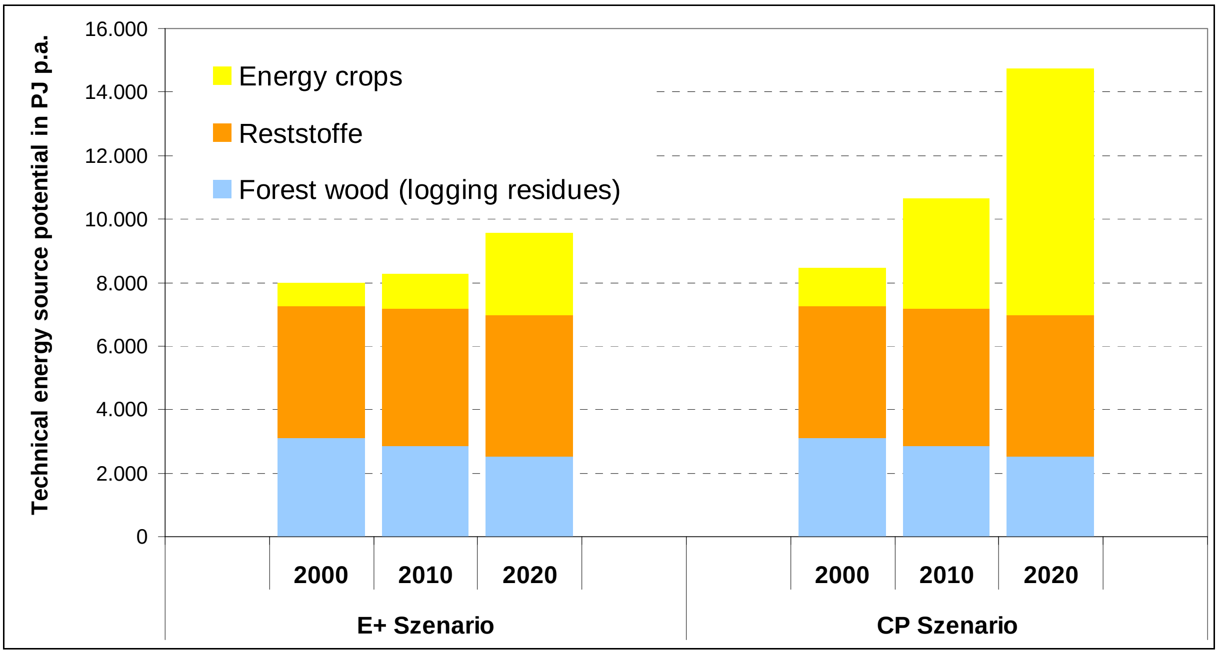

Figure V: **Potential for bioenergy sources for the EU-28 countries**

1.4 Biomass demand and markets

The **demand** for biomass and for the energy (sources) obtained from biomass is controlled by the framework of energy policy.

The final energy supply from biomass in the EU-25 countries was just under 2,200 PJ p.a. in 2004, approximately 90% of which was accounted for in the EU-15 countries. The share of gross domestic energy consumption accounted for by bioenergy in the individual countries ranged from under 1% (Belgium, Luxembourg, Slovakia and Cyprus) to over 10% (Latvia, Denmark and Sweden). Bioenergy sources were used primarily to generate heat. Growth in electricity generation was strong in most EU-15 countries while only isolated activities can be observed in the acceding countries. Only some of the EU countries showed significant fuel production in the period under consideration. Overall, the data show a market in flux, whose further development cannot easily be estimated from previous trends.

The future demand for biomass to be used for energy will align itself with political objectives of the European Union and its member states and will be controlled by an adjusted framework for the energy industry. Scenarios for the energy industry can be used for estimates. The modelling used in the FORRES 2020 study[viii] is used as a basis in the following. This study analyses the future establishment of renewable energy sources in the EU-27 countries (EU-25 plus Bulgaria and Romania) through 2020 considering different political framework conditions. It is based on a techno-economic model of the market penetration of renewable energy sources and provides conclusions for biogenic heat, biogenic electricity and biofuels in each member state. The scenarios considered in the study are based on different intensities of measures for introducing renewable energy sources:

- The Current Policy (CP) scenario is based on extrapolating the current binding measures for promoting renewable energy sources and the existing barriers and restrictions.
- The Environmental+ (E+) scenario is based on the FORRES Advanced Renewable Strategy scenario. This scenario models future development based on the best-practice strategies of each EU country. The FORRES projections are supplemented by the aims of the European Biofuels Directive currently in discussion for 2020. These aims range from 8% to 20% based on the energy content of the consumption of all petrol and diesel fuels and are included in this study at 15% as an example.

The future demand for bioenergy sources will increase considerably in all EU countries from 2000 to 2020 in both scenarios. The two scenarios lead to a future bioenergy demand that is twice as great at the highest end of the scale as at the lowest. Even in the E+ scenario, bioenergy sources generally account for less than 30% of final energy consumption through 2020. In terms of quantity, the demand for biogenic energy sources in the EU-28 countries is essentially determined by the EU-15 countries (especially by France, Germany, Italy and Spain), while the proportion of final energy consumption accounted for by bioenergy is generally higher in the new member states (EU-10).

In the case of a **European market,** the demand for biomass and for the energy (sources) obtained from biomass can be covered if the bioenergy sources are transport-worthy, i.e. if they have defined qualities and energy densities and are able to be stored. The result is

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[viii] Analysis of the Renewable Energy Sources' evolution up to 2020 – FORRES 2020 – is NOT a binding model of the EC or individual member states. It shows potential development if the basic conditions in the member states are continued or if these conditions are extrapolated. www.eu.fhg.de/forres

nationwide supply options for woody biomasses, cereals, oilseeds and biofuels, the latter of which are especially advantageous due to their high energy density. Together with the fuel production and distribution infrastructure, which is geared toward nationwide supply, both European and worldwide trade flows are likely to establish.

Currently, bioenergy source trade within Europe and throughout the world is insignificant. The important markets can be estimated as follows:

- Biodiesel: Rapeseed and RME production in Europe should develop substantially over the short term and establish corresponding European markets for the (limited) resources. Additional markets exist outside of Europe, potentially within the fat and oil markets expanding throughout the world, which are characterised by strong growth especially in palm oil (Malaysia).
- Bioethanol: European ethanol production is expected to further expand, and trade will take hold. Additional markets exist outside of Europe and can be expanded considerably in the future (Brazil).
- Forest wood: Considerable quantities could be mobilised in Germany and Europe in the short term, but these quantities, due to their energy density, have only a limited ability to be transported. Increased demand for forest wood as an energy source can lead to increased imports of wood for material use. Worldwide, the use of wood for energy dominates and is growing rapidly in developing countries. Given the availability of BTL technology, increased fuel imports to Europe can be expected (with concurrent export of the technology).
- Waste wood: The markets for waste wood in Europe are already established. Trade flows outside of Europe are not expected.
- Wood pellets: The pellet market offers a significant growth potential over the short term, but it is expected to remain linked to selected residue resources (even throughout the world).
- Bioelectricity: Given the limited grid capacities, trade with bioelectricity will only be possible to a limited extent in Europe through 2020.

1.5 Supply scenarios

A ***bio-flow*** model was developed for this project to estimate how biomass use will affect each of the EU-28 states in the various scenarios and which biomass trade flows may occur in the future as a result.

The supply balance is calculated by comparing the energy potential available based on available biomass and the demand for final energy sources from biomass in different scenarios. This target/actual comparison results in a balance for each member state for a given analysis date. This balance can be used to determine possible developments in the biomass markets and can in the end indicate future biomass trade flows. In terms of technology, the following areas of application and developments are assumed:

- Pure heat supply is considered in the model only on the basis of forest wood (logging residues) and is extrapolated from 2000. At that time, the EU-28 used approximately 2,200 PJ p.a. for heat supply, of which over 95% was achieved in plants used exclusively for heat production. Additional heat from biomass is supplied due to increased CHP electricity generation.

- The model initially considers electricity supply by means of residues, primarily in CHP operation. Suitable technologies are assumed for each different type of biomass (for example, usage of black liquor in industrial heat and power plants with high electrical and thermal efficiency; use of excrements, harvest residues and industrial biogas substrates in biogas plants).

- Fuel supply is based on different energy crop systems, which, in 2000, are limited to rapeseed, sunflower and sugar beet for biodiesel/bioethanol production. Beginning in 2010, fermentation of energy crops for supplying biogas as a fuel and the use of whole plants for supplying ethanol are assumed, while the use of different energy crops for BTL production is assumed from 2020 onwards.

The following figures VI and VII show the expected final energy demand (“Target”), the expected final energy supply (“Potential”) and the resulting supply balance (“Balance”). This leads to the following supply scenarios for Europe:

- ➢ If current policies are maintained (CP scenario), the demand for biomass in most countries will stay well below the potential supply until 2020. Import demand is only expected in Italy, Great Britain and to a limited extent in Greece and the Benelux countries. Furthermore, EU-15 countries with a large agricultural industry (France, Germany, Spain) could offer significant volumes to the European market.
- ➢ If the framework for the energy and environmental sector is developed further (E+ scenario), the demand for biomass will develop faster than the supply of additional potentials. It is therefore expected that the demand for biomass will exceed supply in many EU states by 2020, particularly in the EU-15. This particularly applies to Italy and Great Britain, but also to a great extent to France, Germany and Spain.
- ➢ Sweden, whose potential is largely determined by the forest products industry, is the only country with a still significant excess supply.The acceding countries are currently still able to meet their national demand; however, beyond that they are only able to offer limited quantities to the European market. This means that Europe has a significant import demand for biomass and bioenergy sources.

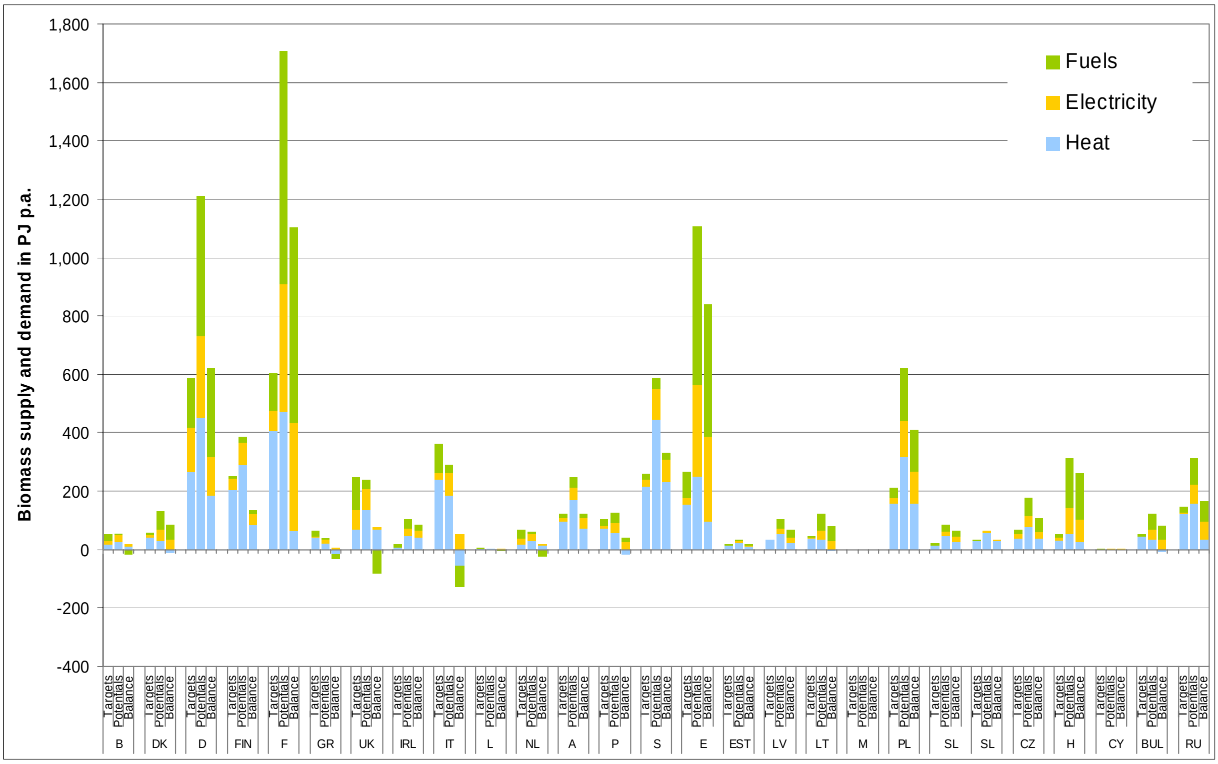

Figure VI: **Supply balance for final energy sources in the CP scenario in 2020**

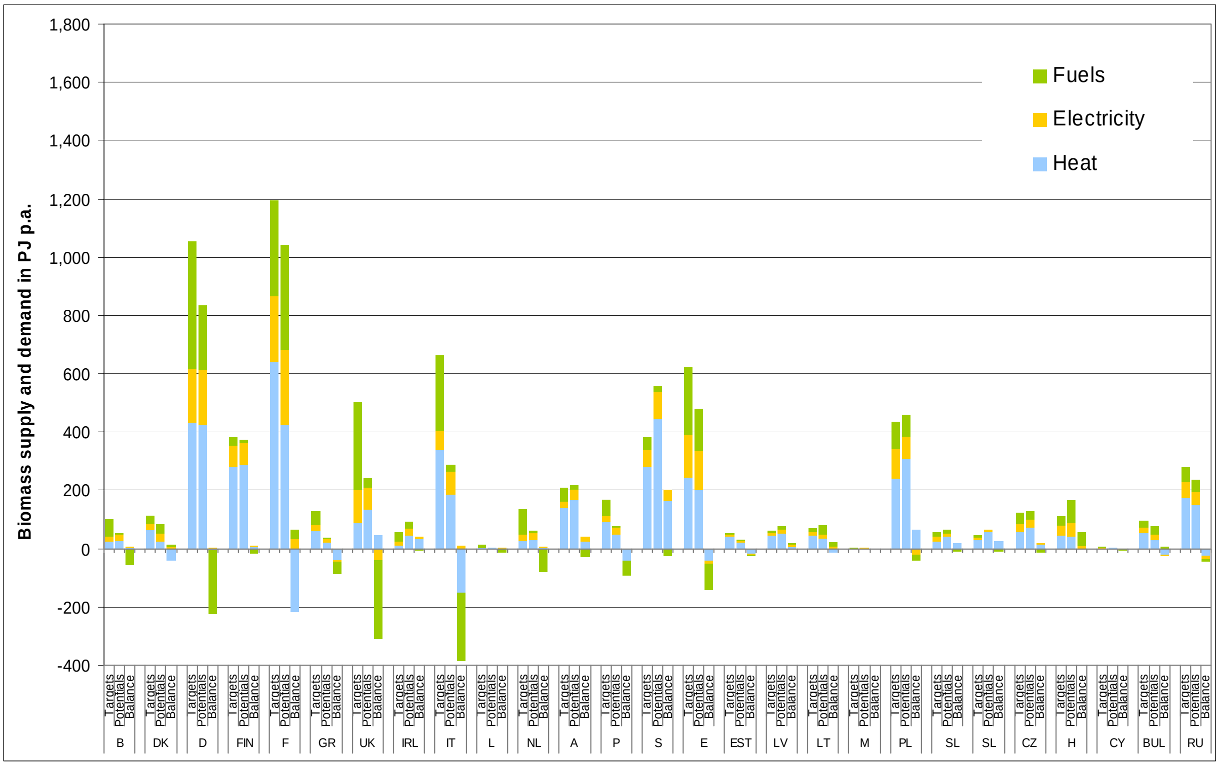

Figure VII: **Supply balance for final energy sources in the E+ scenario in 2020**

A cumulative analysis of the EU-28 over the timeline (Figure VIII) further indicates that a shortage of biomass supply will only occur if the framework concerning the energy and environmental sectors is developed further. If further development of the framework is restricted to the energy sector OR the agricultural sector, there will at least be sufficient quantities of biomass and bioenergy sources available to meet demand in Europe. Furthermore, it becomes clear that if both the energy and environmental goals are pursued jointly, a shortfall will occur no sooner than 2020, whereby the fuel target of 15% biofuel is decisive.

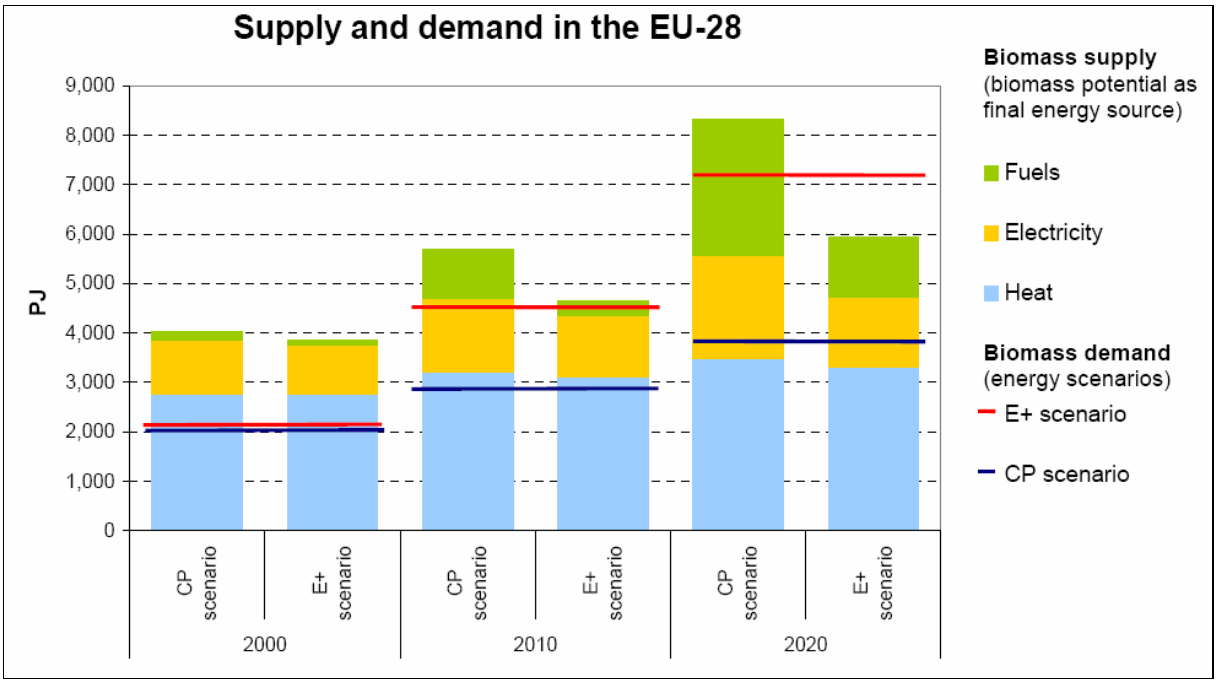

Figure VIII: **Supply and demand in the EU-28**

European trade flows are therefore heavily dependent on the further development of the political framework for the energy and environmental sectors in the individual countries. These will determine the volumes of biomass or bioenergy sources supplied to the European market. Developments in the populous and predominantly agricultural countries (France, Germany, Spain, Poland) are decisive for the flow of materials. The policies followed in each of the EU-28 countries, including the extent to which harmonisation and synchronisation are promoted by the EU, are key in determining where the trade flows will form.

1.6 Ecological aspects

In terms of the environmental effects of bioenergy trade in the EU-28 countries, this study examines whether and to what extent emissions and cost advantages exist for supplying bioenergy sources as an import option for Germany as opposed to national usage in the export country. The focus is on the emission of greenhouse gases (GHG), expressed in CO_2 equivalent units, as well as acidifying air pollutants (in SO2 equivalent units), which are modelled on the basis of the GEMIS computer model[ix].

[ix] Global Emission Model of Integrated Systems – see www.gemis.de

The examples show that environmental figures for a potential biomass trade will differ depending on the country and the framework conditions – CHP electricity generation is always less costly in countries where relatively high emissions occur during electricity generation (e.g. Poland), whereas exports are a viable alternative for countries with low-emission electricity generation (e.g. Romania). Furthermore, there are multiple advantages of using "domestic biomass" for heat production in the new member states and candidate countries due to the comparatively high emissions of greenhouse gases and air pollutants of the reference systems used in those countries.

The results show that, with few exceptions, the import of solid fuels (pellets, wood chips) and biogenic fuels (bioethanol, RME, BTL) offer few environmental advantages compared to production using domestic resources. The cost effects also tend to be minimal. Exceptions are bioethanol from Poland and Brazil and BTL from Poland (figure IX).

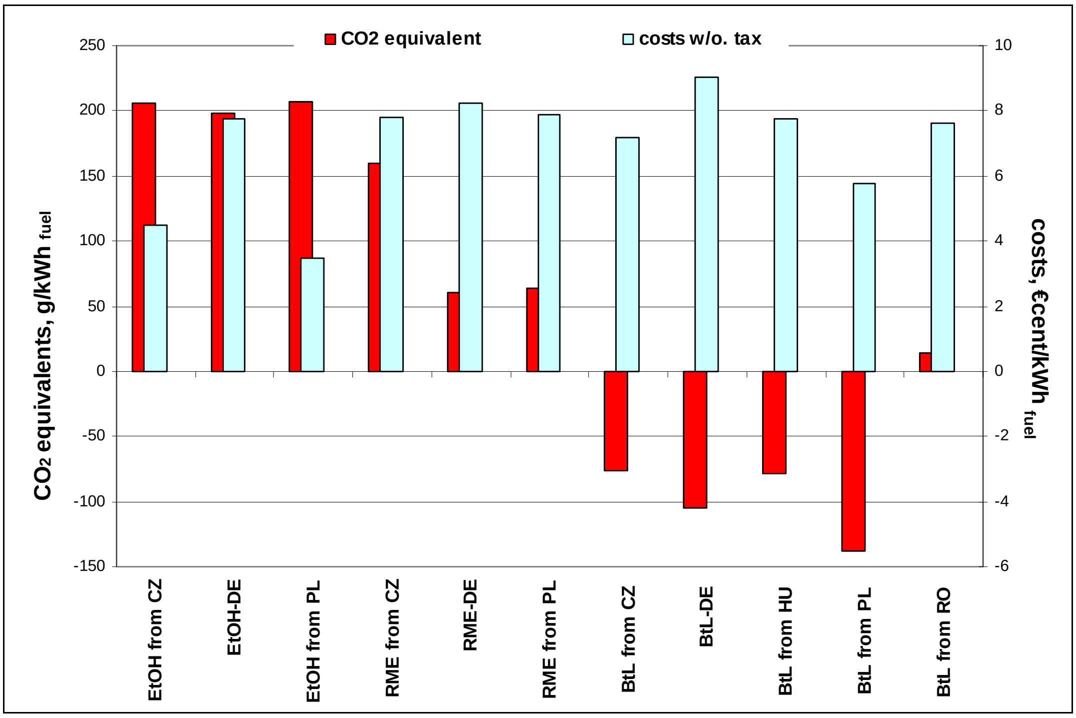

Figure IX: **Greenhouse gas and cost figures for biofuel variants in 2020**

When considering the situation in the EU and the medium-term development, there are no significant incentives or disadvantages to trading large quantities of biomass between the member states or candidate countries. Some of the differences observed in greenhouse gas emissions could also be realised to a great extent using the flexible instruments provided by the Kyoto Protocol (joint implementation, emissions trading) and *without* the need for physically importing bioenergy sources.

The significant cost advantages sometimes offered by potential imports of bioethanol and FT diesel from Poland and BTL from the Czech Republic must also be considered from the point of view that these fuels are attractive for the domestic markets in the Czech Republic and Poland since the export trade balance and balance of payments can be improved by avoiding the import of fossil energy sources.

1.7 Conclusions

This study shows that there are numerous possibilities for sustainably expanding biomass use based on “domestic raw materials” in Germany and Europe. Better coordination of the political frameworks for the agricultural, forestry, energy and environmental sectors in particular is needed, which also reduce current uncertainties in the development of the supply and demand of biomass and increase planning security for example. Further, the framework conditions for sustainable biomass use must ensure appropriate and efficient utilisation of existing resources and appropriate supplementing of these resources with biomass or bioenergy imports.

The following actions can therefore be recommended:

- The majority of the European countries, including Germany and France, can afford a significant and increasing contribution to energy supply using “domestic biomass”. Domestic raw materials can be used to a great extent especially when the necessary long-term planning security is created for investments and the forced market introduction of bioenergy as part of energy policy is aligned with the speed at which agricultural land is made available.
- The political framework for the agricultural and forestry sector must allow for the demands of increased biomass use while taking into account environmental requirements at the European and member state levels. In addition to support of intensified energy crop production, this requires energy crop production geared towards variety and the establishment of new cultivation systems to accommodate landscaping and environmental requirements and the operation structures in the different EU-28 countries.

- In terms of energy policy, parallel expansion of the use of electricity, heat and fuels from biomass can help promote energy crop production geared towards variety. Energy policy aims and promotional instruments for electricity, heat and fuels must be better coordinated, however, to prevent competing use and planning uncertainties. In terms of limited resources, efficiencies must be better taken into account to allow further expansion of electricity generation from biomass focussing even more on CHP systems for example. Environmental aspects must be accommodated to a greater extent.

- In terms of trade policy, a framework for additional worldwide trade of bioenergy sources must be created, and appropriate fuel, environmental and social standards must be established to ensure sustainable biomass production in all countries of origin.

- Different bioenergy source markets will establish themselves as part of increasing biomass use. The implementation of energy, agricultural and environmental policy targets for biomass use in the individual countries will have a key effect on the corresponding trade flows in Europe. The more “uneven” the development, the greater the extent to which trade flows will develop in Europe. Full implementation of all relevant measures for biomass use in all member states is therefore an essential requirement for sustainable and regionally balanced biomass use.

- If biomass is used to a significant extent in future, this will also have definite effects on the food market. It can also affect food production, leading to corresponding effects on the agricultural biomass potentials. These types of interactions cannot currently be analysed satisfactorily because the necessary tools (models) do not yet exist. Methodical research is still required in these areas.

3 Biomass supply ... 52

Arno Henze, Anne Scheuermann, Jörg Schweinle, Daniela Thrän, Michael Weber, Jürgen Zeddies

6 Biomass markets ... 231

Nicolle Fröhlich, Arno Henze, Jörg Schweinle, Michael Weber, Jürgen Zeddies

List of figures

List of tables

List of abbreviations

AL	agricultural land
a	annum (year)
AI-AIV	waste wood class I - IV
ACP	Africa, Caribbean and Pacific
Art.	Article
BAFA	German Federal Office of Economics and Export Control
Benelux	Belgium, the Netherlands, and Luxembourg
CHP plant	combined heat and power plant
BIOBIB	Bioenergy Feedstock Development Program Bibliography
GDP	gross domestic product
BTL	Biomass to Liquid
CAPSIM	Common Agricultural Policy Simulation Model
CDM	Clean Development Mechanism
CFPP	cold filter plug point
CIF	Cost, Insurance and Freight
CITES	Convention on International Trade in Endangered Species of Wild Flora and Fauna
COMELEC	Comité Maghrébin de L'Electricité / Maghreb Electricity Committee
CP	Current Policy scenario
DDGS	Distillers Dried Grains with Solubles
DIN EN	German industry standard
DME	dimethyl ether
E+	Environmental scenario
E+	Environmental scenario
EAGGF	European Agriculture Guidance and Guarantee Fund
EBA	Everything But Arms
EC	European Commission
ECE	Economic Commission for Europe
EEA	European Environmental Agency
EEG	Erneuerbare-Energien-Gesetz (German Renewable Energy Sources Act)
RES Directive	Renewable Energy Sources Directive
UESR/UES	Unified Energy System of Russia (UESR), Unified Energy System of former Soviet countries as well as Bulgaria and Romania (UES)
EFISCEN	European Forest Information Scenario Model

Efm ob	Erntefestmeter - solid cubic metre over bark (measuring unit to define the harvested timber quantity after deduction of harvest losses and unusable parts)
Efm ub	Erntefestmeter - solid cubic metres of harvested timber under bark (measuring unit to define the harvested timber quantity after deduction of harvest losses and unusable parts)
EFSOS	European Forest Sector Outlook Study
EC	European Community
TEC	Treaty establishing the European Community
RDP	Rural Development Programme
ETBE	ethyl tertiary butyl ether
EtOH	ethanol
EU-10	New EU member states since 01/05/2004
EU-15	EU member states before 01/05/2004
EU-25	All EU member states as of 01/05/2004
EU-28	EU member states including acceding and candidate countries (Bulgaria, Romania and Turkey)
EUROSTAT	Statistical Office of the European Communities
EEC	European Economic Community
R & D	research and development
FAO	Food and Agricultural Organisation
FAOSTAT	Statistical databases of the United Nations' Food and Agricultural Organisation
FAPRI	Food and Agricultural Policy Research Institute
FFH	Flora Fauna Habitat Directive
FLEGT	Forest Law Enforcement, Governance and Trade
FOB	Free on Board
FSC	Forest Stewardship Council
FT diesel	Fischer-Tropsch diesel (synthetic diesel)
GAK	Joint Task for the „Improvement of Agricultural Structures and Coastal Protection“
CAP	Common Agricultural Policy (EU member states)
GATT	General Agreement on Tariffs and Trade
GE	grain equivalent
GEMIS	Global Emission Model for Integrated Systems
GJ	gigajoules
CCGT	combined cycle gas turbine
LU	livestock units

H_u	heating value
FADN	Farm Accountancy Data Network
IPP	Integrated Product Policy
ITTO	International Tropical Timber Organisation
JI	Joint Implementation
chap.	chapter
KfW	Kreditanstalt für Wiederaufbau (German Reconstruction Loan Corporation)
COM	Commission (EU)
SRF	short rotation forestry
kW	kilowatt
kWh	kilowatt hour
CHP	combined heat and power generation
LDC	Least Developed Countries
LHO	Landeshaushaltsordnung (German State Budget Regulations)
MIP	Market Incentive Programme
MCPFE	Ministerial Conference on the Protection of Forests in Europe
MDF	medium density fibreboard
Mercosur	Mercado Común del Sur (Southern Common Market)
Mg	megagram
MinÖlSt.	Mineralölsteuer (mineral oil tax)
MJ	megajoule
Mtoe	million tons oil equivalent
MW	megawatt
MW_{el}	megawatts of electrical power
MWth	megawatts of thermal energy
RRM	renewable raw materials
NFFO	Non Fossil Fuel Obligation
NFP	National Forest Programme
NRW	North-Rhine Westphalia
OECD	Organisation for Economic Co-operation and Development
ORC	Organic Rankine Cycle
DOM	dry organic matter
PEFC	Programme for the Endorsement of Forest Certification Schemes
PJ	petajoule (1015)
PME	plant methyl ester

ProBAS	process-orientated basis data
REF	reference case
RME	rapeseed methyl ester
CS	crude sugar
bdt	bone-dry tons
TBFRA-2000	Temperate and Boreal Forest Resource Assessment (conducted by UN/ECE and FAO)
GHG	greenhouse gas
DM	dry matter
TWh	terrawatt hours
UCTE	Union for the Coordination of Transmission of Electricity (European integrated network)
UN	United Nations
UNCED/IPF	United Nations Conference on Environment and Development
	International Panel on Forests
UNO	United Nations Organisation
VAT	value-added tax
Vfm ob	Vorratsfestmeter - solid cubic metres of standing timber over bark (volume of the growing stock in the forest)
Reg.	Regulation
% vol	percent by volume
WS	white sugar
WTA	World Trade Analyzer
WTO	World Trade Organisation
SC	sugar cane
SB	sugar beet

Conversion of units

	kJ	kcal	kWh	m^3 natural gas	kg coal equivalent (CE)	kg oil equivalent (OE)	barrel
1 kJ	1	0.2388	0.000278	0.000032	0.000034	0.000024	$1.76 \cdot 10^{-7}$
1 kcal	4.1868	1	0.001163	0.00013	0.000143	0.0001	$7.35 \cdot 10^{-7}$
1 kWh	3,600	860	1	0.113	0.123	0.086	0.000063
1 kg CE	29,308	7,000	8.14	0.924	1	0.70	0.0052
1 kg OE	41,868	10,000	11.63	1.319	1.428	1	0.0074
1 barrel	5,694,048	1,360,000	1,582	179.42	194.21	136	1
1 m^3 natural gas	31,736	7,580	8.816	1	1.082	0.758	0.0056

Country abbreviations

AT	Austria
BE	Belgium
BG	Bulgaria
CY	Cyprus
CZ	Czech Republic
DE	Germany
DK	Denmark
ES	Spain
EE	Estonia
FR	France
FI	Finland
GB	Great Britain
GR	Greece
HU	Hungary
IT	Italy
IE	Ireland
LU	Luxembourg
LV	Latvia
LT	Lithuania
MT	Malta
NL	Netherlands
PT	Portugal
PL	Poland
RO	Romania
SE	Sweden
SK	Slovakia
SI	Slovenia
TR	Turkey

1 Introduction

The central aim of the energy programmes on the national and European level is to increase renewable energies' share of the energy system. Biomass plays a very important role in all these programmes. On the German energy markets, the German government has set clear priorities by means of initiatives such as mineral oil tax exemption for biofuels, and the German Renewable Energy Sources Act (Erneuerbare-Energien-Gesetz, EEG), which are aimed at quickly and effectively supporting the generation of energy from biomass.

The resulting momentum for bringing new technologies onto the market, however, only achieves lasting success on the national level if it also makes ecological sense, and is economically attractive, in the context of aiming towards a harmonised European energy market. Here on the European level, there is an increase in the available biomass resources due to the eastern enlargement of the EU on the one hand, and on the other hand the political objectives on the European and national level mean that a significant increase in demand for various biomass products (e.g. biofuels) can be expected across Europe. It is therefore inevitable that there will be a rise in the trade of biofuels. This is already becoming evident today, and will also significantly influence and change the German market.

With these issues as a backdrop, the objective of this project is to analyse and assess possible strategies towards increased biomass use in the provision of solid, liquid, and gaseous bioenergy sources to supply electricity, heat, and fuel, in the context of (German, European, and global) circumstances, interconnections, and guidelines for Germany[1] This will allow conclusions to be drawn, which will make it possible to make statements regarding the future establishment of a framework for environment, energy, industry and agriculture, for an increased use of biomass in Germany and the European Union (EU).

To this end, an overview of the European **framework** regarding policy on energy, forestry and agriculture, as applied in the EU-28 states[2] (chapter 2) will follow.

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[1] The present studies supplement the BMU (Federal Ministry for the Environment, Nature Conservation and Nuclear Safety) research project “Stoffstromanalyse zur nachhaltigen energetischen Nutzung von Biomasse” (Material Flow Analysis of Sustainable Biomass Use for Energy) concluded in May 2004 (http://www.erneuerbare-energien.de/1024/index.php?fb=/sachthemen/ee/aktuell_biomasse/&n=11894).

[2] EU member states as of 01/01/2005 as well as Bulgaria, Romania and Turkey

This is followed by an analysis of the potential of the European **biomass supply** (chapter 3) and of the **demand for bioenergy** (chapter 4), each considering various scenarios up to the year 2020.

With this as a basis, the examination of the **supply chains** comprises the analysis of the technical systems for the supply and use of bioenergy, the inference from use scenarios, and their economic, ecological appraisal (chapter 5).

Subsequently, significant **biomass markets** within the EU are described and assessed, along with where they fit in with regard to the expected European biomass trade. Furthermore, actual market segments such as the pellet market and the bioethanol market are also examined in the global context (chapter 6).

Finally, the examinations are summarised, and corresponding **conclusions** are drawn. Also included by way of summary, is a description of the required political measures on the German and on the EU level, and of the required modifications to measures which have already been introduced, necessary for the realisation of an advancement in biomass use along with an advancement in the reduction of environmental impact at a minimum cost (chapter 7).

2 Framework

This description of the framework is to aid the appraisal of the current and future biomass use in Europe. It comprises an overview of the relevant instruments of European policy in the fields of energy, forestry, and agriculture, their principal orientation and developments, an additional description of the situation in selected member states, and the estimated effects on, for example, biomass supply and demand, production costs and market developments.

2.1 European energy policy

2.1.1 European measures

White Paper on Renewable Energy Sources (1997)

In its 1997 White Paper on Renewable Energy Sources, the European Commission set itself the target of doubling renewable energy sources' share of total gross domestic consumption (primary energy consumption) by 2010, bringing it to 12% /1/. Furthermore, the White Paper included descriptions of objectives for the various individual energy sources, with the target for biomass for the year 2010 at 135 Mtoe p.a. (5,628 PJ p.a.) without further differentiation between biogenic solid fuels, biogas, and biofuels. The aims of the White Paper form the basic foundation for the various measures for increasing the share of biomass use, as described in the following.

Directive on the promotion of electricity produced from renewable energy sources in the internal electricity market (2001)

One of the steps made towards achieving the objectives of the White Paper was the *Directive 2001/77/EC on the promotion of electricity produced from renewable energy sources in the internal electricity market* (RES Directive) which came into effect on 27 October 2001 /2/. According to this directive, renewable energy sources' share in power generation across the entire EU should rise from around 14% in 1997 to about 22% in 2010. Among the various European measures towards the reduction of climate-relevant emissions, the RES Directive plays a key role with regard to the achievable emission reductions, and should achieve savings of 100 to 125 million Mg of CO_2 equivalent /50/. Within the directive, indicative (non-binding) targets are set for each member state, whereby the respective country is free to decide which instruments to use to reach this target. The target for Germany is an increase to 12.5% by 2010; this means doubling the 6.25% of the year 2000. This lifted the previous target from the German government's National Climate Protection Programme of October 2000 (doubling to a 10% share, with 2000 as the basis year) quite considerably.

Directive on the promotion of cogeneration based on a useful heat demand in the internal energy market (2004)

The European *Directive 2004/8/EC on the promotion of cogeneration* (CHP Directive) of 11 February 2004 calls for a harmonisation of CHP power calculation methods, simplification of grid access, and regular national and European reports. The original version envisaged an indicative target for CHP power in the EU of 18% of the gross power generation, which would have meant nearly doubling the 10% reached in 2000. This was not adhered to. Now there is more of an emphasis set on accommodating specific national frameworks /77/. Thus, with regards to the development of CHP, the Europe-wide effects which can be expected from this directive are only limited. Targets and measures for the increased use of biomass in CHP are not defined.

Directive on the promotion of the use of biofuels or other renewable fuels for transport (2003)

In the field of biogenic fuels, the *Directive 2003/30/EC on the promotion of the use of biofuels or other renewable fuels for transport* was passed on 8 May 2003 /3/. This stipulates that the EU member states should ensure that a minimum share of biofuels and other renewable fuels be introduced in their respective markets. This share, measured by energy content, is to be 2% by 31 December 2005, and is to increase to 5.75% by 31 December 2010 (Art. 3 (1)). For the year 2002, this would mean approximately 610 PJ p.a. in the EU-15 /114/. The call for obligatory quantity targets and obligatory blending of biofuels with conventional fuels proved unenforceable. Nevertheless, supportive measures and biofuel sales volumes must be reported to the Commission annually. If the objectives are not achieved, the EU can set mandatory targets for individual countries. Thus, it can be assumed that the indicative quantity targets stipulated in the directive will accelerate biofuels' introduction to the market throughout the EU.

Directive restructuring the Community framework for the taxation of energy products and electricity (2003)

On 27 October 2003, the Council of the European Union passed the *Directive 2003/96/EC restructuring the Community framework for the taxation of energy products and electricity*. This grants member states a mineral oil tax reduction, extending to a complete exemption for pure biofuels, or the biogenic component of fuel. Nevertheless, over-compensation must not occur (Art. 16 (1), (3)). This directive goes further than the Commission's original suggestions to approve only a maximum 50% mineral oil tax exemption. It is particularly relevant in Germany, as it enables complete exemption from mineral oil tax.

Voluntary commitment of car manufacturers to the reduction of average specific CO_2 emissions (1998/99)

Additionally, in 1998/99, European, Japanese, and Korean car manufacturers committed themselves to a 25% reduction of their average specific CO_2 emissions in the passenger vehicle sector within 10 years, meaning that these emissions are not to exceed 140 g of CO_2 per vehicle kilometre as of 2008/2009. This agreement constitutes a significant measure towards implementation of the European strategy for reduction of average specific CO_2 emissions in the private vehicle sector to 120 g of CO_2 per vehicle kilometre by the year 2010 /53/. By the year 2000, these emissions were reduced from 187 g to 168 g of CO_2 per vehicle kilometre, due mainly to the increased sales of diesel-powered vehicles /50/. In this context, the attainability of the voluntary target is being critically evaluated /52/. A further reduction of 17% of the emissions in 2000 would be necessary, i.e. an increase in the annual reduction rate from 1.5% to 2% /50/. The interim report is currently being reviewed by the European Commission /52/.

Directive establishing a scheme for greenhouse gas emission allowance trading within the Community (2003)

On 13 October 2003, the Council of the European Union passed the *Directive 2003/87/EC establishing a scheme for greenhouse gas emission allowance trading within the Community* /77/. Within this directive, it is planned that by 1 January 2005, emissions permits are to be distributed to the operators of climate-relevant installations in accordance with a national allocation plan, and as of 2008, reallocation is to occur at five-year intervals. In addition, on 29 January 2004, guidelines were established for the monitoring and reporting of greenhouse gas emissions in accordance with the above-mentioned directive /77/. Corresponding measures towards the setup of allowance trading are currently being developed in the member states (see TGH-G and DEST in Germany), so that a punctual introduction of allowance trading can be expected, and corresponding effects are to be reckoned with as of 2008.

Directive on the energy performance of buildings (2002)

The European Parliament and the Council of the European Union passed the *Directive 2002/91/EC on the energy performance of buildings* (Buildings Directive) on 16 December 2002. The objective of this EU directive is to support the improvement of the energy performance of buildings in consideration of the respective external climatic and local conditions, the interior climate requirements, and the cost-effectiveness. For new buildings, decentralised power supply systems based on renewable energy sources (including biomass) constitute one of the factors to be considered (Art. 5). There is no explicit mention (promotion) of heat from biomass.

Campaign for take-off (2000 - 2003)

To achieve the objectives of the White Paper, a four-year information campaign was launched in the year 2000, to support the market penetration of renewable energy sources. This also involved mapping out various indicative targets for biomass use for the period up to 2003. These included /55/:

- an additional 10,000 MW_{th} from biomass CHP plants,
- one million additional buildings heated by means of biomass,
- 1,000 MW of additionally installed biogas systems,
- the production of 5 million tons of biofuels.

These targets were not further specified for the individual nations, and were only partly integrated into the reports /56/ /50/.

Campaign Sustainable Energy Europe (2005 - 2008)

To achieve the objectives of European energy policy, the Campaign for take-off was followed up by the launch of the Campaign Sustainable Energy Europe in 2005 for a further four years. To enable measurement of the success of the campaign, indicative targets were set for selected sectors. In the biomass sector, the following specifications are to be achieved by 2008 on the EU level /115/:

- 6,000 new biogas systems,
- 450 new biomass CHP systems,
- 13,000 newly installed central heating systems running on biomass,
- increase of bioethanol production to 5 times the current level, and
- increase of biodiesel production to 3 times the current level.

Coordinated European Biomass Action Plan

In its midterm review of progress with regards to the EU-15 targets for the share of renewable energy by the year 2010, the EU concluded that the sectors of heat generation, cooling systems, and power generation from biomass have seen insufficient development. Therefore, if expansion targets are still to be achieved, a coordinated biomass plan is deemed necessary /92/. This Biomass Action Plan, compiled in such a manner as to span several General Directorates of the EU, includes additional instruments for the promotion of biomass (also for heat generation) and should be decided upon by the end of 2005. Also currently being discussed, are further legislative stipulations, R&D measures, and additional public relations work. The issue of biomass imports is also the subject of controversial discussion in the EU, so at this stage the exact nature of the intended plan is yet to be defined /94/.

2.1.2 Orientation and developments

2.1.2.1 Electricity

The use of renewable energy sources for power generation can be promoted by means of various energy policy instruments.

Investment incentives help to cross the "hurdle" of high start-up capital. They are primarily aimed at the promotion of investment in renewable energy sources which at this time cannot (yet) be depicted economically. Investment incentives usually consist of between 20% and 50%, in some cases up to 100%, of the investment costs. Loans at reduced interest rates will also be considered to be investment incentives.

Some EU countries support power generation from renewable energy sources by means of **tax incentives** in various forms. Some of these forms are reductions or exemptions from the general energy tax, or from special emission taxes, and lower value-added tax.

A **feed-in tariff** for electricity from renewable energy sources is a frequently used promotion instrument. Such tariffs can take the form of a guaranteed minimum remuneration, or an additional remuneration on top of the usual market price for electricity. In almost every instance, the electricity supply companies are legally obliged to pay the (independent) electricity producers the stipulated remuneration. The feed-in tariff can be paid directly by the user, or by means of subsidies. The level of the feed-in tariff is usually set for a certain period (several years) to make it possible to provide the required investment security.

A **quota scheme** facilitates a minimum share of power generation or consumption for renewable energy sources. The state stipulates a framework, within which the market must generate, sell, or distribute a predefined portion of renewable energy sources. These portions can usually be traded between different companies or plants (allowance trading).

In a "tendering system" (**NFFO Non Fossil Fuel Obligation**), it is the cheapest supply of power from renewable energy sources which counts. This puts the potential investors and electricity producers in the respective categories (wind power, hydropower, biomass, etc.) into competition with each other. This system can be applied to investment incentives, feed-in tariffs, or limited rights (e.g. site area for wind energy), whereupon the allocation criteria are already stipulated before the evaluation of tenders. The acceptance of a tender is connected with an obligation to sell a certain amount of electricity generated from renewable energy sources, at a best price. The electricity producer receives the difference between this best price and the usual market price which is transferred to all energy consumers. As in each tendering round the most cost-effective tender gets accepted, the additional costs caused by the use of renewable energy will be kept as low as possible.

2.1.2.2 Heat

Within the goal-setting framework for the use of renewable energy sources in the heating market, which comprises more than a third of energy consumption in the EU-15, biomass has a prominent position /114/. The EU White Paper on the use of renewable energy sources defines the objective of nearly doubling from 1,593 PJ to 3,140 PJ for the EU-15 member states between 1995 and 2010. In the heating market, biomass is currently, and will probably continue to be, the most significant renewable energy source, taking a 95% share /115/.

In the EU, individual initiatives for the promotion and support of biomass in the heating market have indeed been carried out, and more are planned (see chapter 3.1.1), yet these are far from the scale of the targets already set as directives for electricity and fuels (see chapter 3.1.2.3). Correspondingly, the heating market only features to a limited extent in the reports on the share of renewable energy sources in the EU /4/.

The use of biomass in the heating market can in principle be promoted by means of the same political instruments illustrated earlier for the electricity sector. On the part of the EU, the following activities are being considered or suggested in addition to the current measures /4/:

- launch of an initiative specifically aimed at renewable energy sources for heating and cooling applications,
- initiatives and legislative suggestions for improved exploitation of the potential of modern biomass heating,
- obligation of heating oil and gas suppliers to extend their product portfolios to include, for example, wood pellets and biogas.

It remains to be seen whether and how these as-yet unrealised concepts will be integrated with the European energy policy instruments. Here, the promotion of heat from biomass in the currently discussed Biomass Action Plan (see section 2.1.1) plays a significant role. Also being discussed, is a Heat Directive which would promote environmentally friendly heat (modern technology, local district heating systems) from wood. At this time, however, it is uncertain whether it will be implemented /94/.

2.1.2.3 Fuel

Each EU member state is required to submit a national concept for the introduction of biofuels to the market no later than 18 months after Directive 2003/30/EC comes into effect. In so doing, the member states can indeed set themselves quantity targets which are lower than those mentioned in the directive if, for example, there is a lack of national resources for the production of raw materials due to insufficient land capacity /4/.

2.1.2.4 Emissions trading

With the introduction of emissions trading in the European Union, additional costs will arise for greenhouse-gas-related activities as of 2008. In the energy sector, joint incineration of biomass in coal-fired power stations could become relevant, although the type and scope of such measures depend on many different factors (certificate price, emissions of the electricity mix, the type and scope of the replacement investments in the generation mix, etc.).

The other foreseen possibilities within the framework of emissions trading, namely Clean Development Mechanism (CDM) and Joint Implementation (JI) have as yet only been realised to a small extent in most member states, so notable effects cannot (with the exception of the Netherlands) be expected before 2012 /51/.

2.1.2.5 Development of the framework

Within European energy policy, a comprehensive range of instruments has been set up to increase the use of biomass. Yet, it must be noted that according to current projections, the EU climate protection targets which form the basis of the White Paper will not be reached on schedule. For this reason, the existing instruments may well be intensified in the coming years, or supplemented by further instruments. It is currently evident, from the point of view of climate protection, that there is a need for action in the energy sector, especially in the following areas /50/:

- There has as yet been no stopping the drastically increasing trend of emissions of climate-relevant gases in the transport sector.

- While the emission of greenhouse gases from households has to some extent been decoupled from the relatively pronounced increase in building numbers, there is still an increasing trend.

- While in most of the EU-15 countries there is a clear need for action, most of the acceding countries (with the exception of Slovenia) have already reached the targets due to plants with extremely high emissions being closed down as a result of economic change.

Projections based on current trends clearly show that the EU's climate protection targets will only be reached in individual member states /50/. Therefore it can be expected that further national measures will be introduced in efforts to comply with the directives, bringing additional stimulation of biomass use. Here, it is worthy of note that an extendable range of instruments has been set up for the electricity and fuels sectors, whereas in the heating sector no comparable targets and instruments are foreseen, neither on the EU level, nor on the national level.

2.1.3 Situation in selected EU member states

2.1.3.1 Germany

Generation of electricity from biomass

In April 2004, the German Bundestag passed a comprehensive amendment to the German Renewable Energy Sources Act (EEG) which was then approved by the German Bundesrat in July 2004. In the amendment, the promotion of power generation from renewable energy sources was improved considerably. This granted systems which generate electricity from biomass:

- an output-related base remuneration of 8.4 to 11.5 euro cents/kWh,
- an additional bonus of 2.5 to 6 euro cents/kWh for the use of only natural products from agriculture and forestry (RRM bonus),
- an additional bonus of 2 euro cents/kWh for the use of combined heat and power (CHP bonus),
- an additional bonus of 2 euro cents/kWh for the use of innovative technologies (technology bonus).

This makes remuneration rates of up to 21.5 euro cents/kWh attainable for small biogas systems (Table 1).

For a 10 MW system with a steam engine and CHP, the use of logging residues would mean a remuneration rate of 12.2 euro cents/kWh.

Table 1: EEG remuneration rates for biomass in August 2004 in euro cents/kWh$_{el}$

	from biomass					from landfill gas, firedamp and sewage	
	Minimum/Basic payment		RRM bonus	CHP-bonus	Technology bonus$^{1)}$	Minimum/ Basic payment	Technology bonus$^{1)}$
	from 01.01.2004	for AIII-AIV as of 01.07.06					
Output up to 150 kW	11.5	3.9	6.0	2.0	2.0		2.0
Output up to 500 kW	9.9	3.9	4.0			7.67	
Output up to 5.000 kW	8,9	3.9	2,5			6.65	
Output up to 5.000 kW	8,4	3.9	0.0			6.65	

$^{1)}$ The technology bonus mentioned in §8, paragraph 4, is only granted if the system is operated using combined heat and power generation, and if the power is generated by means of fuel cells, gas turbines, steam engines, Organic Rankine Cycle systems, multi-component mixture systems (particularly Kalina Cycle systems) or Stirling motors.

Heat generation from biomass

To increase the market penetration, to reduce the system costs, and to improve the system cost-effectiveness of systems which utilise renewable energy sources, a Market Incentive Programme was introduced by the German government in 1999. The promotion currently in place within the scope of this programme provides for the following biomass support options in the heating market:

- Investment incentives for systems with automatic feeding of 8-100 kW for solid biomass and log wood boiler systems of 15-100 kW[12]. The incentives take the form of grants, which are to be applied for at the German Federal Office of Economics and Export Control (BAFA).

- Investment incentives for systems with automatic feeding of more than 100 kW using mainly natural wood, by means of low-interest loans and the possibility of partial debt cancellation. These incentives are the responsibility of the German Reconstruction Loan Corporation (KfW).

Additional investment incentives can be accessed within the scope of the building refurbishment programmes on the nationwide and regional levels, and the nationwide CO_2 reduction programmes.

The promotion of biomass use in the heating market is indirectly complemented by the absence of an "energy tax" on biogenic fuels. This creates a financial advantage over fossil

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[12] Here, and subsequently, output limits are based on the rated heat output.

fuels based on oil and natural gas, which are taxed on the basis of the Mineral Oil Tax Act. Nevertheless, no taxation is foreseen for the use of coal.

Further measures for the promotion of biomass use in the heating market are being discussed. One idea under consideration is a quota model for renewable energy sources in the heating market, which could, for example, be implemented within the scope of a "Heat Act". New stimuli could arise from the European initiatives Campaign Sustainable Energy Europe, and Biomass Action Plan (currently in preparation).

Fuels from biomass

In Germany, a 100% tax exemption for biofuels in pure form and in blends by means of an amendment to the Mineral Oil Tax Act was already passed in the German Bundestag in June 2002, subject to the approval of the EU Commission, which was granted on 18 February 2004. On 28 November 2003, the German Bundestag approved a further amendment to the Mineral Oil Tax Act, which allots an extension of the tax relief (mineral oil tax exemption) for biofuels and biomass heat sources to 31 December 2009. Energy products which arise exclusively from biomass as stipulated in the Biomass Ordinance are defined as biofuels and biomass heat sources.

Furthermore:

- in order to be classed as a biofuel, bioethanol must contain at least 99% vol. alcohol, and not be denatured (ethyl alcohol 2207 1000),
- the tax exemption must not cause over-compensation of the higher production costs associated with biofuels in comparison with fossil fuels,
- the tax exemption must be adapted to market developments regarding the prices of raw materials,
- protective measures are to be proposed at the EU Commission in the event that imports from outside the EU should disturb the European biofuels market,
- authorities responsible for any bioethanol produced outside Germany must issue a manufacturer certification.

The arranged proposal of protective measures is the subject of debate amongst market experts, as these measures may be difficult to implement in light of the WTO's continued dismantling of trade barriers.

There is currently no legislation on the EU level, nor in Germany, for a blending obligation with regards to bioethanol (a blending obligation is envisaged in the German government's coalition agreement). This strengthens the market position of the mineral oil industry, which now, consolidated in light of a low bioethanol price, expects incentives for its use.

As of 2005, the Federal Ministry of Finance of the German Bundestag is to submit an annual report on the introduction of biofuels and biomass heat sources into the market. The first report, issued on 17 June 2005, showed over-subsidisation of biodiesel by 5 cents a litre in pure form, and by 10 cents a litre as a component in blends with fossil diesel, in the year 2004. Hence, it is suggested that biodiesel be taxed proportionately in the future /116/.

2.1.3.2 EU-25

Appendix 1 includes a description of the significant targets for the EU-25 countries as stipulated in the RES Directive, as well as those on the national level. Alongside this, significant energy policy instruments (current in 2003), intended to promote the implementation of the targets for increased biomass use, are listed. Details regarding the EU membership candidates Turkey, Bulgaria, and Romania are not provided.

Electricity

The EU-25 has set itself the goal of raising renewable energy sources' share of gross electricity consumption from 12.9% in 1997 to 21.0% in 2010 /2/. In Figure 1, a summary of the individual countries' indicative targets for the year 2010 is shown, in comparison with renewable energy sources' share of gross electricity consumption in 1997. In some countries (Portugal, Austria, Slovenia, Latvia, and Sweden), only a slight increase (by a factor of no more than 1.2) is necessary. On the other hand, some countries (Malta, Cyprus), have as yet hardly used renewable energy sources in electricity consumption at all, or must raise their share enormously by 2010 (Estonia by a factor of 25, Great Britain by a factor of 6, Belgium, Poland, and Hungary each by a factor of 5).The target for Germany, an increase by a factor of 3 (from 4.5% to 12.5%) is also challenging.

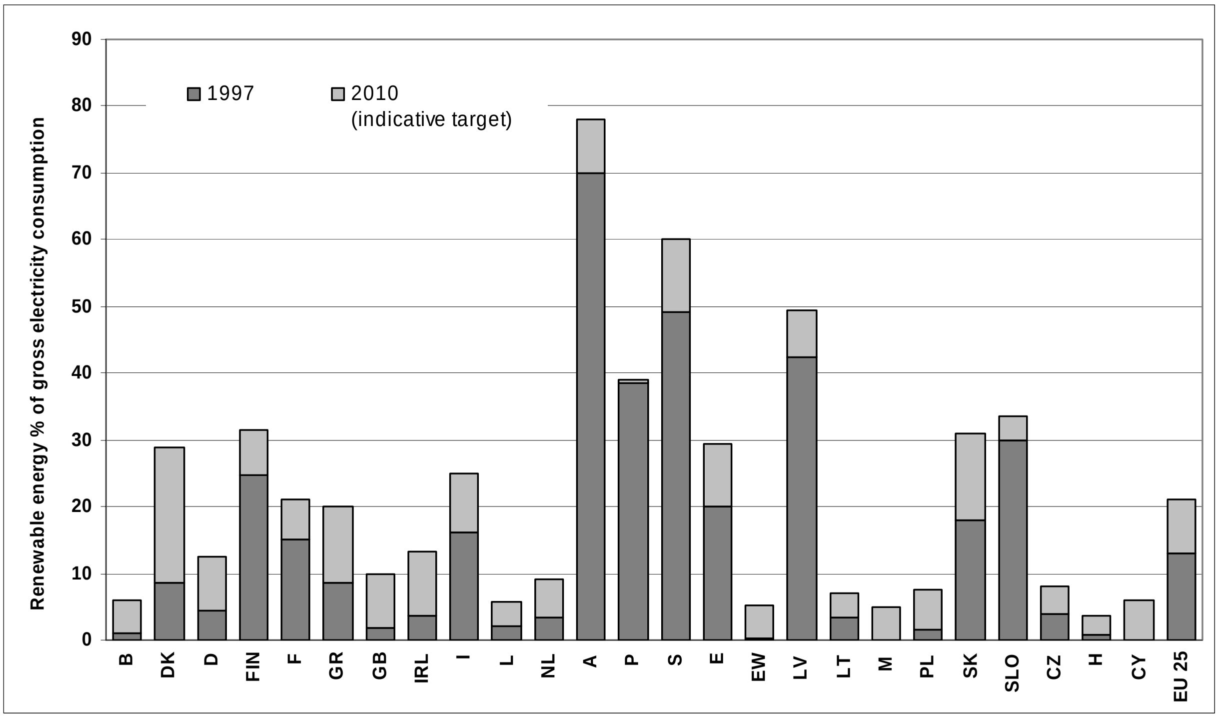

Figure 1: **Share of renewable energy sources in gross electricity consumption 1997 and indicative targets for 2010 in the EU-25 countries**
Source: /2/

As already mentioned, the member states are free to decide which energy policy instruments they use to reach the stipulated targets. Table 2 summarises the energy policy instruments for the generation of electricity from biomass in the EU-25 countries. This has meant that most of the EU-25 countries (76%) promote power generation from biomass mainly by means of investment incentives and by granting a feed-in tariff. Half of the countries also (or instead) grant a tax incentive. This means either that part of the investment costs are deducted from the taxable income, or that the electricity generated from biomass is (partly) exempt from tax (energy tax, purchase tax, CO_2 tax, etc.). Around 30% of the EU-25 countries promote power generation from renewable energy sources by means of establishing a quota, and only two countries (France and Ireland) use NFFO (Non Fossil Fuel Obligation, allocation).

Table 2: **Overview of the energy policy instruments for the promotion of electricity from biomass in the EU-25**
Source:/5//6//7//8//9//11/ (status as in July 2004)

	Investment incentive	**Tax incentive**	**Feed-in tariff**	**Quota scheme**	**NFFO**
Belgium	×	×	×	×	
Denmark	×		×	×	
Germany	×		×		
Finland	×		×		
France	×		×		×
Greece	×	×	×		
Great Britain	×	×		×	
Ireland		×			×
Italy	×		×	×	
Luxembourg	×	×	×		
Netherlands	×	×	×		
Austria	×	×	×		
Portugal	×	×	×		
Sweden	×	×		×	
Spain	×		×		
Estonia		×	×		
Latvia			×	×	
Lithuania	×		×		
Malta	Strategy for promotion of renewable energy sources currently being developed				
Poland	×	×		×	
Slovakia	×				
Slovenia	×	×	×		
Czech Republic		×	×		
Hungary			×		
Cyprus	×		×		
EU-25	**19**	**13**	**19**	**7**	**2**

The level of the feed-in tariff for electricity from biomass in selected EU-25 countries is shown in Figure 3. In most countries, the tariff depends on the scale of the respective system, the biomass used, and sometimes on the region and time of day. In addition, the feed-in tariff is often guaranteed for a certain period (7 to 20 years). The average remuneration granted is around 5 to 7 euro cents/kWh. Considerably higher remuneration for electricity from biomass is granted in Germany (up to max. 21.5 euro cents/kWh) and Austria (up to max. 16.5 euro cents/kWh).

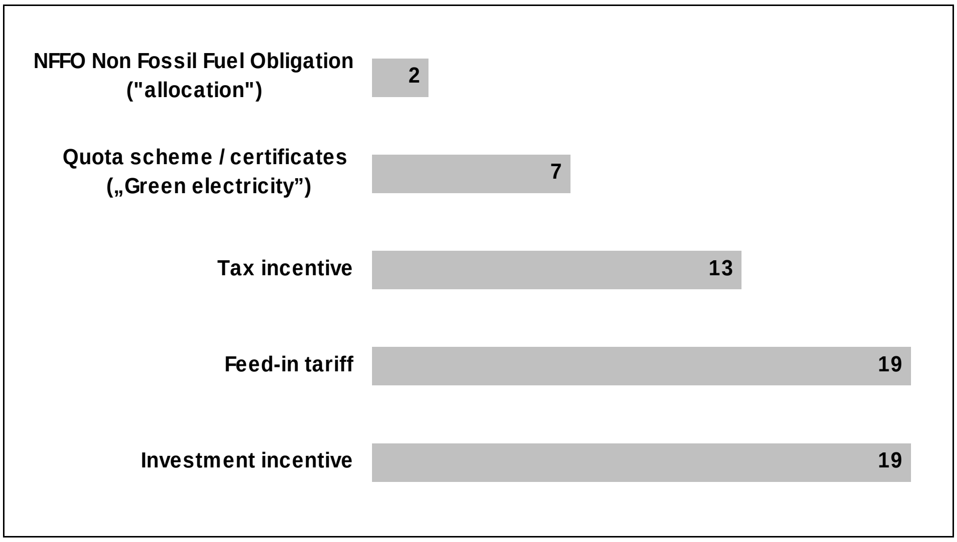

Figure 2: **Frequency of the energy policy instruments for the promotion of electricity from biomass in the EU-25 countries**

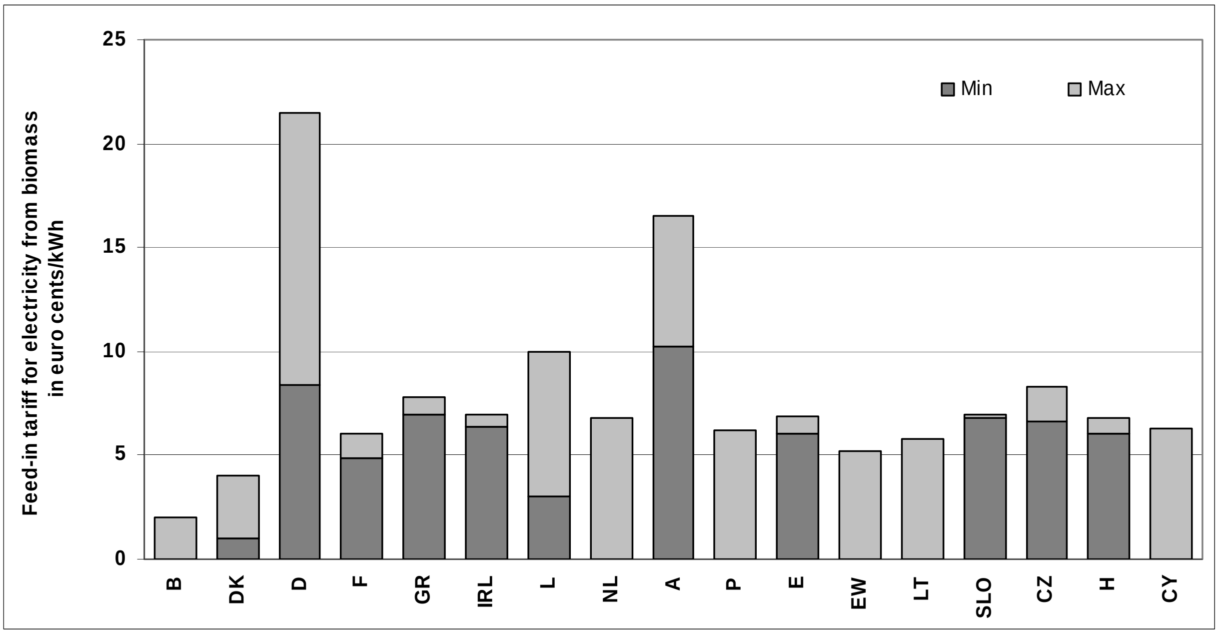

Figure 3: **Level of the feed-in tariff granted for electricity from biomass in selected EU-25 countries**

The maximum investment subsidy for biomass systems is between 20% and 40% (Figure 4) The level of the subsidy usually depends on the system's type (technology used) and size, and is limited to a specified subsidy amount.

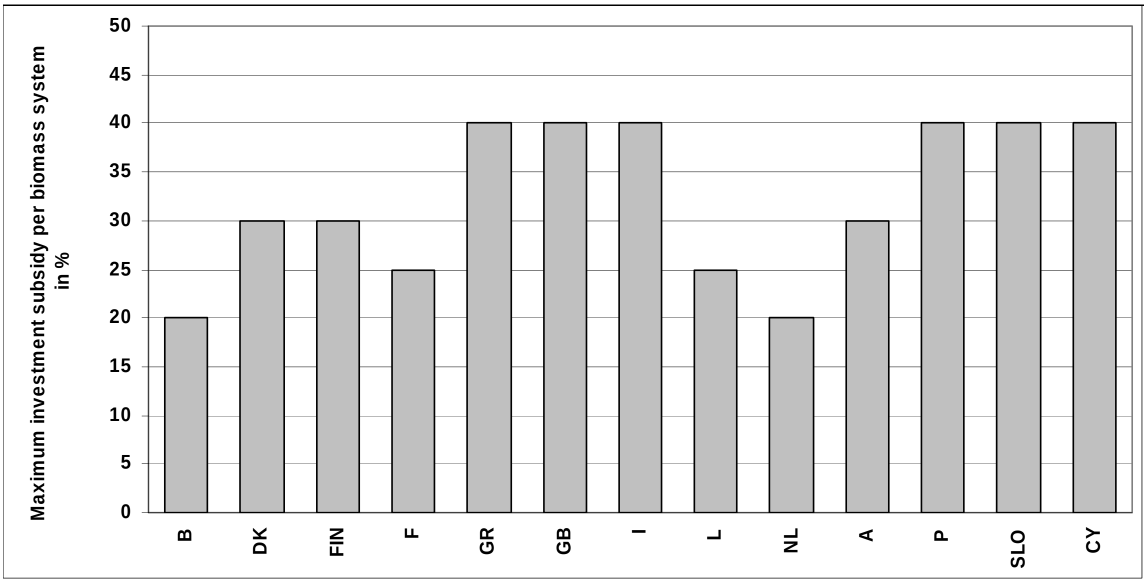

Figure 4: **Maximum investment subsidy for biomass systems in selected EU-25 countries**

Heat

Unlike for the previously described electricity sector, there are no EU directives for the heating market based on biomass, let alone quantified targets for the individual EU member states. Only the already described doubling of biomass use from 1995 to 2010 for the entire EU (EU-15) has as yet been indirectly defined as an objective, albeit one which calls for additional measures if it is to be attained. If current trends continue unchanged, it may come to pass that in the year 2010, only around two thirds of the targeted levels will have been reached (Figure 5).

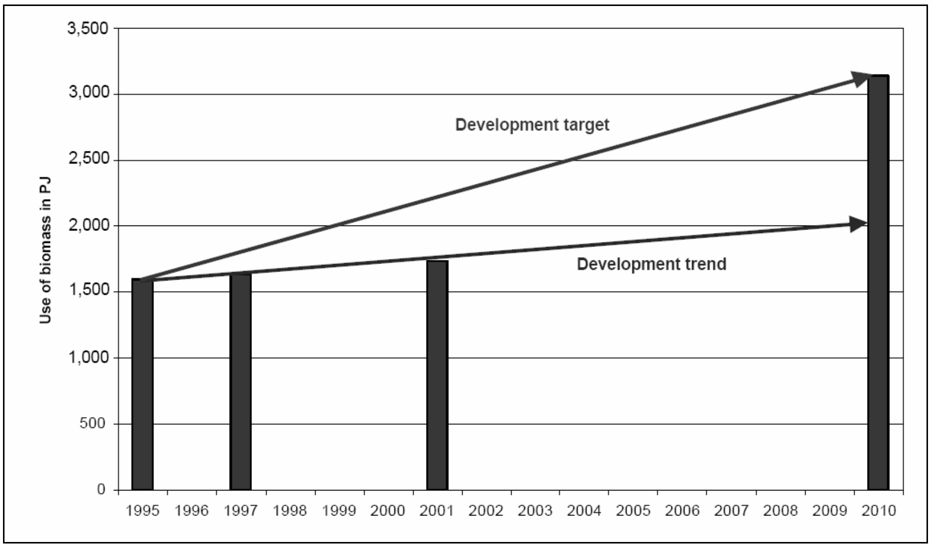

Figure 5: **Target and trend developments of biomass use in the heating market in the EU-15 member states**
Source: /1//5//6/

The partially hesitant development of energy policy instruments for the promotion of biomass use in the heating market can be considered as the background of this development. This is presumably due to the lack of specific targets for the individual countries. An overview of the energy policy instruments in the individual EU member states is provided in table 3. Research has shown that the supply and depth of information on the promotion of biomass use in the heating market is nowhere near as comprehensive as, for example, in the electricity sector. As far as energy policy instruments are concerned, the significance of biomass use in the heating market, although reaching respectable proportions in individual EU member states, has as yet been paid less attention.

Table 3: Promotion instruments for biomass in the heating market in the EU-25 countries

	Investment incentive	Tax incentive	Feed-in tariff	Quota scheme	NFFO
Belgium	×				
Denmark	×	×			
Germany	×	×			
Finland	×	×			
France	×	×			
Greece	×	×			
Great Britain	×				
Ireland	No instruments				
Italy	×	×			
Luxembourg	Promotion only in connection with power generation				
Netherlands		×			
Austria	×				
Portugal	×				
Sweden	×	×			
Spain	×				
Estonia		×			
Latvia	No information				
Lithuania	No information				
Malta	Strategy for promotion of renewable energy sources currently being developed				
Poland	×		×		
Slovakia	No information				
Slovenia	×	×			
Czech Republic	×	×			
Hungary	×				
Cyprus	×				
EU-25	**17**	**11**	**1**	**0**	**0**

The energy policy instruments clearly focus on investment incentives and tax incentives. Tax incentives generally exempt biomass from taxes on fossil energy sources. In some instances, an indirect tax incentive arises by means of a CO_2 tax which does not apply to biomass. In individual cases, tax-privileged depreciation possibilities on the investment are employed as a promotion instrument. The only other instrument identified is the feed-in tariff in Poland. The level of this tariff is however freely negotiable between the heat producer and the heat consumer.

Fuel

The EU has set itself the target of increasing the proportion of biofuels and other renewable fuels, measured against the energy content of all petrol and diesel fuels, to 2% by 2005, and to 5.75% by 2010 /3/. This target applies to all member states. In Table 4, the various energy policy instruments aimed at promoting the use of biofuels in the EU-25 countries are summarised. However, in 30% of the countries (mainly in the new member states) there are currently no specific promotion measures in place. In a further 5 countries, the use of biofuels is only promoted by means of (usually financial) support of demonstration projects and pilot projects.

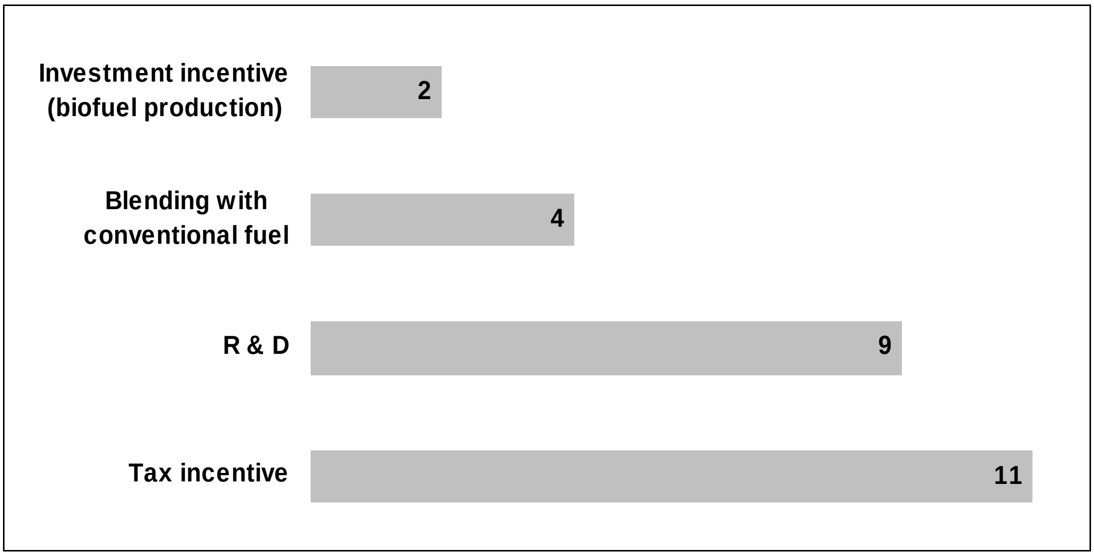

Figure 6: **Frequency of the energy policy instruments for the promotion of biofuels in the EU-25 countrie**

Table 4: **Overview of the energy policy instruments for the promotion of electricity from biofuels in the EU-25**
Source: /5//6//8/ (status as in July 2004)

	Investment incentive	Tax incentive	R & D	Blending with conventional fuel
Belgium			X	
Denmark			X	
Germany		X		X
Finland			X	
France	X	X		X
Greece			X	
Great Britain		X		
Ireland			X	
Italy		X		X
Luxembourg				
Netherlands		X	X	
Austria		X	X	X
Portugal		X	(X)	
Sweden		X	X	
Spain	X	X		
Estonia				
Latvia				
Lithuania				
Malta				
Poland				X
Slovakia				
Slovenia				
Czech Republic		X		
Hungary		X		
Cyprus				
EU-25	**2**	**11**	**9**	**5**

2.1.4 Consequences for biomass use

In European energy policy, clear conditions regarding increased biomass use have been set, particularly for the electricity supply and transport sectors. Currently, the corresponding guidelines are being implemented at the national level, so it can be expected that the rather moderate increase in biomass energy use in previous years will become more dynamic in the future. As the European framework has as yet left the concrete implementation to the member states, further development may take on different forms in the respective member states. It can be expected that corresponding measures will be implemented in the acceding countries with some delay, as these countries are currently confronted with a broad array of changes, and furthermore the pressure to act in order to reach the climate protection targets by 2010 is generally absent. Therefore, it might be the case that an increased expansion will to a large extent only be realised after 2010.

Also comparatively uncertain in all the EU countries is the further development of heat generation from biomass which in the well wooded nations (which include Germany) has traditionally by far the greatest significance of all the renewable energy sources, but for which there are as yet no European guidance instruments planned.

Here, new stimuli may arise from the EU's coordinated biomass plan, which is however yet to be submitted.

2.2 European forestry policy

2.2.1 Orientation and developments

There is no European forestry policy! This statement is true, yet not completely accurate. Forestry and the forest products industry are indeed targeted by political decisions and measures on the EU level. It would however be incorrect, when compared to the Common Agricultural Policy, to describe this as a determined, coordinated and coherent EU forestry policy. While there are a few genuine forestry policy activities in the EU, it is mainly the decisions and measures within agricultural, environmental, energy or economic policy which directly or indirectly influence forestry and the forest products industry. The reason for this dates back to the very beginnings of the EU.

The founding treaties of what was then the EEC included no explicit legal foundation in the area of forestry policy. The term itself, forestry, is not defined in any detail in the Treaty establishing the European Community (TEC). On the other hand, Articles 34-35 of the TEC specify the means towards achieving the Common Agricultural Policy (CAP):

- joint organisation of the agricultural commodities markets,
- supportive measures,
- regulation of competition,
- agricultural structural policy.

In Article 37 of the TEC, the Commission was given the mandate to convene an agricultural policy conference once the TEC had come into effect, which within two years was to present suggestions to the EU Council of Ministers towards the structure and implementation of the CAP. The subject of the CAP is the products of the soil, stockfarming, and fisheries, as well as products of first-stage processing directly related to these products, as defined in Article 32 TEC. This definition basically enabled the inclusion of wood, as product of the soil. As this definition only presented a basic declaration without precise detail, it was inclusion in the "positive list" in Annex II of the TEC which determined what qualified as an agricultural product according to the TEC. It was possible to include agricultural products in the Annex II list until 31/12/1959. In the first European forestry conference, the option of including wood in the list was rejected by all member states. Nevertheless, the representatives of the six member states considered a common forestry policy to be necessary, and called for the setup of a "qualified forestry sector" within the Directorate General for Agriculture and Rural Development. This request was not implemented, so forestry policy authority remained confined to the national level.

Due to the lack of a foundation of legal authority, forestry policy activities were only possible in connection with the objectives of other policy areas, particularly in the area of EU agricultural policy. Due to the fact that, as mentioned, wood was not included in Annex II of the TEC, within the CAP it was only possible to support forestry measures of limited consequence. This occurred in the area of agricultural structural policy.

Four examples of this are listed here:

- Commission proposal for a directive for the promotion of forestry measures,
- Council Regulation on the protection of the Community's forests against atmospheric pollution,
- Council Regulation for the protection of forests in the Community against fires,
- Council Regulation on the tasks of the Structural Funds and their effectiveness and on coordination of their activities between themselves and with the operations of the European Investment Bank and the other existing financial instruments.

To describe the examples mentioned above more fully would go beyond the scope of this report. Moreover, some of these measures are from quite some time ago. Below, the more recent measures are presented and explained in somewhat more detail. Here it is to be pointed out that even though the European Union has not formulated any direct objectives or guidelines for the use of forest products for energy, the energy industry framework (see section 2.1), and especially the objective of promoting the use of renewable energy sources for producing energy, have indeed had direct effects on forestry and the forest products industry.

Furthermore, in the areas of sustainable forest development and forest management, the following recent political activities on the European level, alongside the Ministerial Conferences on the Protection of Forests in Europe, have had direct or indirect influence on forestry and the forest products industry:

European Union Forestry Strategy

The European Union Forestry Strategy presented jointly by the European Commission, Council, and Parliament in 1998 [COM (1998) 649, 03/11/1998] is set up as a type of skeleton agreement, the shape and implementation of which is the responsibility of the member states. On one hand, the strategy is aimed at contributing to the further development of measures already in existence, including the above mentioned measures in the international arena, and on the other hand, the following are to be supported and promoted by means of a common strategy:

- rural development,
- sustainable forest management,
- the multifunctional role of forests,
- protection of forests,
- biodiversity,
- measures against climate change,
- use of wood for energy,
- wood from sustainable forestry as an environmentally friendly raw material.

In addition, more attention is to be paid to the contribution of forestry and forest products industry to general economic development, and there is to be more consideration of the forest and forest products in sector policy (agriculture, environment, energy, trade, industry, research, domestic market, development and cooperation).

In a dedicated section, the use of wood as a source of energy is discussed. The White Paper for a common strategy and action plan entitled "An Energy Policy for the European Union" is referred to. The target of covering 12% of energy consumption by means of renewable energy sources in the year 2010 is highlighted, and it is indicated that use of biomass must increase if this is to be achieved. It states that the role of forests as an energy source, as well as short rotation forestry (SRF), forest residues, and low quality wood should be fundamentally promoted. Nevertheless, restrictions are also formulated:

- that the potential should not be overstated,

- that wood is currently the most expensive energy source, and that addressing this with tax adjustments should not be allowed to affect the continuity of a sustainable supply for the timber industry,

- that short rotation forestry should not be allowed to bring about adverse effects on the environment.

Despite the recently failed attempt to include forestry and the forest products industry in the European constitution as a separate sector, groups within the European Parliament are still actively pursuing this goal. Parliament and groups within the Commission are pushing for a more coordinated and coherent forestry policy in the EU, to counteract the fragmentation which is currently evident in forestry policy within the EU.

European Union Strategy for Sustainable Development

In the Strategy for Sustainable Development [COM(2001) 264, 15/05/2001], the EU set itself the objective of further developing its strategies for the incorporation of an environmental perspective into all relevant areas of common policy with a view to their being implemented as soon as possible. This should enable sustainable development to be strategically implemented as follows:

- National sustainability strategies: the member states are called upon to develop their own national sustainability strategies, and to introduce comprehensive national consultation processes in this area.

- International dimension: sustainable development also requires global solutions. In order to accommodate this comprehensive approach, the Union will strive to make sustainable development an objective of bilateral development cooperation, and of cooperation with international organisations.

Alongside the general political framework, four key areas were selected, where the principle of sustainable development is to be pushed:

(1) Limitation of climate change: Commitments within the scope of the Kyoto Protocol on Climate Change are to be met. The target of a 22% share of total electricity consumption community-wide for renewable energy sources by the year 2012 is affirmed.

(2) Sustainability in the transport sector: By 2003, revised guidelines for the trans-European transport networks are to be set. Investment in public transport, railways, etc., is to be given priority in the future. In addition, the complete internalisation of social and environmental costs is also to be promoted within the scope of a sustainable transport policy.

(3) Prevention of dangers to public health:
By 2004, the new Chemicals Policy is to be in place, which is to ensure that within one generation, chemicals are to be manufactured and used only in manners which do not lead to negative effects on health and on the environment.

(4) Managing natural resources more responsibly:
In connection with the Common Agricultural Policy, in future there is to be more emphasis on the promotion of healthy, high quality products, and environmentally friendly production methods, including ecological production. The promotion of renewable raw materials and the protection of biodiversity were also emphasised.

The needs of the forest and forestry were addressed most in the section "Managing natural resources more responsibly".

Common Agricultural Policy (CAP)

As already explained in the introductory sections of this chapter, forestry policy measures in the EU are only possible in connection with measures in other areas. One important area in this regard is the Common Agricultural Policy (CAP). This is the foundation for forestal promotion. Firstly, forestal promotion is part of the so-called "accompanying measures" as in Regulation (EEC) No. 2078/92, and secondly, it is included in the agricultural structural policy measures pertaining to the European Agricultural Guidance and Guarantee Fund (EAGGF) as in Regulation (EC) No. 1257/1999. While the reforestation of woodlands is promoted via the "accompanying measures", financial aid for the maintenance and development of economic, ecological and social functions in rural areas is granted via the EAGGF.

Forestry will also be affected by the efforts of the CAP reform to decouple promotion from production quantity, and to instead enable:

- payments for care and maintenance of the land,
- protection of natural resources,

- and protection of rural regions.

The above-mentioned Regulation on the European Agriculture Guidance and Guarantee Fund (EAGGF) will be replaced in 2007 by the Council Regulation on support for rural development by the European Agricultural Fund for Rural Development (EAFRD), which is soon to be passed. From 2007, the support of rural areas is to occur along three axes, by means of the following measures:

1. Improvement of the competitiveness of agriculture and forestry
    - Improvement of the financial value of forests
    - Increasing the added value of agricultural and forest products
    - Improvement and development of the infrastructure in connection with the development and adaptation of agriculture and forestry
2. Improvement of the environment and the land
    - Afforestation of agricultural land
    - Initiation of agro-forestry systems on agricultural land
    - Afforestation of non-agricultural land
    - Natura 2000 payments
    - Payments for environmental protection in the forest
    - Restoration of forest potentials and introduction of forest protection measures
3. Quality of life in rural areas and diversification of the rural economy (no specifically forestry-related measures on axis 3)

Compared with the old Regulation (EC) No. 1257/1999, measures in the forestry area are being escalated. The promotion of agro-forestry systems can be seen as a new important measure with regard to renewable energy sources. This encompasses short rotation plantations, which can also be used for energy.

EU Action Plan for Forest Law Enforcement, Governance and Trade

The EU Action Plan for Forest Law Enforcement, Governance and Trade (FLEGT) is the EU's reaction to the increasing trade in illegally felled timber from Southeast Asia, South America, and Russia, but also from Western and Eastern Europe. Therefore, FLEGT is not only directed outwards, but also inwards, at the member states. Primarily, FLEGT is to act against the progressive destruction of forests, the endangerment of sustainability which this causes, and the distortion of competition caused by illegally felled timber, by means of close cooperation with the public and private sectors. Voluntary partnership agreements between the producing countries and the EU are to ensure that only legally felled timber is traded. For this to work, it is necessary that:

- all partner countries agree on a uniform definition of legal felling,
- all partner countries commit to setting up credible legal and administrative structures so that the export of legally felled timber can be guaranteed.

Finally, in addition to the political activities and measures relevant to the forest and forestry which have already been explained in some detail, the areas which go beyond the scope of this final report are listed. These are activities in the following areas:

- Integrated Product Policy (IPP) - Life Cycle Thinking
- EU eco-label system.

In recent years, with regard to sustainable forest development and forest management in the international arena, the EU has been, and still is, actively participating in shaping the Rio process. Also worthy of note, are activities in the areas of development cooperation and international trade: the following summary gives an overview of these manifold international activities:

UNCED/IPF

National forest programmes, criteria and indicators for sustainable forest management

Biodiversity Convention

Protection and sustainable use of forests

Climate Convention

Joint Implementation, Clean Development Mechanism

Desert Convention

Dry forests

CITES

Controlled trade in endangered species

GATT and WTO negotiations

Trade and the destruction of forests (illegal logging), certification

ITTO

Trade and sustainable forest management

2.2.2 Situation in selected EU member states

Since the previous section has taken a brief look at the EU's forestry policy activities, the different orientations of national forestry policies will be explored in the following, with Germany, Finland, and Latvia as examples. Finland was selected because the forestry and forest products sector remains a pillar of the Finnish national economy, so forestry policy is of utmost importance. Latvia was selected because, after gaining independence, this country saw its forestry develop into an economically significant factor, and due to this occurrence, the limits of sustainability appear to have been reached.

2.2.2.1 Germany

Much like on the EU level, it could be said that forestry policy activities in Germany are fragmented. The reason for this is the federal structure of this republic. According to the German Basic Law, the legislative power in the forestry sector lies in the hands of the individual federal states. The Federal Forests Act authorises the federal government to enact framework legislation. Thus, the federal government's scope for implementation of forestry policy is very limited. As a description of the forestry policy objectives, measures, and instruments of the 16 federal states would be too extensive for inclusion here, the following will only outline some forestry policy measures and initiatives of the federal government and/or of national significance.

Support of forestry

As already explained in section 2.1.2, forestry is supported as part of the EU's Common Agricultural Policy. In Germany, it is the federal states which implement the relevant EU regulations. The core of the support programmes, both financially and in terms of content, is the "Joint Task for the Improvement of Agricultural Structures and Coastal Protection" (GAK). GAK support always takes the form of co-financing, i.e. the EU covers part of the subsidy payment, the remainder is paid by the member state. In Germany, GAK support of forestry measures focuses on:

- silvicultural measures (shift to close-to-nature forestry, afforestation, maintenance of young stands),
- promotion of forestry alliances,
- forest road construction,
- measures addressing new types of forest damage,
- investments for the improvement and rationalisation of the supply, processing, and marketing of forest products.

In the year 2001, depending on the size of the business, GAK forestry support for the operation of private and corporate forests was between €13 and €17 per ha of forest area, while for agricultural businesses with no other significant source of income, €339 per ha of agricultural land was paid.

National Forest Programme

In 1999, a German National Forest Programme, based on the international commitments of the "Rio Conference" of 1992, was initiated as a continuing dialogue process with the participation of all organisations and associations with forest-related interests /119/. In accordance with the agreements of the special session of the United Nations General Assembly, the term "national forest programme" signifies a comprehensive framework for achieving sustainable forestry. Here, it was stipulated that a national forest programme is to consider the following principles:

- national sovereignty and self-responsibility of resource use,
- consistency with national legal frameworks,

- consistency with international commitments and understandings,
- partnership and participation of all interested groups,
- holistic and intersectoral approaches to forest development and conservation,
- a long-term and iterative process of planning, implementation, and monitoring.

It is to include, among others, the following elements:

- forestry policy guidelines regarding important spheres of action in connection with sustainable forest management,
- the significance of forestry and the forest products industry for society,
- interfaces to other sectors (coordination),
- formulation of future forestry policies in important spheres of action with the participation of interested parties (identification of the active players),
- strategies for sustainable development in the forest, to safeguard its economic, ecological, and social functions,
- identification of necessary actions.

In the joint discussion between the players in the National Forest Programme, five spheres of action were initially selected, whereby for each sphere, the current situation and necessary actions were discussed at "round tables". This was not intended to provide final solutions for all of Germany's forestry policy problem areas, but rather to first establish a consensus, as far-reaching as possible, on the concerns and possible solutions. The following spheres of action were selected:

- the forest and society
- the forest and biodiversity
- the role of the forest in the global carbon cycle
- the significance of wood as a renewable raw material

- the contribution of forestry and the forest products industry to the development of rural areas

At the end of 2003, the second phase of the dialogue, which was conceived as an on-going social dialogue process, and which saw the German name of the National Forest Programme change from *Nationales Forstprogramm* to *Nationales Waldprogramm* /120/, came to an end. Based on the results of the first phase, the following topics were discussed (either for the first time, or in more detail than previously) in the second phase of the process, from 2001 to 2003:

- the forest and international cooperation / international trade,
- biodiversity, forest management and conservation,
- selection of forestry policy instruments,
- the economic significance of forestry and the forest products industry,
- the new role of forests.

Charter for Wood

With the initiation of a Charter for Wood, the German government, together with significant social groups, is campaigning for increased use of the raw material wood in the areas of construction, housing, and use for energy. This is because increased use can have advantageous climate-related, energy-related, environmental, and resource-related political effects, it can improve the economic situation for forestry and forest product operations, can safeguard jobs, and create new jobs.

Amendment to the Federal Forests Act

To meet society's changing demands regarding the protection and use of forests, the Federal Forests Act, which has been almost unchanged for nearly 30 years, is to undergo an amendment. In this amendment, particular attention is to be paid to the criteria for sustainability. In consideration of the results of the intensive dialogue process "German National Forest Programme", significant aspects of the amendment are laid out in *Eckpunkte des Bundesministeriums für Verbraucherschutz, Ernährung und Landwirtschaft zur Zukunft des Waldes* (Key Points for the German Federal Ministry of Food, Agriculture and Consumer

Protection for the Future of the Forest). This document states that the Federal Forests Act should essentially be changed in four areas:

- The content of the existing regulation regarding orderly and sustainable cultivation should be more detailed.
- It should be made clear that leaving old trees and deadwood in situ does not bring the owner any increased liability for premises.
- Joint sale of timber by alliances of forest owners should be made easier.
- Numerous superfluous stipulations should be removed.

Spin-off of companies from state forestry administrations

Since the mid-1990s, it has been discussed whether the state forestry administrations in the individual federal states should spin-off companies. One of the stimuli for this discussion was the study written by Helmstädt et al.: *Für eine leistungsfähige Forstwirtschaft* ("For an Efficient Forestry Industry"); another was the Scientific Advisory Council for what was then the Federal Ministry of Food, Agriculture and Forestry. Both call for a separation of the economic, advisory, and juridical tasks in state forestry operations /220/. The legal form of such a company could be that of the state company (according to § 26 of the LHO (German State Budget Ordinance)), the public institution, or alternatively, they could be privatised, either formally or materially.

There has since been considerable progress made in the spin-off of companies from state forestry administrations. The following federal states have chosen the state company alternative:

- Saarland (1999),
- Hesse (2001),
- Saxony-Anhalt (2002),
- North-Rhine Westphalia (2005),
- Saxony (as of 01/01/2006).

The following federal states have chosen the option of founding a public institution:

- Bavaria (2005),
- Lower Saxony (2005),
- Mecklenburg-Western Pomerania (as of 01/01/006).

In Brandenburg, the founding of such an institution is also being considered. In Baden-Württemberg, Rhineland-Palatinate, Schleswig-Holstein, and Thuringia, there are no current plans to change the legal form, yet comprehensive changes to the administrative structures are indeed planned, and some have already been implemented.

Recommendation of the Council for Sustainable Development: "Forestry as a model for sustainable development: a new focal point for the national sustainability strategy"

In April 2001, the German government established a Council for Sustainable Development, with the task of supporting the further development of the government's sustainability strategy with suggestions regarding targets and indicators, and of suggesting projects for the implementation of this strategy /221/. Another task of the Council for Sustainable Development is the promotion of social dialogue on sustainability.

In line with its task, the Council for Sustainable Development has recently recommended that the government make forestry and the forest products industry a model to provide a demonstrative guideline for sustainable development. In one of the national sustainability strategy's focal topics, "sustainable forestry and protection of resources", the council sees two opportunities:

- firstly, this would enable the model of sustainability to be sectorally connected, and demonstratively transported;
- secondly, forestry and the forest products industry would be prompted to adjust their efficiency.

The council emphasises that a national sustainability strategy without reference to forestry and to the forest products industry is incomplete. Both industries provide a model in which sustainability plays the main role. The council welcomes the activities of the government in its promotion of the social dialogue process on the topic of forest and forest products, and mentions the National Forest Programme (NFP) and the Charter for Wood. However, it complains that there is no unified strategy consistent within itself, which derives recommendations for action (and action plans) from targets, consolidates them, and makes them operational. Thus it calls for the development of a general strategy which guarantees cross-sector networking with other policy areas, especially energy policy, climate protection policy, and consumer protection. In the dialogue with the forestry and forest products sector, and with reference to the national sustainability strategy, the Council for Sustainable Development orientates its recommendations along the following lines:

- extensive implementation of near-to-nature forestry;
- more utilisation of domestic timber;
- termination of timber imports from dubious sources and exhaustive cultivation;
- acceptance of responsibility for the conservation of forests worldwide;
- communication of the use of forests and forest products as a model of sustainability.

Furthermore, these orientation lines are accompanied by specific recommendations for action, details of which go beyond the scope of this report.

In summary, it can be said that despite having limited room to manoeuvre, the federal government's forestry policy activities are manifold. A significant cornerstone in political action, which is reflected in all the individual activities, is the consideration of sustainable development. This consideration has indeed been embedded in the forestry sector, but has found a new direction in recent years. The most significant manifestation of this new direction is the commitment to near-to-nature forest management. The principle of participation represents a new quality in policy making, which guarantees the inclusion of a broad spectrum of relevant social groups in the process of reaching political decisions.

2.2.2.2 Finland

In Finland, the beginning of the 1990s saw a paradigm shift in forestry policy. While at the start of the 1990s, Finnish forestry policy was almost entirely focused on ensuring the supply of raw materials for the Finnish timber industry, other forestry policy objectives have arisen since the middle of the 1990s. One decisive factor in the reorientation of Finnish forestry policy is the progressive incorporation of Finland into the European Union; another is the globalisation of the Finnish paper, pulp, and timber industries.

Finnish forestry policy has accommodated Finland's increased involvement in the EU, and also in the international processes such as UNCED/IPF and MCPFE, in that the one-sided orientation towards ensuring the supply of raw materials has been broadened to include aspects such as biodiversity, multifunctionality of forests, protection of forests, ecological and social sustainability, etc. In addition, the globalisation of the Finnish timber industry has brought the customer requirements regarding the ecological tolerance of Finnish pulp and paper to the attention of Finnish forestry policy. Thus, the Finnish Forest Certification System has arisen in response to pressure from the markets.

Forestry Act

In the year 1997, Finland's changed forestry policy principles were set in a new legal framework with the passing of a new Forestry Act, and the Act on the Financing of Sustainable Forestry. The aim of the legislative package is to guarantee the economically, ecologically, socially, and culturally sustainable use of Finnish forests. In order to implement these legal specifications, the forest management of all forest owners has been subjected to stricter state control and regulation. First and foremost, forest management must pay closer attention to ecological points of view since the legislation has come into effect. The following new fundamental regulations were established:

- The forest authorities must compile regional use plans.
- Harvesting measures are only permitted in forest stands of a certain age.
- Reforestation of harvested forest stands must occur within a stipulated period.
- The biodiversity of Finnish forests should be sustained by means of adapted use.

It was also newly stipulated that forest stands particularly worthy of conservation may no longer be used. For abstaining from use, the respective forest owner is to receive a state compensation payment in accordance with the Act on the Financing of Sustainable Forestry.

Certification

Primarily due to pressure from the purchasers of Finnish paper and pulp products, the Finnish Forest Certification System was set up around the end of the 1990s in a participatory process, with the objective of verifying the economic, ecological, and social sustainability of Finnish forestry by means of certain criteria and indicators. However, this certification system has met little acceptance on the international arena, which has meant that Finland has played a particularly prominent role in developing the criteria and indicators of the "Programme for the Endorsement of Forest Certification Schemes" (PEFC). Alongside the "Forest Stewardship Council" (FSC), the PEFC is one of the two large-scale, globally active forest certification organisations. Both organisations assess the sustainability of forestry companies according to sustainability criteria and indicators. Today, around 21 million ha of Finnish forests are PEFC certified.

National Forest Programme

As in Germany, due to international obligations, a National Forest Programme (NFP) has also been developed in Finland (Ministry of Agriculture and Forestry, 1999). The approach and objectives are, however, different to those in Germany. In Finland, not only the "round tables" of experts took place, but also a large number of forums which offered the public the opportunity to participate directly and actively in shaping the NFP. In contrast to the German National Forest Programme, which primarily has the nature of a declaration of intent of the participating groups, which is necessary due to the federal structure of the country, the Finnish NFP sets concrete objectives:

- The annual use of domestic timber in Finnish industry is to be increased by 5 to 10 million m^3 by 2010.
- The export value of Finnish timber commodities, paper commodities, and pulp commodities, is to be doubled by 2010.
- The annual use of wood for energy is to increase to 5 million m^3 by the year 2010.

In order to be able to reach these ambitious targets, the Finnish state guarantees the forestry and timber industries an economic framework which ensures an excellent position with respect to global competition.

The ecological objectives in the Finnish NFP are much more softly formulated. It is stated that the assurance of ecological sustainability in the private forest is increasingly to occur by means of contract nature conservation, i.e. compensation payments for abstaining from utilisation. Also the aspect of the multifunctionality of forests is given consideration, in that research activities in this area are to be intensified, and the knowledge gained is to be implemented in practice.

2.2.2.3 Latvia

In Latvia, as in all the Baltic States, and unlike the other new EU member states, state structures had to be built up from scratch after gaining independence from the Soviet Union. This also applies to the forestal area. There was no forestry policy, in the western sense.

The tasks to accomplish upon gaining independence were manifold:

- establishment of a functioning administration,
- installation of a legislative framework,
- clarification of ownership structures,
- inventory of forests,
- definition of binding regulations for forest management.

Latvian forestry policy

Like the other Baltic States, Latvia used the opportunity presented by the need to start from scratch, to formulate modern forestry policy objectives and principles in accordance with international agreements and accords. These were passed by the Latvian Cabinet on 28/04/1998. The fundamental principle is the ecologically, economically, culturally, and socially sustainable use of Latvian forests. The Latvian national forestry policy is orientated towards balancing the various demands which society has of the forest, by means of:

- establishment of an environment advantageous to general economic development,
- protection of the ecological diversity of Latvian forests,
- safeguarding the social functions of forests,
- optimisation of the legislative framework.

The exact nature of this balance is stipulated individually for the following areas:

- forest and forest areas,
- forest ownership,
- economy,

- forest and environment,
- social aspects,
- role of the state in ensuring sustainability,
- forestal education, forest sciences, forest information system.

One significant development with regard to forestry policy which is also taking place in a less direct manner (state institution, public institution) in Germany at the individual federal state level, has already been implemented in Latvia: the transfer of state-owned forests to an incorporated company which has sole responsibility for the cultivation of the national forest, and which is exempt from all sovereign tasks. Sovereign tasks are only carried out by the state forestry administration.

It is evident from the current scale of Latvian felling (see 3.2.2) that the term "sustainability" can be understood and interpreted in different ways. Felling has increased sharply since the nation gained independence, and in recent years has exceeded the annual growth. If this trend continues in the coming years, sustainable timber production in Latvia will be threatened.

Certification

Forestry and the timber industry have developed astonishingly since Latvia gained independence, and have become pillars of the Latvian economy. The strong export bias has led to the introduction of forest certification in Latvia. In contrast to Finland, where certification is mainly in line with the PEFC standard, most of Latvia's forests are certified according to FSC criteria. This includes all state-owned forests.

2.2.3 Consequences for biomass potentials

An isolated assessment of forestry policy action with regard to the development of forest biomass potentials makes little sense, neither on the EU level, nor on the member state level. Due to the fact that there is no coordinated and coherent forestry policy on the EU level, it is currently the decisions on energy policy, economic policy, environmental policy, and agricultural policy which have the strongest influence on the mobilisation of forest potentials. The general political orientation towards sustainable development, increasing the proportion of renewable energy sources, etc., means it does not seem unlikely that the use of wood for energy will also be promoted more strongly on the EU level. Particularly if legal regulations or certification ensure that the utilised wood meets the manifold criteria of sustainable production.

Essentially, the same can be said on the national level. In Germany, for example, which due to its federal structure plays a special role in the interaction among the other EU member states, it is clear that the regulations set in the Renewable Energy Sources Act primarily for the implementation of environmental and energy policy objectives have considerably more effect on the mobilisation of forest biomass potentials than forestry policy decisions made by the federal government, or by the individual federal states. Added to this, the issue of the use of wood for energy has not yet been broached in the forestry policy arena. The example of Finland shows that this does not need to be the case. There, increased use of wood for energy is set as a prioritised forestry policy objective within the National Forest Programme. With regard to the Finnish paper and pulp industries' increasing demand for wood, it remains to be seen as to whether this objective can be reached. In Latvia, the use of wood for energy is a topic not yet addressed by forestry policy, bearing in mind the strong export bias of the timber industry. In the process of stronger integration into the EU, and the increasing influence of the EU's political guidelines, on the medium term it can be expected that the use of wood for energy will play a more significant role in Latvia as well.

2.3 European agricultural policy

2.3.1 Orientation and developments

Europe-wide, the possibilities of biomass production and the manufacturing costs are decisively affected by the following components of the agricultural policy framework:

- Ongoing technical progress in the form of increased yields in the production of agricultural raw materials.
- Ongoing technical progress in the conversion of raw materials, for example feed conversion in breed improvement.
- WTO commitments to reduce subsidised exports of surplus agricultural products from the European Union.

- Decoupling of the existing product-related price equalisation payments for cereals, oleaginous fruits and animal products which will lead to an increased release of land via reduced dairy and beef production.

- Eastern enlargement of the EU, which will lead to production increases, especially of cereals and oleaginous fruits, which are difficult to estimate.

The most important driving factors and developments in the political framework, as relevant to this study, are described below.

GATT Uruguay Round

Production development in the German and European agriculture industries is definitively determined by the core stipulations of the GATT Uruguay Round. These stipulations provide the framework for the level of domestic subsidisation, the scope of export subsidisation, and market access. They also demand that the EU allows more international competition on the domestic market by reducing domestic subsidisation, that the EU exports fewer agricultural surplus products with high subsidies on the global market, and enables an increased minimum market access for other countries.

EU CAP Reform of 1992

The European agricultural policy reacted to this with the EU CAP Reform (1992) which introduced a fundamental separation of market and income policy. The core elements were a gradual reduction of the managed price supports, for example, a reduction of 33% for cereals, 5% for butter, and 15% for beef, and the introduction of global market prices for oilseeds and protein crops, counterbalanced by a guarantee of product-related equalisation payments for the stipulated product areas. Due to the reductions of export quantities and of subsidies on EU agricultural products, and the guarantee of increased market access, mandatory set-aside of land had to be introduced, which varied flexibly according to the market situation until the year 2000, and were fixed at 10% in Agenda 2000. Simultaneously, it was envisaged that renewable raw materials could be produced on set-aside land.

EU Agenda 2000

As a further step towards adaptation of EU agricultural policy to the objectives and conditions of the international free trade pursued by GATT and the WTO, Agenda 2000 was agreed upon at the EU summit of foreign ministers in Berlin on 26 March 1999. This introduced further reduction of price supports for cereals, oleaginous fruits, protein crops, beef, and dairy products while simultaneously increasing the price equalisation payments.

WTO II

Already during the period of Agenda 2000, new proposals were submitted for the current negotiations of the WTO II Round (2006-2012), demanding even further-reaching liberalisation of EU agricultural policy. A proposal from Stuart Harbinson, Chairman of the WTO Agricultural Negotiations Committee, in January 2003, went considerably beyond the EU Commission's own comprehensive proposal of December 2002 regarding reduction of customs duty, export subsidies, and domestic support. The suggestions are shown in more detail in Table 5.

Table 5: WTO II (2006 – 2012)

Proposal from the EU Commission (December 2002)			
Reduction of customs duty			
Average of all agricultural products			- 36%
Minimum			- 15%
Export subsidies (budget)			- 45%
Domestic support			- 55%
Proposal from the Chairman of the WTO Agricultural Negotiations Committee, Stuart Harbinson (January 2003)			
Reduction of customs duty (within 5 years)			
	Category I (rate of duty >90%)	*Category* II (rate of duty 15-90%)	*Category* III (rate of duty <15%)
Average	- 60%	- 50%	- 40%
Minimum	- 45%	- 35%	- 25%
Export subsidies (budget)			
- within 5 years			- 50%
- within a further four years			- 50%
Domestic support (direct financial aid)			
Green box (environmental measures)			Reductions
Blue box (acreage and headage payments)			- 50%
Yellow box (domestic price support)			- 60%

Due to large differences between the proposals made by the most significant partners at the conference in Cancun, Mexico, in September 2003, the efforts to reach an agreement failed. Nevertheless, the WTO II negotiations are highly likely to achieve closure.

Mid-term review, CAP reform of 26/06/2003 and support thereof

In June 2003, based on a so-called mid-term review of Agenda 2000, the European Union established the cornerstones (shown in Table 6) of the political framework for the period from 2004 to 2012/13.

Table 6: Mid-term review of Agenda 2000 (2004 – 2013)

Protein crops:	Replacing the €9.5/t subsidy for protein crops with a €55.57/ha land-based subsidy
CO_2 credit:	Additional land-based premium of €45/ha for the cultivation of energy crops
Beef:	Land dedicated to permanent grassland on 31/12/2002 must be maintained in that state
Dairy:	Quotas retained until 2014/15
	Price reductions from 2004 to 2007:
	Skim milk powder (SMP): -15% (2004-2006: -5% p.a.)
	Butter: -25% (2004-2006: -7% p.a., 2007: -4% p.a.)
	Introduction and gradual increase of dairy cow compensation payments parallel to price reduction (2004: €11.81/t, 2005: €23.65/t, 2006: €35.5/t)
	Increase of milk quotas by 1.5% from 2006 to 2008 (0.5% p.a.), additional quotas allocated to Greece and Portugal (Azores)
Set-aside:	Economic set-aside 10% (2003/04 just 5%)
	Long-term non-rotational set-asides (10 years)
Decoupling:	Farm-based income payment decoupled from production, or regionally uniform land-based income payment (premium sum from a reference period)
	Calculation of payment entitlements for individual farms, per ha
	Negotiability of payment entitlements
Implementation in Germany:	All farm-based direct payments to be gradually decoupled as of 2005
	As of 2005, a grassland premium of €79/ha and an agricultural land premium of €301/ha are paid (average payment across Germany)
	From 2009 to 2013, these payments will be gradually transformed into a regionally differentiated uniform payment for German agricultural land, at an average €328/ha
Degression and modulation:	Modulation 2003-2013
	Climbing reductions: 3% (2005), 4% (2006), 5% (2007), 5% (2008-2013)
	No reduction for farms receiving less than €5000 payments
Cross compliance:	Reduction or exclusion of payments upon non-compliance with certain conditions
Farm-based audits:	Obligatory participation for farms with more than €15,000 direct payments or €100,000 turnover p.a.

The cultivation of so-called Grandes Cultures obliges farmers to set aside 10% of their land by 2002/03 according to the EU's CAP. This percentage was reduced to 5% for the 2004 harvest due to the market situation. Cultivated plants may be grown on set-aside land, if these are not primarily for food purposes. The farmer receives a land payment on the basis of the cultivated plants, regardless of whether the land lies fallow, or whether it is used for the cultivation of renewable raw materials. The only exception is the cultivation of sugar beet (also Jerusalem artichoke and chicory root). This may be cultivated, and the land will still be recognised as set-aside land; however, no land payment will be granted.

In the EU member states there will, in the future, be income payments decoupled from production, which from 2013 (with a few exceptions) will be paid as land payments, regardless of whether the land is used for production, or whether the land is being maintained. In Germany, the average income payment after decoupling will be €328/ha of agricultural land. The payment varies between €265/ha and €360/ha among the German federal states. As a result of decoupling, the contribution margins for food crops and biomass crops will be decreased by the amount of the previously allocated payments. For the cultivation of energy crops, there is an additional coupled land payment (CO_2 credit) of €45/ha, which however is not expected to have any marked effect on supply.

The Central European countries which joined on 1 May 2004, have decided to grant a decoupled income payment, based on grassland and agricultural land, which is currently at an order of magnitude of €100/ha, and can be gradually brought to the level of the income payments in the EU-15 member states. In the candidate countries, there were previously no notable land-based income payments. In this respect, the cultivation of food crops and biomass crops in these countries is generally becoming more competitive. Whether this will lead to an increase in supply due to increased production and utilisation of fallow land is disputed and difficult to predict, because for consistently high portions of leaseholds, an increase in lease prices is already evident, which partly counterbalances the stimulation of production.

EU reform for the future sugar market regime

The European sugar market regime applies until the year 2006. Accordingly, on 24/11/2005, a fundamental reform was agreed upon, to be implemented in the period 2006 – 2010. The European Union currently exports around 30% of its produce onto the global market (including re-exports of duty-free imported sugar from ACP countries). European Union revenue from exporting sugar onto the global market was so low in recent years that it failed to cover the production costs. It is also evident that the production of bioethanol from sugar beet which was established in France two decades ago has as yet been unable to prevail in freely competitive market conditions. Nevertheless, the reform of the European Union sugar market regime is of considerable significance for the potentials of biomass production on agricultural land. Hence the following brief description of the current situation on the sugar market in the European Union, and of the reform of the sugar market regime.

Table 7 shows that in accordance with the current sugar market regime (status quo) over 5 million t of sugar are exported, and when compared with the current level of production, a quota reduction of at least 4 million t must occur. Due to the EU's agreements with countries entitled to customs privileges (EBA for the LDCs), it is expected that in the future, sugar imports into the European Union will almost double.

Table 7: Significant EU-25 sugar market data in the 2010 – 2015 time frame
Source: data provided by the EU Commission

Option	Production		Import	Export	
	Quota	Total		Refunds	Total
	million t	million t	million t	million t	million t
Current	17.5	20.0	1.9	2.8	5.3
"Status quo" 2010 - 2015	13.5	16.0	4.0	1.5	4.0

After the EU Commission proposed to keep all elements of the sugar market regime largely unchanged in July 2004, there was no paradigm shift for the sugar market, but rather a compromise. Retaining the quota scheme, the November 2005 reform does not envisage a quota reduction, but a price reduction for sugar (36%), and correspondingly, for sugar beet (39%) in four stages. For the candidate countries there is no quota reduction, because on average, these countries do not produce any sugar surplus worthy of note. For the EU-15, the reform of the sugar market regime means that around 25% of the land currently used for the production of quota beets is likely to be released; in Germany this corresponds to around 100,000 ha and in the EU-15 around 400,000 ha. This land is well suited for the cultivation of cereal, rapeseed, and sunflower crops, so it will not become fallow. Instead, it may mean that the obligatory set-aside rate will have to be increased.

In connection with the sugar market regime, it must be taken into consideration that the WTO ruled in favour of a so-called panel of several WTO member states against the European Union in May 2005. This means that the European Union must abstain from re-exporting 1.3 million t of sugar imported from so-called ACP states as part of preferential agreements, and from exporting 3.0 million t of so-called C sugar onto the global market. Correspondingly, there must be a 20% (400,000 ha) reduction of cultivated land in the EU-25. This in turn leads to increased production of cereal, rapeseed, and sunflower crops, and possibly to an additional increase in land set-aside.

Sugar beet offers a high land potential for the production of biomass. It can be used for the production of bioethanol, and for generating electricity in conjunction with the feed-in tariffs (EEG) which were increased in 2004. Here, the degree to which the companies in the sugar industry will utilise the EU restructuring fund after the reform in order to use existing sugar factories with total or partial capacities for ethanol production will be decisive. The established sugar market regime envisages that the sugar industry, as compensation for abstaining from sugar production, receive a one-off restructuring payment of €730 in 2006/07 and 2007/08, €625 in 2008/09, and €520 in 2009/10 per t of sugar, which is to be financed by mandatory payment of a restructuring levy of €126.4, €173.8, €113.3 and €0 per t of sugar produced in the respective years.

Independent of this, the WTO commitments must be implemented during this period, as well as in the following period. This factor alone will bring about a restriction on European sugar beet production for the food sector with a simultaneous product price reduction. At present, it cannot be conclusively determined as to whether the European sugar industry will in future strive to maintain sugar beet production, and utilise the sugar beets not intended for sugar production in the production of bioethanol, or whether it will undertake corresponding cutbacks in processing capacities, which would mean the release of around 150,000 – 250,000 ha of beet land in Germany, and 400,000 – 1,000,000 ha in the EU-15, land which could either be set aside, or used for biomass production.

At present, around 20 million t of white sugar are produced in the EU-25, on around 2 million ha of sugar beet land. For self-sufficiency in the EU-25, around 16 million t of white sugar are needed.

Environmental and nature conservation policy

On the EU level, and on the member states level, a large number of directives and regulations have been brought into effect to protect biodiversity. With the implementation of the FFH Directive, and the increased integration of nature conservation with the use of the land, as well as the designation of nature conservation areas, a clear path has been established. If the FFH area designations in Germany account for 10%, and nature conservation areas 3% of the land, it is clear that the land requirement is not yet fully covered. In many of Germany's federal states, EU programmes are complemented by agri-environmental programmes which are primarily directed at reducing the environmental impact of materials, but are less effective in the protection of species. At the European level, the June 2003 reform of the Common Agricultural Policy strives towards an intensified rededication of means, shifting from the so-called first column (direct payments) to the second column (rural development). This is aided by the observance of the additional regulations in the areas of environment, feed safety, food safety, animal health and animal welfare (cross compliance). These regulations, which encompass 19 requirements, will contribute towards keeping agricultural land in a good agricultural and ecological condition, retaining permanent grassland, and reducing the environmental impact of materials. Upon implementing the agricultural reform at the national level, the member states have gained more room to manoeuvre, which is being used to varying degrees by the member states, to accelerate the growth of ecological farming. As yet, ecological farming has been adopted by around 4% of Germany's farms, accounting for about the same percentage of the total land area. Since the year 1994, the number of farms using ecological farming methods has indeed tripled, but it is difficult to predict how the scale of ecological farming will develop, and whether it will reach the target of 20% by the year 2020. Worthy of note is that environmental objectives and nature conservation objectives sometimes have to compete against biomass objectives.

2.3.2 Situation in selected EU member states

It is generally known that the European Union's agricultural market is the sector which has, through 40 years of joint political framework, been extensively harmonised. This has brought equal market regulations, price supports, and foreign trade regulations for all EU member states. The same cannot be said of tax policy, environmental policy, social policy, and other areas. These areas are of great significance in the tapping of biomass potentials, for example via exemption from the national mineral oil tax, minimum feed-in tariffs on the electricity grid, and other instruments. These specific conditions have to be dealt with in conjunction with the markets for biomass and biogenic final energy sources.

Thus, for the orientation and development of agricultural policy, it is merely indicated here that in the continuing implementation of the 26/06/2003 CAP reform, the form which the payments take differs only slightly between the member states, and that the candidate countries in particular have the possibility of supplementing the EU's decoupled direct payments with additional payments at the national level. However, once the transitional periods have expired, the candidate countries will also be subject to the same agricultural policy framework as the other member states. Chapter 5 looks at the specific situation regarding the promotion of demand for biogenic final energy sources in selected EU member states.

2.3.3 Consequences for biomass potentials

The development of agricultural policy to date has been decisively determined by the agreements of the GATT Uruguay Round, WTO I and the awaited, yet somewhat uncertain, results of WTO II. It has been orientated towards reduction of domestic support and export subsidies, and towards opening the market to other countries. The EU and other industrial countries with high levels of agricultural support have reformed their national policies accordingly. This means it can be expected that this process will be accelerated upon conclusion of WTO II, and in a further WTO round, after the expiry of the peace obligation, will lead to a far-reaching reduction of all support elements in agricultural policy to be completely implemented by around 2020.

In this process, it is already evident that to an increasing extent in the EU, land which is no longer needed for food production becomes non-productive land. Only part of this land has as yet been used for the production of biomass because the economic and legal framework has only recently been significantly improved in this area of production. Nevertheless, it is evident that the EU has a much higher potential for biomass production from agricultural raw materials, and that this increases with the completion of the eastern enlargement. After all, on 1 May 2004, with eight Central European and two Mediterranean countries, the European Union gained 75 million inhabitants and 38 million ha of agricultural land. The negotiated accession criteria provide for particular promotion of rural areas in the new member states, and the introduction of direct payments to farmers. This will also improve the competitiveness of energy crops in the acceding countries.

Without going into all the details individually, this allows the following conclusions to be drawn for the future development of biomass production from agricultural raw materials.

- The relative advantageousness of the cultivation of cereals, oilseeds, and protein crops to meet the demand for food will see further decline in the EU.

- The relative advantageousness of the cultivation of energy crops will be subsidised to a slightly higher extent (€45/ha) but this will not make it significantly more competitive.

- Due to price reduction, and the decoupling of the previously granted product-based headage payments, as well as of milk payments in the future, the use of marginal land for beef and dairy production will become increasingly unattractive economically, freeing up potentials for the production of renewable raw materials.

- The setting aside of land will be continued in the form of mandatory economic set-aside, whereby this land may be used for the production of renewable raw materials.

- The reform of the sugar market regime, which was definitively finalised on 24 November 2005, will be of great significance to the potentials and costs of biomass production on agricultural land; its influence on the subsequent actions of the sugar industry is difficult to estimate at this time.

In general, the considerations and calculations lead to the conclusion that there will be many additional resources for biomass production in the future. This is primarily accounted for by the agricultural land set aside in accordance with the Common Agricultural Policy. The set-aside rate generally covers 10% of the so-called market regulation crops (cereals, oil crops, and protein crops). As shown in Table 8, which outlines set-aside, subdivided into the respective set-aside types, set-asides of several years for environmental protection purposes are currently insignificant in Germany. So-called economic set-aside comprised around 1.2 million ha in 2003. Mandatory set-asides accounted for around 820,000 ha of this land, and voluntary set-asides for around 400,000 ha. Renewable raw materials can be cultivated on land of either category. In Germany, over 300,000 ha of set-aside land were used for cultivation of renewable raw materials up to 2003. In 2003/04, the set-aside rate was reduced to 5% as an exception. Voluntary set-asides have increased, and the cultivation of renewable raw materials on set-aside land has declined.

Land used for sugar beet cultivation presents another resource for the provision of land for biomass. This land can amount to 150,000 – 200,000 ha in Germany, and 400,000 – 1,000,000 ha in the EU.

Table 8: Set-aside in Germany, subdivided into set-aside types (in hectares)
Source: /118/

Type of set-aside	1999	2000	2001	2002	2003	2004 [1]
Total land set-aside	1 164 891	1 113 046	.	.	.	.
thereof						
economic set-aside	1 162 260	1 109 881	1 127 265	1 135 535	1 221 480	982 077
thereof: obligatory set-aside	827 209	807 742	818 533	814 530	817 829	427 838
unsolicited set-aside	335 051	302 139	308 732	321 005	403 651	554 239
thereof: without cultivation of renewable primary products	796 772	778 167	805 110	792 779	893 088	766 822
with cultivation of renewable primary products	365 488	331 714	331 640	342 756	328 392	215 255
set-asides of several years for environmental protection purposes (at least 10 years) [2]	2 631	3 165	.	.	.	.

[1] Preliminary - [2] Data not possible due to changed European Commission data types as of 2001.

Further potential area is offered by the reduction of dairy and beef production due to the decoupling of product-based payments as of 2009. In Germany, this corresponds to 4.4 million ha of grassland and feed crops, whereby an estimated 1/3 will no longer be required for cattle farming, as it becomes less extensive. Land where intensive production locations for dairy production and beef cattle are currently situated may potentially be available for biomass production, roughly estimated at 1 – 1.5 million ha.

Finally, it is to be noted that especially in the new member states from the eastern enlargement, potential land and potential yields are made accessible if, alongside food production, economically attractive conditions are established for bioenergy sources, and the corresponding manufacturing facilities are built in those countries.

3 Biomass supply

3.1 Definitions and methodology

The potential of the different bioenergy sources to be used for energy can be categorised as theoretical, technical, economic and realisable potential /62/.

- The theoretical potential of renewable energy is derived from the physical supply of renewable energy sources (all phytomass and zoomass) and represents a theoretical limit of the available energy supply. Generally only a small percentage of this potential can be tapped due to insurmountable technical, ecological, structural and administrative restrictions. This potential is therefore essentially irrelevant when assessing the actual usability of the renewable energy supply.

- The technical potential, however, refers to the percentage of theoretical potential that can be used given current technical possibilities. Calculating the technical potential takes into account the available utilisation technologies, their efficiency, availability of sites also in terms of competing uses, as well as “insurmountable” structural, ecological (e.g. nature conservation areas) and other non-technical restrictions.

- The economic potential of an option of using renewable energy refers to the percentage of the technical potential that can be used economically in the context of given basic energy industry conditions. Before the economic competitiveness of the renewable energy source or system can be assessed, other competing energy supply systems must be defined for the application areas. The economic potential for using renewable energy sources is affected by conventional energy systems and the prices of energy sources.

- The realisable potential refers to the expected actual contribution of an option for using renewable energy sources. It is usually lower than the economic potential, at least at times, since it usually cannot be tapped immediately and can only be used to its full extent over the very long term (e.g. due to limited manufacturing capacities or lack of information). The realisable potential can be greater than the economic potential, however, if for example the option for using renewable energy is subsidised (e.g. market introduction programme).

The options for supplying energy from biomass are determined primarily by the potential of the usable biomass as well as by the available conversion technology. This technical fuel potential refers to the share of the total available biomass that can be used taking into account given technical restrictions.

To determine the types of potential examined in this study – forestry potentials (section 3.2), potentials of agricultural area (section 3.3) or derived energy crop potentials (section 3.5) and the potentials of residues (section 3.6) – we must first calculate the amounts that can be used to produce energy. These data, which are expressed in mass units, are then converted to energy units. The basic thermo-chemical, bio-chemical and physico-chemical conversion processes for biomass use must be taken into account, and different efficiencies and degrees of utilisation must be used when determining the energy potentials (chapter 5). For example, the technical potential of an energy source for thermo-chemical conversion processes is calculated using substrate-specific heating values, whereas the technical potential of an energy source for bio-chemical conversion processes (such as biogas production) is calculated using substrate-specific gas yields and an average biogas heating value of 21.4 MJ/m³. Cases are examined individually for physico-chemical conversion, which is only relevant for oil energy crops (such as rapeseed).

3.2 Forestry potentials

Wood was long the most important energy source in Europe. Use of fossil energy sources did not become widespread until industrialisation and the demand for energy increased as a result. Since then, wood has played a secondary role as a source of energy. The following potential calculations for 2000, 2010 and 2020 show that wood can contribute more to energy production.

3.2.1 Methodology

Derivation of forestry potentials for 2000

The following derivation of raw wood potentials of the EU-28 countries is based on the 2000 statistics as reported in FAOSTAT, EFSOS and TBFRA-2000 /222//223//224/. Since the above statistics only include data on wooded areas, commercially exploitable wooded areas, tree species distribution, felling quantity, roundwood production, import and export quantities, and prices of roundwood and firewood, the raw wood potentials of the EU-28 countries have to be derived based on these data. The annual increase in above-ground wood biomass, felling, and produced roundwood and firewood were used to derive the theoretical and technical potentials of raw wood.

$$Annual\ growth = Theoretical\ potential\ of\ raw\ wood$$

The annual growth in above-ground wood biomass based on commercially exploited wooded areas corresponds to the amount of timber that can be used annually while still remaining sustainable. This annual sustainable usable amount of timber equals the **theoretical potential of raw wood**. The increase in wooded areas that cannot be exploited for commercial purposes, including nature conservation areas is not taken into account. Quantities are given in bdt, not in solid cubic metres of standing timber (Vorratsfestmeter) over bark (Vfm ob) as is usually the case. The volume in bdt is equal to the solid cubic metres of standing timber multiplied by 0.5.

$$Felling = Roundwood + Firewood + Logging\ residues + (Harvest\ losses)$$

Felling is recorded in statistics as all timber that is felled in a year. Felling consists of merchantable (diameter > 8 cm) and non-merchantable wood (diameter < 8 cm). The merchantable portion is subdivided into roundwood, which is used as a material, and firewood, which is used to produce energy. Roundwood and firewood are recorded in FAOSTAT. Logging residues and harvest losses, which cannot be used as material or to produce energy, are also produced. Volume is usually measured in solid cubic metres of harvested timber (Erntefestmeter) over bark (Efm ob). The volume in the unit of measure used here (bdt) is equal to the harvested volume multiplied by 0.5.

Roundwood accounts for the largest portion of felling. Roundwood is the volume of felled timber that can be utilised as material. Volume is usually measured in solid cubic metres of harvested timber (Erntefestmeter) under bark (Efm ub) in forestry. The harvested volume under bark equals the harvested volume over bark minus the bark. Bark is usually estimated at 10%. Volume in the unit of measure used here (bdt) including bark is equal to the volume in harvested volume multiplied by 0.5.

Firewood includes merchantable wood that can be used to produce energy. This wood can be log wood or wood chips. Since log wood and wood chips are usually measured in different units, firewood is recorded in cubic metres of harvested timber under bark (Efm ub) in FAOSTAT. Volume is converted to bdt including bark by multiplying by 0.5.

The merchantable wood from felling that cannot be utilised as a material or to produce energy is referred to as **logging residues**. Logging residues are included in felling volume in statistics and not listed separately. The logging residues are estimated at 12.5% of felling for all countries. Volume is indicated in bdt.

Harvest losses: Stump wood and wood that is lost during harvesting is referred to as harvest loss. Harvest losses are not recorded or listed separately in statistics. They are included in the felling volume and are estimated at 7.5% of felling. Volume is indicated in bdt.

$$Technical\ potential\ of\ raw\ wood\ from\ felling = Firewood + Logging\ residues$$

$$Technical\ potential\ of\ raw\ wood\ from\ growth = Theoretical\ potential\ of\ raw\ wood - Felling$$

The **technical potential of raw wood** indicates the amount of raw wood that can be used to produce energy given current technical possibilities. It comprises two different groups: felling that can be used as material (firewood and logging residues), referred to as **technical potential of raw wood from felling** in the following, and the annually growth that is not felled, referred to as **technical potential of raw wood from growth** in the following. This distinction reveals the amount of wood that would be available for energy production if logging residues were used and how much additional wood could be used if annual growth were utilised to capacity. One hundred percent of logging residues and unused wood growth is assumed to be part of the technical potential of raw wood. Volume is indicated in bdt.

Derivation of forestry potentials for 2010 and 2020

The derivation of forestry potentials for 2010 and 2020 is based on a different procedure than that used for 2000. Unlike for 2000, where potential is derived from a statistical data bases, the potential is derived from model assumptions from the European Forest Sector Outlook Study (EFSOS) conducted by the UNECE and FAO. The EFSOS forecasted future trends in demand for wood products and the resulting change in forest resources in 37 European countries. Figure 7 shows the model structure used in the EFSOS.

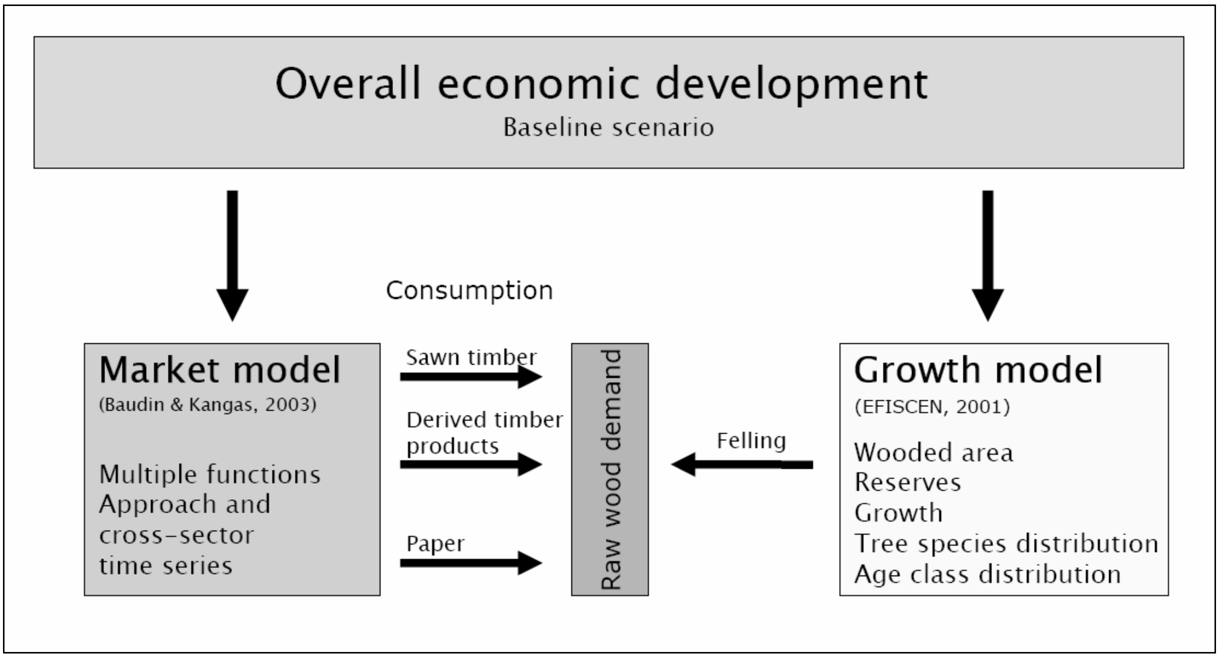

Figure 7: **Model structure of EFSOS forecasts**

Projections of trends in demand are based on supply and demand comparisons and on the time-series-based market model by KANGAS and BAUDIN (2003)[13] /120/. This market model forecasts the demand for sawn timber, derived timber products, pulp and paper based on overall economic development. The simulation does not include future demand for wood as an energy source. The raw wood or felling derived from the demand serves as an input variable for modelling forest resources in the 37 European countries studied. Models were developed using the European Forest Information Scenario Model (EFISCEN) developed by PUSSINEN et al. (2001) and NABUURS (2001) /127//131/. The large-scale matrix model is especially suited for projections at the regional or state level. The model uses felling to simulate the development of standing volume, timber growth, wooded areas, tree species distribution and age class distribution for five-year periods.[14] The following estimate of forestry potential for 2010 and 2020 is based on these data.

$$\textit{Technical potential of raw wood from felling} = \textit{Felling} - \textit{Roundwood}$$

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[13] For more information on the model specification, see Kangas, K. and Baudin, A. (2003): Modelling and projections of forest products demand, supply and trade in Europe. Geneva Timber and Forest Discussion Paper 30 (ECE/TIM/DP/30). United Nations, Geneva.

[14] For more information on the model and results, see Schelhaas, M.-J., Van Brusselen, J., Pussinen, A., Pesonen, E., Schuck, A., Nabuurs, G.-J., Sasse, V. (2003): Outlook for the development of European forest resources. Geneva Timber and Forest Discussion Papers (ECE/TIM/DP/C), United Nations, Geneva.

As mentioned above, the market model only simulates the demand for raw wood used as a material, which makes subdividing felling into roundwood, firewood and logging residues for deriving the potentials for 2010 and 2020 impossible. Unlike for 2000, the **technical potential of raw wood from felling** is therefore derived from the difference between felling volume and roundwood used as a material (see above). As in 2000, the **technical potential of raw wood from growth** equals the difference between the projected felling volume and projected timber growth. Together, the two volumes equal the total technical potential of roundwood. The method used to derive the theoretical potential of raw wood is also the same as the method used for 2000. The projections for 2010 and 2020 are shown using the development of commercially exploitable wooded areas, felling volume and volume of roundwood used as a material.

The important data for calculating the potential are also summarised in short country sheets in appendix B.

3.2.2 Results

Appendix 3 contains an overview of all results for all countries. The following sections summarise the forestry potentials for Germany, the EU-15 countries and the EU-28 countries.

3.2.2.1 Germany

The results for Germany differ from those of the other EU-28 countries in two ways. First, the excellent amount of data available enables the potential of raw wood to be broken down into different categories, and second, the data are based on 2001 instead of 2000 due to the 1999 storm and the associated shifts in wood markets. The felling volume and roundwood production in 2000 were approximately 25% higher than the long-time average and would therefore be as representative as the technical potential of raw wood.

Not only is felling divided into the standard categories of roundwood, firewood and logging residues, experience in Germany makes it possible to estimate harvest losses and the non-merchantable share of felling.

With 31% of its area covered by forests, Germany is one of the more forested of the EU-28 countries. France, Poland and Italy are similarly forested. Only Sweden has more annual growth, with twice as much as Germany. At 4.4 bdt/ha in 2001, growth in commercially exploitable wooded areas was above the Central European average and on par with the Czech Republic. Germany has the highest technical potential of raw wood.

Figure 8 shows the relationships between the theoretical potential of raw wood, felling and the technical potential of raw wood for 2001. Only around 55% of the annual growth of approximately 45 million bdt was used. Accordingly, the amount of unused growth in terms of technical potential of raw wood is also large at 17 million bdt, whereas the potential for residues is around 7.5 million bdt.

As shown in Table 9, statistics show around 1.5 million bdt of firewood in 2001. This wood and an unrecorded volume, which is difficult to quantify and was likely logging residues, was used to produce energy. The total technical potential of raw wood from felling was around 7.5 million bdt in 2001.

While projections show a slight decline in the theoretical potential of raw wood for 2010 and 2020 (Table 9), the technical potential of raw wood is expected to decline considerably. Projections show an approximately 36% drop to around 7.0 million bdt by 2020 due to the increasing demand for roundwood. Germany has by far the greatest technical potential of raw wood of the EU-28 countries.

Table 9: Germany’s forestry potential 2000 – 2020

	Units [in 1000]	**2000**	**2010**	**2020**
Commercially exploitable forest	ha	10,142	10,403	10,612
Standing volume	bdt	1,690,301	1,769,572	1,906,010
Theoretical potential of raw wood	**bdt**	**45,051**	**43,394**	**42,027**
Felling	bdt	24,677	27,122	29,262
From that:				
roundwood	bdt	18,251	20,613	22,239
firewood	bdt	1,491		
logging residues	bdt	3,085		
Technical potential of raw wood from unused growth	bdt	17,412	16,273	12,765
Technical potential of raw wood from unused felling	bdt	7,537	6,509	7,023
Total technical potential of raw wood	bdt	24,949	22,782	19,788

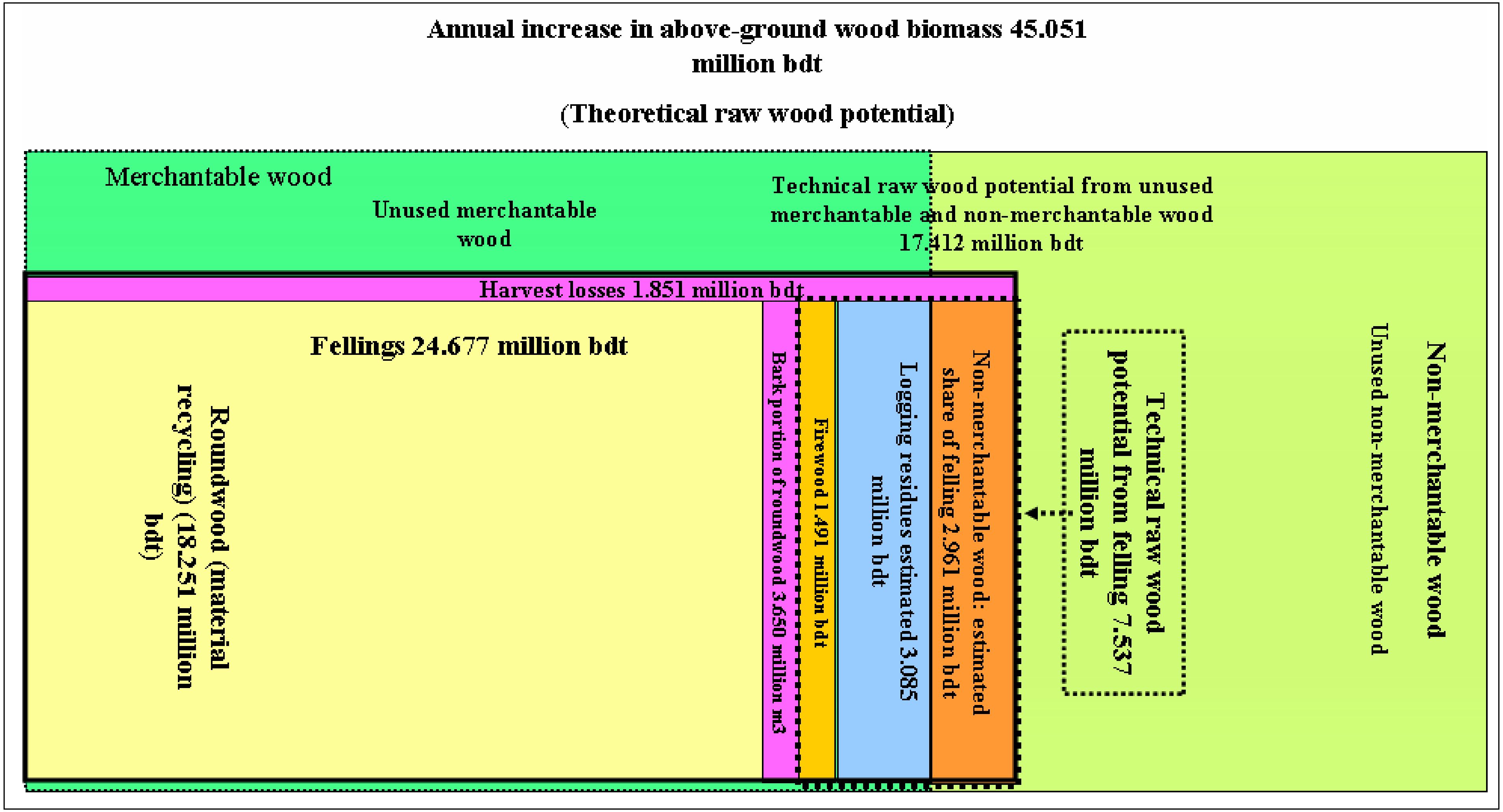

Figure 8: **Raw wood potentials for Germany 2001Source: derived from FAOSTAT and EFSOS**

In Central Europe, the highest annual timber growth or highest theoretical potential of raw wood is expected in Germany followed by France and Poland. Within the EU-28 countries, only Sweden is expected to top Germany in 2010 and 2020.

3.2.2.2 EU-15 countries

The theoretical potential of raw wood (annual growth) of the EU-15 countries in 2000 was considerable with nearly 241 million bdt, as shown in Table 10. This is equivalent to 2.54 t/ha of commercially exploitable wooded area. Around 67% of this area was used for felling. Statistics show 9% of felling being used for firewood. The technical potential of raw wood consisted of 67% unused growth and 33% firewood and logging residues not used as material and was equivalent to 2,056 PJ p.a. This was the maximum amount available for energy use. The technical potential of raw wood from felling was around 36 million bdt p.a. or 664 PJ p.a.

Table 10: Forestry potential of the EU-15 countries 2000 – 2020
Source: [1]/224/, [2]/223/;[3]//222/

	Units [in 1000]	**2000**	**2010**	**2020**
Wooded area:	ha	113,567[1]		
Commercially exploitable wooded area:	ha	94,833[2]	95,536	96,091
Annual growth or theoretical potential of raw wood:	bdt	240,942[2]	237,011	237,064
Felling:	bdt	166,707	171,871	186,649
From that:				
roundwood	bdt	118,302	132,648	144,052
firewood	bdt	15,064[3]		
logging residues	bdt	20,838		
Technical potential of raw wood from felling:	**bdt**	**35,902**	**39,223**	**42,597**

The theoretical potential of raw wood is expected to drop by around 2% to 237 million bdt by 2010 and to remain constant through 2020. Felling is expected to total approximately 172 million bdt in 2010 and around 187 million bdt in 2020. This equals an increase of around 11%. Demand for roundwood used as a material will increase 22% by 2020 from 118 million bdt p.a. to 144 million bdt p.a. The overall drop in the theoretical potential of raw wood and the increased demand in roundwood used as a material will cause the technical potential of raw wood to drop. While the potential will still be around 105 million bdt p.a. or 1,943 PJ p.a. in 2010, it is expected to drop to 94 million bdt p.a. or 1,739 PJ p.a.[15] in 2020.

3.2.2.3 EU-28 countries

The total theoretical potential of raw wood of the EU-28 countries in 2000 equalled the impressive sum of almost 349 million bdt (Table 11), or the equivalent of 2.61 t/ha of commercially exploitable wooded area. Sixty-nine percent of this considerable potential was used for felling. Firewood accounted for 11% of felling. The technical potential of raw wood consists primarily (66%) of unused growth and 34% firewood and logging residues. The “minimum” potential of raw wood was around 56 million bdt or 1,024 PJ in 2000. A maximum of 165 million bdt or 3,046 PJ could have been used to produce energy.

As is the case for the EU-15 countries, the theoretical potential of raw wood in the EU-28 countries is expected to decline by more than 2% to 341 million bdt p.a. by 2020. Greater economic growth is expected in the new EU member states than in the EU-15 countries. This growth is expected to lead to greater demand for roundwood and felling in the ten new member states. The projected demand for roundwood is therefore expected to increase 27% to 212 million bdt p.a. by 2020. Since felling is not expected to increase only around 15%, the theoretical potential of raw wood will fall by slightly more than 17% to around 137 million bdt p.a. by 2020. This is equivalent to 2,535 PJ p.a. of available energy.

Figure 9 shows the technical fuel potentials of the EU-28 countries broken down into firewood, logging residues and unused growth in PJ for 2000. The greatest potentials are in Germany followed by France, Sweden, Poland, Romania, Italy, Finland and Austria. The fuel potential from felling is the greatest in Scandinavia. The fuel potential from growth varies widely and was even negative for some countries in 2000 (Portugal, Lithuania, Estonia). Actual felling exceeded the theoretical potential of raw wood, meaning that use must be reduced to the same degree for other years. The total potential for the EU-28 countries in 2000 was around 3,070 PJ p.a.

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[15] Assuming a heating value of 18.5 MJ/bd kg

Table 11: Forestry potential of the EU-28 countries
Source: [1]/224/, [2]/223/, [3]/222/

	Units [in 1000]	2000	2010	2020
Wooded area1:	ha	156,905[1]		
Commercially exploitable wooded area:	ha	133,579	134,493	134,274
Annual growth or **theoretical potential of raw wood:**	**bdt**	**348,847**[2]	**344,452**	**341,040**
Felling:	bdt	240,604	250,594	276,522
From that:				
roundwood	bdt	166,343[3]	191,852	211,606
firewood	bdt	26,141[3]		
logging residues	bdt	30,076		
Technical potential of raw wood	**bdt**	**56,216**	**58,742**	**66,451**

The potential distribution is expected to change little by 2010. As shown in Figure 10, Germany, Sweden, France, Poland, Finland and Romania will have the greatest potential as before. Driven by greater projected felling, the technical potentials of raw wood from felling increase especially in France, Germany and Finland. As in 2000, felling will exceed the theoretical potential of raw wood in Latvia and will also exceed the theoretical potential of raw wood in Belgium for the first time. Neither country will have unused potential available for energy production. The total fuel potential will drop by slightly more than 7% to 2,841 PJ p.a.

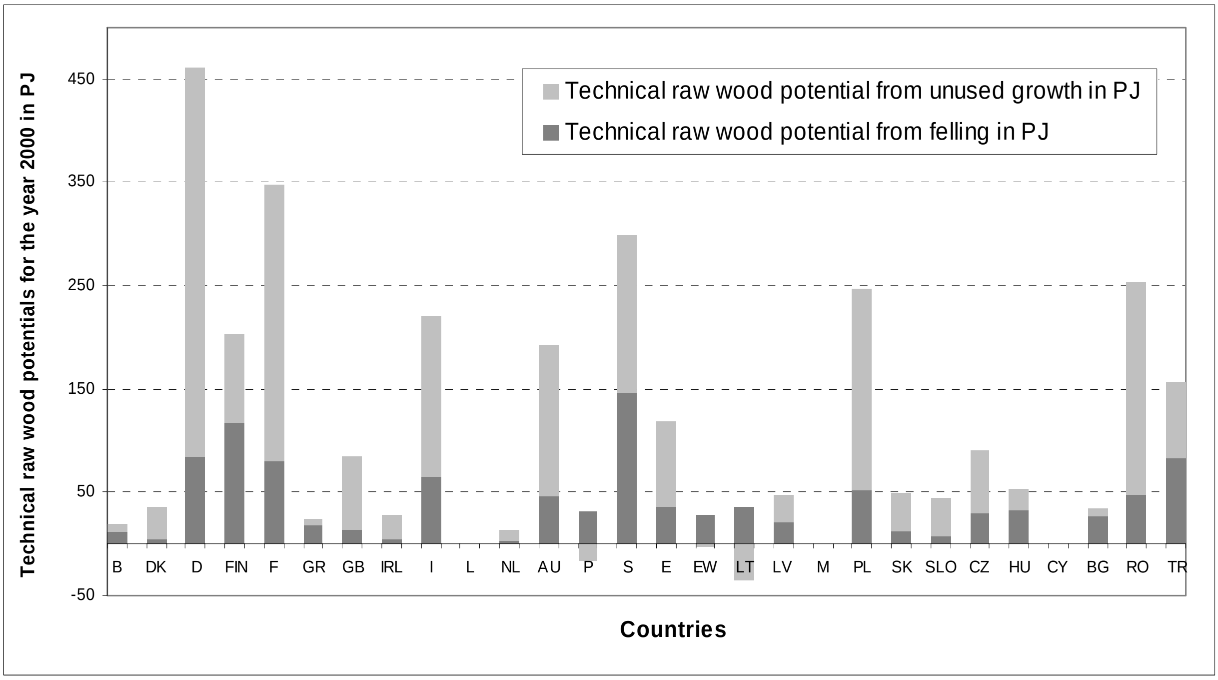

Figure 9: Technical fuel potential from forestry in the EU-28 countries in 2000

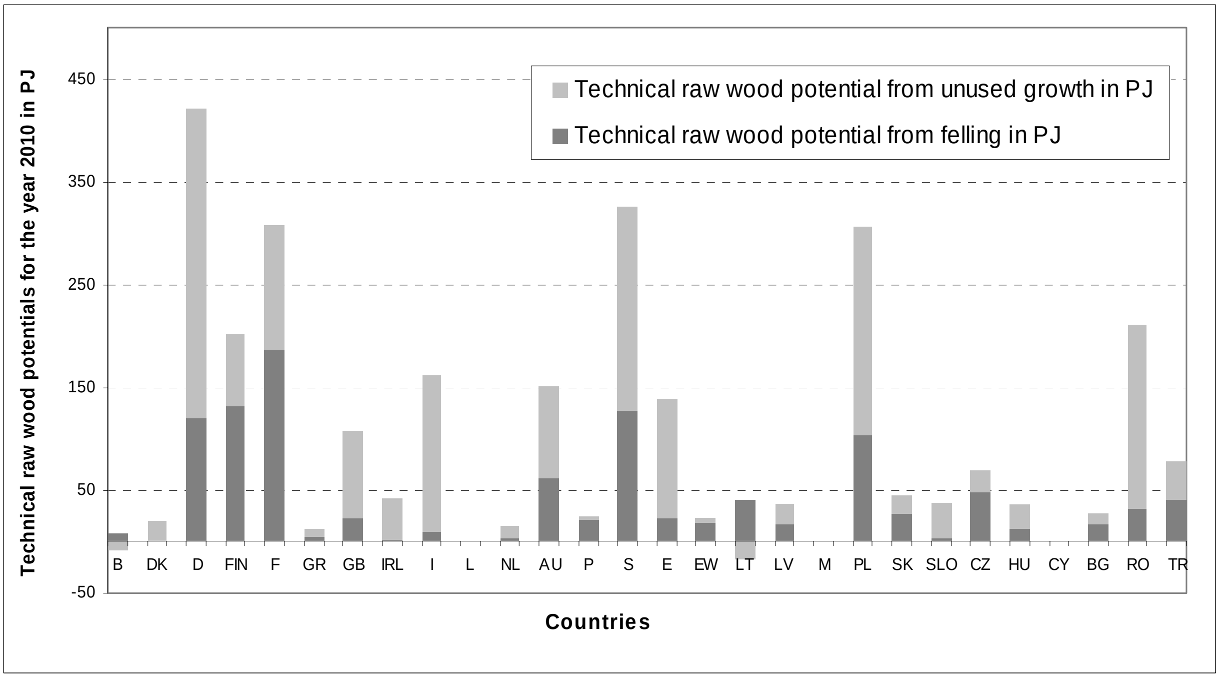

Figure 10: Technical fuel potential from forestry in the EU-28 countries in 2010

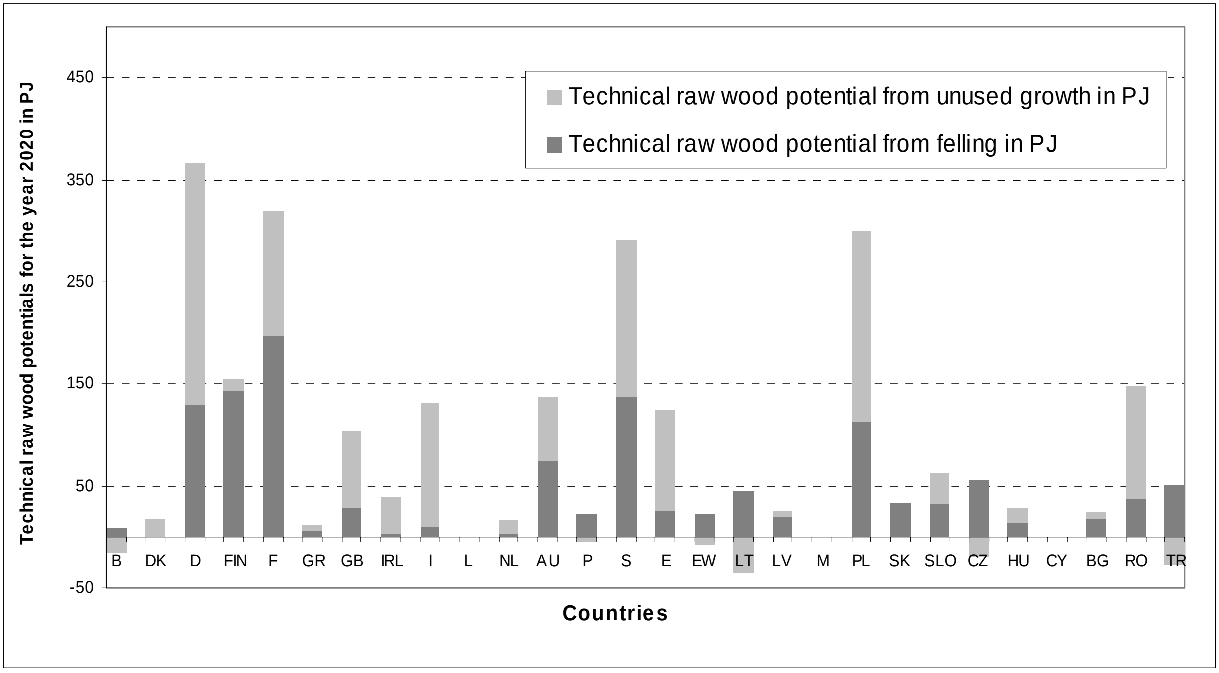

Figure 11: **Technical fuel potential from forestry in the EU-28 countries in 2020**

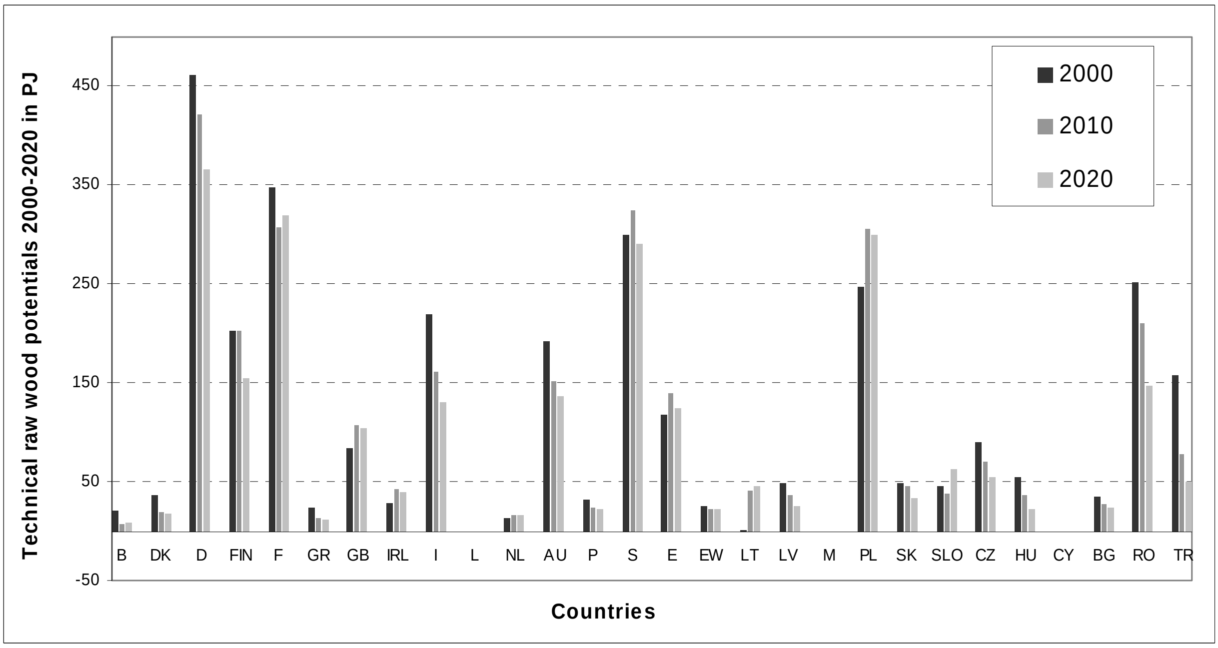

Figure 12: **Technical fuel potentials from forestry in the EU-28 countries in 2000 – 2020**

The downtrend in fuel potential is set to continue through 2020 according to EFSOS projections. Fuel potential is expected to drop to 2,484 PJ p.a. by then. As shown in Figure 11 and Figure 12, the fuel potential will drop from 2010 to 2020 in all EU-28 countries except France. Felling is expected to exceed the theoretical potential of raw wood in Portugal, the Czech Republic and Turkey in addition to Belgium and Latvia. No reserves of unused growth for energy production are expected for these countries in 2020.

3.2.3 Scenario comparison

The trends in potential described in the previous section are based on the assumption that overall economic development in the EU-28 countries will continue and that usage restrictions for sustainable forest management will not be expanded.

The following comparison with the results of a potential estimate by the European Environmental Agency (EEA) is intended to show how forestry potentials will develop if wooded areas used for forestry purposes are managed using a less sustainable approach than before to the benefit of nature conservation or not managed using a sustainable approach at all.

As for this study, the EFISCEN growth model is the basis for the EEA potential estimate. In addition to a maximum target sustainable fuel potential, whose composition of logging residues and unused growth corresponds to technical fuel potential in this study, LINDNER et al. (2005) also derived a protected area scenario. This scenario assumes that 5% of managed forests are protected (e.g. as Natura 2000 areas), and 5% of the potential is due to deadwood and not available for use. Comparing the technical fuel potentials of this study with the EEA projections results in the following:

Table 12: Scenario comparison of technical fuel potentials from forestry

	EFISCEN		EEA			
	Technical fuel potential 2010	Technical fuel potential 2020	Forest energy potential 2010	Forest energy potential 2020	Forest energy potential (max. protected area 2010)	Forest energy potential (max. protected area 2020)
EU-15 countries	1,931	1,721	2,071[1]	1,927[1]		
EU-25 countries	2,526[2]	2,263[2]	2,481[3]	2,305[3]	1,850[3]	1,840[3]

1 Not including Greece, Luxembourg; 2 not including Malta, Cyprus; 3 not including Greece, Luxembourg, Malta, Cyprus

As shown in Table 12, the projections of the maximum sustainable usable technical fuel potentials for 2010 and 2020 are similar for both the EU-15 countries and the EU-25 countries. The EEA estimate for the technical fuel potential for the EU-15 countries is around 100 PJ greater in 2010 and around 200 PJ greater in 2020. The EEA potential estimates for the EU-25 countries are lower in 2010 and higher in 2020 than those of this study. It is irrelevant that the EEA EU-15 and EU-25 potential estimates do not include Greece as Greece's technical fuel potential is only 20 PJ p.a. at most.

Expanding nature conservation areas and increasingly leaving deadwood in forests in the EU countries would reduce the technical fuel potential by around 25% compared to the maximum usable volume, as the protected area scenario for 2010 and 2020 shows. Usage restrictions on a relatively small area, as the scenario shows, could significantly reduce the technical fuel potential.

3.2.4 Factors influencing further development

The continuing development of forest potentials depends primarily on two factors: the future political conditions at the EU and member state level and economic conditions, especially market prices, for fossil energy sources and raw wood products for material use.

Regarding future political conditions at the EU level, it stands to reason that the reduction of greenhouse gases and turning to sustainable development of environmental, energy, economic and agricultural policy will contribute to this reduction. Using biomass to produce energy will most certainly play a role in this context. It is difficult to estimate whether the Commission will give greater priority to using biomass and especially timber to produce energy than is currently the case and provide subsidies for this purpose.

Economic conditions will of course also affect the use of timber for energy production. If economic integration of the new Central and Eastern European countries proceeds swiftly, the increase in the demand for raw wood for material use can be expected to be disproportionately high, and the theoretical potential of raw wood in the individual EU countries can be expected to decrease. This could have positive effects on the mobilisation of existing potentials if prices for wood for material use increase and the market prices for firewood and logging residues increase, making processing of previously unused raw wood potentials profitable. Higher market prices for fossil energy sources should have the same effect on the mobilisation of existing potentials. Higher prices may also make it possible for market prices for firewood and logging residues to increase, enabling previously unused potentials to be mobilised.

Cultivation options for forest plants are difficult to estimate, however. Cultivating profitable tree species or provenances of native tree species seems difficult in Central Europe (especially in Germany) due to the current nature conservation and forestry policy, which aims to regenerate forests naturally. In theory, cultivating profitable tree species could increase biomass potentials over the long term. Portugal and Spain have already adopted this strategy and planted eucalyptus. Last summer's devastating forest fires in Portugal showed that considerable risks are associated with this method.

3.3 Potential of agricultural areas

3.3.1 Definitions and methodology

Agricultural potentials for bioenergy sources are available in an incredible variety of forms. The following quantification focuses on the cultivation of energy crops that can be used as bioenergy sources with current technical possibilities. Agricultural residues such as manure, cereal straw and the like are covered in separate sections as are the forest potentials from agricultural and forestry operations. Energy crops cultivated as permanent crops on agricultural or usable land such as short rotation plantations (pastures and the like), miscanthus and other energy grasses are included in agricultural potentials. They can be produced and used as bioenergy sources in rotation with traditional agricultural energy crops.

The potential estimates refer to the technical potential as defined in the introduction. According to the definition, food crops are given priority over bioenergy sources when production is comparatively less expensive than imports under given political conditions defined for the foreseeable future and when these areas are not subject to "insurmountable" structural, environmental (e.g. nature conservation areas) and other non-technical restrictions. This definition implies, for example, that for economic reasons fallow areas that were used for agricultural purposes until they were set aside represent technical potential for bioenergy sources since a variety of forms of using bioenergy production would be possible even at economically marginal sites if energy production were comparatively less expensive, e.g. due to higher energy prices.

Forms adapted to sites would depend on natural environment and could include fast-growing plantations, permanent grassland or afforestation.

As calculations below demonstrate, agriculture in Germany and in the EU has a high technical potential for biomass production. Agriculture's economic potential is determined by prices of energy sources and especially by agricultural policy, such as the proportion of land that must be set aside, subsidies of agricultural surpluses for export, the price policy for a product that was previously heavily subsidised (sugar), tying direct payments to production or removing direct payments and the like. Estimations of the economic potential under given conditions and implementation of agricultural policy conditions are essential criteria for policy decisions.

The potential estimate for usable biomass from agriculture can be based on different methods. The present study first determined the potential of areas grouped as arable land and grassland. A following analysis uses economic allocation principles to group potential available land for producing bioenergy sources by products or product groups supplied by agriculture under the given economic conditions (section 3.5).

In the following section, a first step estimates the technical potential based on available statistics. The next step quantifies the economic potential according to the preceding definition based on representative agricultural operations and taking into account economic competitiveness of the bioenergy sources. The third step estimates other potentials under the hypothetical assumption of modified basic conditions for the supply of bioenergy sources.

3.3.2 Technical potential

Potential estimates are based on EUROSTAT and FAO data, which were gathered consistently for each country. A 3-year and in some cases 5-year average around the reference year 2000 was used as a basis to offset short-term deviations. The biomass potential available in the basis is expressed in absolute cultivated area and percent potential biomass area of the total area. The potential for bioenergy sources in the reference period consists of the elements explained below (see Figure 13):

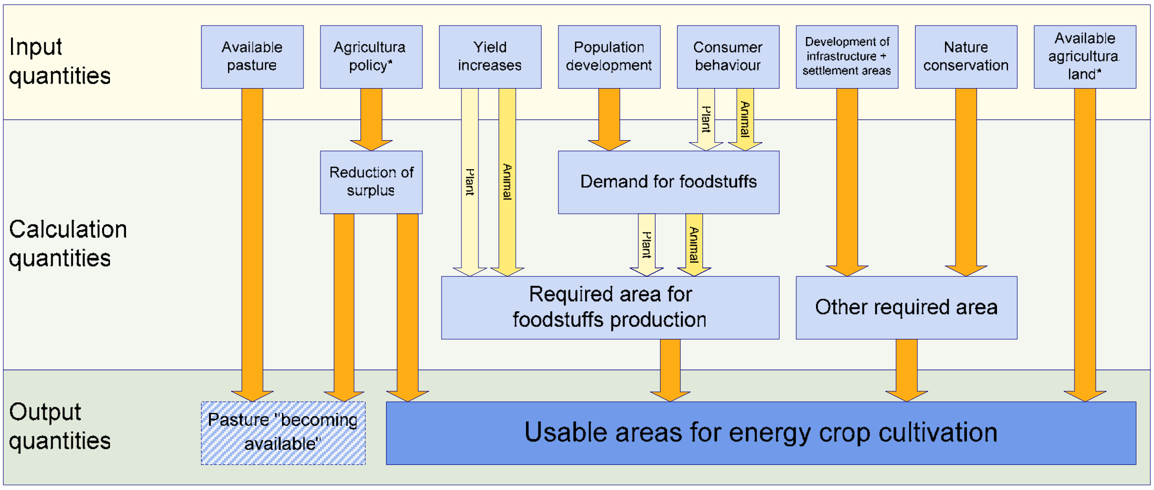

Figure 13: **Matrix for calculating the area under energy crop cultivation**

Fallow land

Fallow land (referred to as green and black fallow in EUROSTAT) is defined as land that can be used for agricultural purposes. It contains land that must be set aside (land that is not used to produce renewable raw materials) and land that is set aside voluntarily for which the EU ensures direct payments in the reference period.

Market regulation product surpluses

Agricultural areas where surpluses of market regulation products (cereal crops, sugar, oleaginous fruits, protein crops, milk, beef, etc.) are produced, which are primarily exported to the global market with subsidies, are considered potential land for bioenergy sources. This applies strictly for surpluses exported to non-EU countries. The calculation results for the EU-15 and EU-25/28 countries in the following take only exports to non-EU countries into account. The calculations for individual member states include all export-import surpluses, in other words, even exports to other EU countries. Imports from EU member states are subtracted from exports in the country calculations. The total member state import-export balances therefore equal the EU-15/25 balance.

Products with export surpluses from improved animal feed production (pork and poultry production) are not considered potential for bioenergy sources. We can assume that countries with export surpluses for these products such as Denmark, the Netherlands, etc. have a comparative cost advantage or produce qualities that can be exported to the upper market and price segment. We can also assume that for agricultural products with deficit self-sufficiency such as soya that the respective country does not have the comparative cost advantages of competitive energy generation with the result that these imports continue and that these countries are not aiming to increase self-sufficiency or have already increased self-sufficiency of these products to the detriment of biomass potential.

Projection of future developments

The estimates of potentials for bioenergy sources for 2010 and 2020 differ from the basis as follows:

- Food consumption due to changes in population and per capita consumption. Higher consumption decreases and lower consumption increases the available potentials for bioenergy sources.

- The expected redesignation of land previously used for agriculture for municipalities, traffic and other purposes. Redesignation of this land reduces the potential for bioenergy sources.

- Increases in yield in crop production. These increases make potentials available for bioenergy sources.

- Increased efficiency in animal production. These increases reduce the amount of feed required, releasing a corresponding amount of potential for bioenergy sources.

Balancing individual variables creates an aggregated future potential of increased or decreased bioenergy source production. This potential can be used for different energy crops whose scope is not defined in this statistics-based analysis.

The estimates take the following assumptions into account.

- Cultivated land, fallow land, harvest volume, average yields, imports, exports, degree of self-sufficiency of agricultural products for food production, agricultural land, population and per capita consumption are based on official statistics. The corresponding basic data of the agricultural, commercial and consumption structure are provided in the appendix on “structure data” for the EU countries, the EU-15 and EU-25 aggregates and, when available, the EU-28 countries (F 1–F 30, tables 1 – 7).

- Land made available for bioenergy sources from existing overproduction is calculated from the import-export surplus balance. A factor of 7 is used to convert sugar to beets (1 t sugar = 7 t sugar beets), and beet production calculated this way is converted to potential land made available for beet production using the average sugar beet yield.

- Surplus production of milk and dairy products is converted to whole milk equivalents. 1 kg butter = 20 kg and 1 kg cheese = 10 kg of whole milk equivalent. The amount of whole milk equivalents used for export surpluses is expressed as surplus production in percent for total milk production. The surplus percentage of the whole milk equivalent for export is divided by the total production minus the whole milk equivalent for export (otherwise exports would be underestimated). The same method is used for calculating the export surplus percentage for beef, pork and poultry. As previously mentioned, export surpluses for pork and poultry are not considered potential land for bioenergy sources, however.

- To estimate the amount of land made available for bioenergy sources from surplus dairy and beef production, the roughage area (grassland and forage crops for ruminants) is allocated to dairy, beef production, etc. (goats, sheep, etc.) using the definition of livestock units of the animal stock. The stock of livestock units consisting of dairy cows, heifers over two years old, female cattle one to two years old and female calves are allocated to milk production and veal calves, bull calves, male cattle one to two years old, male cattle over two years old, slaughter heifers and other cows for beef production. Available roughage area is distributed to dairy, beef and other animals including other grazers/browsers (sheep and goats). This definition can be used to convert milk export surpluses to land made available for bioenergy sources.

- Feed savings due to improvements in feed conversion compared to the basis are based on the conclusion that feed conversion in pork and poultry production has seen a comparatively uniform annual increase of approximately 0.5% in the EU-15 countries in the last three decades. 3.75 times the amount of grain is required for pork, and 1.8 times as much is required for poultry. Overall feed grain savings are converted for 2010 and 2020 to land made available for bioenergy sources taking into account the expected increase in yield at respective points of time. Land would be overestimated if the increase in yield were not taken into account.

- The effect of the changing population and per capita consumption is calculated by balancing rates of change. A positive balance indicates increased consumption and a decrease in the potential for bioenergy sources. This rate of change is adjusted using the change in yield factor because higher land yields are achieved in the projection of 2010 and 2020 potentials and because failing to correct for yield would underestimate the potential land made available for bioenergy sources.

The estimate of trends in land, yield, population and per capita consumption is based on available estimates (population), time series from 1994 and later (starting later in some countries), regression analyses and plausibility. Individual assumptions are explained in the following.

Table 13: **Changes in agricultural land and yields (regression analysis)**

Country	Rates of change in agricultural land1) in % per year	Rates of change in yields in % per year (weighted average 1994 - 2002)	Expected rates of change in % per year		Cereals yield level (weighted mean) dt/ha		
			2000 - 2010	2010 - 2020	2000	2010	2020
Germany	-0,051	1,516	1,516	1,516	65,9	76,5	89,0
Great Britain	-0,571	0,268	1,000	1,500	68,4	75,6	92,2
France	-0,246	1,108	1,108	1,500	71,5	79,8	96,3
Italy	-0,270	0,670	1,000	1,500	49,4	54,6	66,5
Spain	-0,113	3,738	3,000	3,000	32,1	43,2	58,0
Netherlands	-0,214	-0,168	1,000	1,500	73,4	81,1	98,8
Belgium/Luxembourg	0,315	1,943	1,943	1,943	80,1	97,1	117,7
Greece	-0,911	0,064	1,000	1,500	37,6	41,6	50,7
Portugal	0,544	3,341	3,000	3,000	27,7	37,3	50,1
Sweden	-0,752	1,400	1,400	1,500	46,8	53,8	63,0
Austria	-0,313	0,634	1,000	1,500	56,5	62,4	76,1
Denmark	-0,385	0,354	1,000	1,500	60,4	66,7	81,3
Finland	-0,947	-2,474	1,000	1,500	33,2	36,7	44,7
Ireland	-0,003	1,492	1,492	1,500	73,6	85,3	99,1
EU-15	**-0,264**	**1,432**	**1,432**	**1,500**	**56,3**	**64,9**	**75,9**
Cyprus	-2,640	-2,540	-2,540	-2,540	18,7	14,4	11,2
Czech Republic	-0,009	0,736	1,000	1,500	42,5	46,9	57,2
Estonia	-5,712	11,878	3,000	3,000	20,6	27,7	37,2
Hungary	-0,628	4,661	3,000	3,000	54,9	73,8	99,2
Latvia	-0,266	2,662	2,662	2,662	22,2	28,9	37,5
Lithuania	-0,089	3,839	3,000	3,000	26,8	36,0	48,4
Malta	-4,160	0,047	1,000	1,500	40,0	44,2	53,9
Poland	-0,222	1,297	1,297	1,500	29,4	33,5	39,7
Slovakia	-0,030	-1,796	1,000	1,500	35,7	39,4	48,1
Slovenia	-1,244	1,369	1,369	1,500	52,2	59,8	70,3
EU-25	**-1,422**	**1,360**	**1,356**	**1,500**	**48,1**	**55,0**	**64,8**
Bulgaria	-1,457	0,833	1,000	1,500	28,6	**31,6**	**38,5**
Romania	0,029	-2,319	1,000	1,500	24,3	26,9	32,8
Turkey	0,127	1,451	1,451	1,500	22,3	25,7	30,0

1) corresponds to the area used for agriculture

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

Redesignation of land

Redesignating agricultural area for other purposes is defined based on the 1991–2002 “Agricultural Area” data base in FAO statistics. As a rule, the regression coefficient was used as the basis for area change. The data in Table 13 show that the results seem barely plausible in some countries such as Cyprus, Malta and Estonia. To what extent this can be attributed to inconsistencies due to new statistical definitions, incorrect data collection or actual redesignation of agricultural areas cannot be explained. Regression analysis is used throughout due to the comparatively low importance for estimating biomass potential for the entire EU.Trends in food consumption

The potential of agricultural biomass used to produce energy is determined by overall food consumption. Total food consumption is determined by two factors: the population and per capita food consumption. Forecasts of change rates in the population and aggregated per capita consumption in grain equivalents (GE) and the resulting change rates in overall food consumption are shown in Table 14 for the EU-28 for 2000 to 2010 and 2010 to 2020 (see Appendices C, D and E).

As shown in Table 14, in the period to 2010, the population of all EU-15 countries will grow. Of the 10 new member states, only the populations of Cyprus and Malta will grow, and of the 3 candidate countries, only Turkey will experience population growth. The populations of EU-15 countries Germany, Italy, Spain and Greece are expected to decline from 2010 to 2020. The total population of the EU-15 countries is expected to increase by 1.83% between 2000 and 2010 and by 0.65% from 2010 to 2020. The population of the EU-25 countries is expected to increase by 1.32% between 2000 and 2010 and by 0.22% from 2010 to 2020.

Estimates show a 12.45% increase in world population from 2000 to 2010 and a 10.74% increase from 2010 to 2020. Given the rise in population, growth in food demand is expected to slow over the long term in the world and especially in the EU. Population projections for 2010 and 2020 are based on data from the German Federal Statistical Office, the European Commission and the UNO provided in appendix C.

Table 14: **Changes in population, per capita food consumption and total food consumption in grain equivalents (GE) in % for 2000/2010 and 2010/2020**

	Population Change		Change in consumption per capita		**Total change in consumption**	
	2000 - 2010	2010 - 2020	2000 - 2010	2010 - 2020	**2000 - 2010**	**2010 - 2020**
Germany	1,07	-0,29	2,10	0,00	**3,17**	**-0,29**
Great Britain	3,56	3,49	7,00	0,00	**10,56**	**3,49**
France	3,17	1,10	3,20	0,00	**6,37**	**1,10**
Italy	1,53	-0,75	4,40	0,00	**5,93**	**-0,75**
Spain	0,17	-1,18	5,50	0,00	**5,67**	**-1,18**
Netherlands	6,30	3,72	-1,50	0,00	**4,80**	**3,72**
Belgium/Lux.	2,75	2,22	1,40	0,00	**4,15**	**2,22**
Greece	1,50	-0,65	7,10	0,00	**8,60**	**-0,65**
Portugal	1,09	2,10	8,00	0,00	**9,09**	**2,10**
Sweden	3,63	3,51	5,70	0,00	**9,33**	**3,51**
Austria	1,47	1,17	4,80	0,00	**6,27**	**1,17**
Denmark	3,28	2,49	6,00	0,00	**9,28**	**2,49**
Finland	1,80	1,10	3,30	0,00	**5,10**	**1,10**
Ireland	8,63	4,36	2,00	0,00	**10,63**	**4,36**
EU-15	**1,83**	**0,65**	**5,00**	**0,00**	**6,83**	**0,65**
Poland	-0,75	-1,69	6,60	5,40	**5,85**	**3,71**
Czech Republic	-1,06	-2,22	3,20	5,50	**2,14**	**3,28**
Hungary	-2,97	-3,34	7,30	5,30	**4,33**	**1,96**
Slovakia	0,00	-0,93	0,00	5,60	**0,00**	**4,67**
Lithuania	-4,06	-4,29	8,10	5,00	**4,04**	**0,71**
Latvia	-5,27	-5,29	5,70	5,70	**0,43**	**0,41**
Slovenia	-0,41	-2,14	6,50	3,90	**6,09**	**1,76**
Estonia	-4,24	-2,83	5,40	5,00	**1,16**	**2,17**
Cyprus	12,09	10,33	9,20	5,00	**21,29**	**15,33**
Malta	4,85	3,65	5,60	3,70	**10,45**	**7,35**
EU-25	**1,32**	**0,22**	**5,20**	**0,90**	**6,52**	**1,12**
Turkey	14,43	11,13	0,00	7,00	**14,43**	**18,13**
Romania	-3,75	-4,19	6,90	7,00	**3,15**	**2,81**
Bulgaria	-6,89	-7,88	6,90	7,00	**0,01**	**-0,88**

No usable projections on the development of per capita food consumption are available for 2010 or 2020. Consumption trends of the most important 10 or 11 foods in the EU-25 and 3 acceding countries from 1994 to 2002 form the basis for the 2010 and 2020 projections (see appendix D 1 – D 29). Consumption is indicated in product weight and grain equivalents (GE). Consumption in grain equivalents is shown for each country and for the EU.

For all countries, linear consumption trends were estimated for the grain equivalent (GE) aggregate and for beef and milk, the beef/milk aggregate and remaining food based on consumption data from 1994 to 2002 (see appendix D 30). The results show that simple linear trend projections are not plausible. This holds true in the EU-15 countries – primarily

Germany – for individual products in particular such as beef (extreme drop in consumption due to the BSE crisis) and in the 10 new member states more or less for the trend in food consumption as a whole. Due to the increased supply of products in the food and especially the non-food segments, both the makeup and level of food consumption changed. For example, Latvia's extremely high consumption of beef dropped by less than a third, and total food consumption aggregated in grain equivalents fell in most of the 10 new member states while the demand for non-food items increased.

Comparing the development of per capita income (used in place of GDP due to statistical availability) – the most important determining factor of aggregated per capita food consumption – to the development of per capita food consumption from 1995 to 2000 aggregated in grain equivalents results in different realisations for EU-15 countries and the new member states and supports the conclusions drawn. In all EU-15 countries, where real per capita income increased, except the Netherlands and Germany, per capita consumption expressed in grain equivalents also increased, and in Spain, Great Britain and Denmark with an income elasticity greater than 0.5. Whereas the slight drop in aggregated consumption in grain equivalents in Germany is the result of substitutions for beef, consumption in the Netherlands decreased for all important foods. Unlike in most EU-15 countries, aggregated per capita consumption in the new member states except Cyprus, Hungary and Slovenia fell despite generally higher income growth per capita.

We can thus conclude that projecting development of per capita consumption is especially difficult. The overall drop in per capita consumption in the Netherlands could be an initial indication of a healthier diet. If this were to be expected in other countries, a long-term drop in per capita consumption would have to be projected, especially in EU-15 countries with a high level of consumption. Given the dramatic rise in consumption in some countries, this development seems unrealistic for the time being, however. Unlike in the EU-15 countries, consumption is expected to increase in the new member states with comparatively low per capita consumption, which has even dropped in recent years, as developments in the old and new member states are expected to converge.

As shown in Table 14, with the exception of the Netherlands, projections show an increase in the aggregated per capita consumption in grain equivalents in all EU-15 countries from 2000 to 2010, and the projected value from 2010 is maintained for all EU-15 countries for 2020. A possible overestimate of consumption through 2010 could be offset by maintaining projected values 2010 for 2020. Per capita consumption is not expected to drop by 2010 in the new member states and acceding countries. In fact, consumption is expected to increase in most countries. Projections show an increase in per capita consumption from 2010 to 2020 for all new member states and the acceding countries. Previous estimated consumption trends and projections of absolute per capita consumption are explained in appendix D 30 and E.

Breakdown of land potentials for bioenergy sources on arable land and grassland

Since grassland that is not longer needed for food production in future can only be converted to arable land in exceptional cases and since other bioenergy sources are produced on grassland than on arable land, grouping the potentials for bioenergy sources by grassland and arable land provides interesting information. The following estimate always calculates the percentage of the entire potential of an area covered by grassland using the following method:

- Calculations in the reference period result in area potential for bioenergy sources on grassland due to reductions of surplus production of milk and beef. In countries with surplus milk production, the grassland area allocated to milk production is reduced by the amount of surplus milk production, and the grassland no longer needed for milk production is indicated as potential land that can be made available for bioenergy sources.
- The same procedure is used for surplus beef production. Land made available from both types of production is added and shown as a percentage of all agricultural land that can be made available.

The amount of grassland that can be made available is expected to differ in the estimate of grassland potential for 2010 and 2020. The change is due to redesignation of land to non-agricultural uses and increased or decreased milk and beef consumption caused by changes in per capita consumption and population. We also assume that increases in yield on permanent grassland will be converted. The future potential of grassland to be made available for bioenergy sources is quantified as follows:

- Redesignation of agricultural areas to non-agricultural purposes affects grassland to the extent expressed as the share of agricultural area in the basis.
- The increased or decreased demand for grassland due to changes in the population and per capita consumption for milk and beef equals the grassland used for milk or beef production multiplied by the rate of population change and rate of per capita consumption change.

- Grassland made available in the amount of the assumed yield increase based on overall grassland.

The overall change in demand for grassland compared to the basis and for 2010 and 2020 is shown as potential for bioenergy sources.

3.3.3 Results of estimates of technical potential

The results of the comprehensive calculations indicate the potentials for bioenergy sources by country in the basis and projected for 2010 and 2020. The potentials for Germany are discussed first followed by the potentials for the EU-15 and EU-25/28 countries. Appendix F (F 1 - 30, Tables 8 - 14) contains tables for each EU member state and for the candidate countries. The tables contain similar data as discussed in detail for Germany in the following section.

3.3.3.1 Germany

The potential estimate for bioenergy sources is first shown in Table 15 for the basis. On average in the four reference years from 2000 to 2003 fallow land (green and black fallow) in Germany totalled 861,657 ha according to EUROSTAT. The statistics also indicate land set aside that is already used for cultivation of renewable raw materials and is therefore not included in the potential estimate. We can take the average cereal yield of 6,585 t/ha to calculate the product volume that can be achieved on the basis area. Other biomass potentials in the reference period include export surpluses of the most important energy crops. The average export surplus for cereals in 2000 – 2003 in the statistics was around 8.3 million t for Germany, which was exported to non-EU countries – subsidised to a lesser extent – and to member states (around 3 million t) or otherwise used. Taking the average cereal yield as a basis, 8.3 million t cereal equals 1.264 million ha of potential area for bioenergy sources. Potential area for rapeseed and sunflower is reported from corresponding import balances taking into account average yields, which reduces biomass potential. We assume that the self-sufficiency is the aim of finding substitute crops for these products. Eliminating production of export surpluses for sugar would create potential for bioenergy sources in the amount of 130,000 ha. Overall, the balance for the reference period is 1 million ha, and when fallow land is included, a potential of 2 million ha exists for producing biomass (existing production of bioenergy sources is not included in this potential).

In animal production, there is 2.64% overproduction for milk from exports of milk and cheese and imports of butter. It should be noted that cheese can be exported in part without export subsidies. Based on our assumptions, they would not actually be considered potential biomass area. As subsidy programmes for milk and dairy product sales on the domestic market exist, which are difficult to quantify and therefore not taken into account, non-subsidised cheese exports and subsidised domestic sales of dairy products are not included for simplicity's sake. Beef export surpluses were considerably higher while pork and poultry saw considerable import surpluses.

The data in Table 16 show the structure of animal stocks and are broken down by livestock units into milk, beef, goats and sheep. Milk production accounted for 74% of the livestock units, while beef and other grazers/browsers accounted for 24% and 2% respectively. Of the total 7.7 million ha roughage area, 74% is allocated to milk production and 24% to beef production. Further differentiation by grassland and forage crop land for each type of production is difficult due to a lack of data and cannot be included. As the data in Table 17 show, moving from surplus production of milk and beef to self-sufficiency would potentially free up around 150,000 and 510,000 ha for bioenergy sources. Conversely, expanding pork and poultry production to the point of self-sufficiency would require 160,000 and 52,000 ha, which would then not be available for bioenergy sources. However, as these products are imported due to comparatively high costs (Holland, Denmark and overseas), these potentials are not included in the total estimate of bioenergy source potential (these figures are therefore offset to the right in the table). The balancing of all land potentials for bioenergy sources is 2.6 million ha, or around 15% of the total agricultural area of 17 million ha.

Table 15: **Technical potentials for bioenergy sources in the basis, Germany**

Potential from:		ha	Average yield t	Product quantity t	
Fallow land		**861.657**	**6,585**	**5.674.410**	
Export(+)/Import(-) surplus in crop production					
- Cereals		1.263.765	6,585	8.322.481	
- Rapeseed		-194.722	3,317	-645.835	
- Sunflower		-116.143	2,212	-256.877	
- Sugar beet		129.714	58,407	7.576.251	1)
Crop production balance		**1.082.614**		**14.996.020**	

Potential from:		Product quantity t
Export(+)/Import(-) surplus in animal production		
- Milk		1.058.833
- Butter	2)	-1.522.705
- Cheese	3)	1.187.255
Whole milk equivalent balance		723.383
Total milk production		**28.155.219**
the above as %		**2,64**

Potential from:		Product quantity t
Export(+)/Import(-) surplus in meat production		
- Beef		288.114
Total production		**1.327.125**
the above as %		**27,73**
- Pork		-281.318
Total production		4.055.460
the above as %		-6,49
- Poultry meat		-191.351
Total production		850.667
the above as %		-18,36

1) 1 t sugar = 7 t sugar beets

2) Whole milk equivalent 1 kg butter = 20 kg whole milk

3) Whole milk equivalent 1 kg cheese = 10 kg whole milk

Table 16: **Animal stocks, livestock units and demand for roughage area, Germany**

Animal numbers	Units	Livestock unit definition	Livestock unit division			Total livestock units
			Milk	Beef	Others	
Beef calves	120.188	0,25		30.047		30.047
Calves						
male	1.882.762	0,3		564.829		564.829
female	2.343.847	0,19	445.331			445.331
Cattle 1-2 years						
male	1.215.716	0,7		851.001		851.001
female	2.069.365	0,65	1.345.087			1.345.087
Cattle 1-2 years						
male	129.805	1,2		155.766		155.766
Beef heifers	75.157	1,2		90.189		90.189
other heifers	918.961	1,2	1.102.753			1.102.753
Dairy cows	4.437.358	1,2	5.324.830			5.324.830
other cows	784.868	1,2		941.842		941.842
Goats	155.000	0,1			15.500	15.500
Sheep	2.155.000	0,1			215.500	215.500
Total			**8.218.000**	**2.633.673**	**231.000**	**11.082.674**
Share %			**74,15**	**23,76**	**2,08**	**100,00**
roughage area ha						**6.582.920**
thereof…			**4.881.353**	**1.564.357**	**137.210**	

Table 17: **Summary of potentials for bioenergy sources in the basis, Germany**

Resource		ha	% of agricultural land
Fallow land		861.657	5,06
Reduction of overproduction			
- Crop production		1.082.614	6,36
- Animal production			
- Milk		125.415	0,74
- Beef		339.616	2,00
- Pork	1)	-160.192	-0,94
- Poultry meat	2)	-52.302	-0,31
Balance of potential area	**3)**	**2.409.302**	
Agricultural land		**17.022.667**	
the above as %		**14,15**	**14,15**

1) 3,75 t cereal per t pork
2) 1,8 t cereal per t poultry meat
3) without pork and poultry meat

The data in Table 18 show projected development of potentials for 2010 and 2020 compared to the basis. The population of Germany is expected to increase by 1.0683% over the basis in the space of 10 years. The estimate of per capita consumption based on grain equivalents is expected to increase by 2.11% from 2000 to 2010. An aggregated change of 3.18% is thus expected for additional food production. As yields are expected to increase by around 15% in the same period, 2.76%, not 3.18% more area will be allocated for food production. The calculations assume that in this 10-year period 0.509% of agricultural area will be redesignated for other purposes. The balance of all changes, taking into account area saved by the 15.157% increase in yield, results in a relative amount of land (therefore the negative number) of 11.888% of the area currently available for agricultural purposes in the basis.

Table 18 also shows available agricultural area in absolute figures (17.023 million ha). This amount is reduced by around 87,000 ha due to redesignation. Taking into account increasing yields, around 470,000 ha will be required for the increased demand for food. The increase in yields will result in 2.58 million ha being made available from food production for exports, set-asides or bioenergy production. An additional 0.5% of land will be made available annually due to improved feed conversion in pork and poultry production (figures are derived in Table 19, again taking into account increases in yield to 2010). Compared to the basis in which a potential area for bioenergy sources of 2.6 million ha was estimated, an additional 2.134 million ha will be available, totalling 4.74 million ha of potential area for bioenergy sources in 2010, or 28% of available agricultural land. For 2020, a further 2.757 million ha will be available for bioenergy sources, totalling around 7.23 million ha or 42.5% of the available agricultural land in Germany.

Table 18: **Estimate of changes in potential for bioenergy sources for 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

Table 19: **Feed grain savings in pork and poultry production due to improved feed conversion, Germany**

Production based on consumption	Basis 2000	2010	2020
- Pork t	4.055.460		
- Feedgrain consumption t [1]	15.207.974	-760.399 [3]	-1.520.797 [3]
Land equivalent ha cereals	**2.309.324**	**-115.466**	**-230.932**
- Poultry meat t	850.667		
- Feed grain consumption t [2]	1.531.200	-76.560 [3]	-153.120 [3]
Land equivalent ha cereals	**232.512**	**-11.626**	**-23.251**
Total land equivalent ha	**2.541.836**	**-127.092**	**-254.184**

[1] 3,75 t cereal für 1 t pork
[2] 1,8 t cereal für 1 t poultry meat
[3] annual improvement of feed conversion 0,5 %

The breakdown of arable land and grassland available for bioenergy sources is derived in Table 20 and Table 21. In the basis, just less than 5 million ha of grassland is available in Germany, around 3.7 million ha of which is used for milk production. Returning milk production to self-sufficiency by around 2.6% would free up around 95,000 ha of grassland. By eliminating surplus production of beef, approximately 258,000 ha of grassland would be available for producing bioenergy sources. In all, grassland used for surplus production totals 7.06%. Of the total potential area for bioenergy sources in the basis (around 2.6 million ha), grassland accounts for less than 15% and agricultural land for 85%.

Table 20: **Germany: estimate of potential area for bioenergy sources from grassland in the basis**

Total grassland	ha	4.999.537
Grassland for milk production	ha	3.707.246
Overproduction milk	%	2,64
Released grassland due to renouncement of overproduction	**ha**	**95.249**
Grassland for beef production	ha	1.188.084
Overproduction beef	%	27,73
Released grassland due to renouncement of overproduction	**ha**	**257.929**
Total grassland released	**ha**	**353.178**
the above as % of total grassland		**7,06**
the above as % of potential area for bioenergy sources		**14,66**

Table 21: **Germany: estimate of potential area for bioenergy sources from grassland in 2010 and 2020**

		2010	2020
Redesignation of agricultural land	ha	86.678	86.678
Grassland share of agricultural land	%	29,37	29,37
Redesignation of grassland	**ha**	**25.457**	**25.457**
Change to grassland due to change in consumption			
- Rate of change in population	%	1,0683	-0,2937
- Rate of change in milk and beef consumption	%	0,7000	0,0000
Total change	%	1,7683	-0,2937
Grassland for milk and beef production	ha	4.895.330	4.895.330
Increased(+)/minimum demand(-) for consumption of milk and beef	ha	86.563	-14.380
Release due to yield increase(-)	ha	-757.769	-757.769
Total change in grassland	**ha**	**-645.749**	**-746.692**
Accumulated grassland potential for bioenergy sources	**ha**	**998.927**	**1.745.618**
the above as % of total grassland		**19,98**	**34,92**
the above as % of potential area		**21,99**	**23,91**

Available grassland is reduced in 2010 due to redesignation of agricultural area (86,678 ha). We assume that given the present distribution of arable land and grassland, just under 30% or around 25,000 ha of the land redesignated to grassland will become unavailable.

Changes in population and per capita consumption of milk and beef by 2010 will increase demand for food production by around 1.77% by 2020. This equals around 86,000 ha of the grassland used for milk and beef production. As a result of further increases in yield on grassland, around 758,000 ha will be made available by 2010 and an additional 758,000 ha by 2020. In net terms 645,749 ha of grassland will be made available from 2000 to 2010. This area was added to the available grassland made available in the basis. In 2010, 998,927 ha of grassland will be available for bioenergy sources and in 2020, 1,745 618 ha. According to the calculations, of the total potential area for bioenergy sources, grassland accounts for 14.66%, 21.99% and 23.91% in the basis, 2010 and 2020 respectively. In other words, primarily arable land is available for bioenergy sources in Germany.

Analysing the results

A variety of restrictions must be considered when evaluating the quality of the results. The reported figures are projections under simplified assumptions, which are explained again in the following under different aspects:

- The fallow land in Germany used for the basis is 861,657 ha, around 400,000 ha is land that must be set aside and brought into annual rotation alternately. All of it can therefore be evaluated as potential land for bioenergy sources with the valid average yield. Some of the remaining areas are marginal areas that do not produce the average yield when brought back into production. For projections in 2010 and 2020, this land or more land can be either pulled out entirely of agricultural use due to existing national and European nature conservation goals or expanded to some extent. This potential estimate does not take these aims, which compete with bioenergy production, into account. The use of these technical potentials already assumes higher economic efficiency of bioenergy sources. If available, even fallow land in marginal areas offer multiple possibilities for producing competitive bioenergy sources through to afforestation. Completely discounting the fallow land reported in the statistics for Germany and for the other EU member states and candidate countries would therefore not be appropriate.

- For the estimate of biomass potentials from surplus production of crops, land dedicated to agricultural products that can be produced in the respective country (except soya) was underestimated insofar as rapeseed and sunflower will continue to be imported due to the lack of a comparable cost advantage. The same applies for member states that must import milk and beef. The given demand for bioenergy sources would result in more potential from domestic production.

- The estimates of biomass potentials for 2010 and 2020 assume that self-sufficiency in animal production will remain unchanged. This assumption is simplified. The trend in agricultural policy is to import more animal products in future due to the comparative cost advantage instead of producing them domestically as was previously the case. For beef in particular, self-sufficiency can reduce the supply level, which frees up additional potentials for bioenergy sources.

- Projections of biomass potential do not take into account that output and feed conversion are increasing even in milk and beef production. As a result, at the given consumption level the number of dairy cows decreases and more roughage area will be made available for bioenergy crops. Because this land is primarily grassland that can be used for less attractive purposes apart from biogas and combustion of growth, this potential was not included in the calculation.

- The assumptions on future yield trends have a significant influence on the result. For Germany, the assumption of yield development in the period under consideration equals the result of the regression analysis. There are arguments for both more optimistic and more pessimistic assumptions. Higher rates of increase in yield can be explained by the focus of cultivation in future on higher energy yields (up to 50% higher yield in less than 10 years for maize /237/), regionally differentiated land management and improved management due to quick structural change. The potential estimate assumes that advances in yield derived from developments in yield of the main crops of arable land are equal for both feed crops from arable land and for permanent grassland. EUROSTAT has only isolated longer time series for yields of permanent grassland and trends of those yields. For example, according to EUROSTAT, the yield of permanent grassland in Germany increased from 73.7 dt of dry matter/ha in 1992 to 82.5 dt of dry matter/ha in 2001. The rate of change for yield in Germany was only just over 1% compared with around 1.5% for agricultural market crops. EUROSTAT does not have any yield information at all for many countries, and there is no representative estimate or comparable measure of yield for all countries. The method used in these calculations of applying the progress in yield from arable land to permanent grassland could therefore be an important source of error. Yet failing to take into account progress in yield of permanent grassland does not correspond to reality in most member states.

- Even if an additional 20% of agricultural area were used for organic farming and only 50% of the previous yields were achieved, 3 million ha in 2010 and 5.8 million ha in 2020 would be available as potential land for bioenergy sources in Germany, or one third of the agricultural area in the basis. We would achieve the same result if an additional 10% of agricultural area were redesignated in full from agricultural production to nature conservation uses.

Compared to this calculation, different variants of the estimation method result in either increased or decreased potential for bioenergy sources. A sensitivity analysis is included at the end of this section to estimate the quantitative influence.

3.3.3.2 EU-28 countries

The data calculated for Germany were also determined for all EU member states and the candidate countries as well as for the EU-15, EU-25 and EU-28 countries and are included in the appendix F, F 1 – F 30 (Tables 8 – 14).

The following comments on the results refer only to data from the overview results by country in Table 22,

Figure 14 and focus on each country’s particularities.

Table 22: Technical potential for bioenergy sources by country

Country	Population			Consumption per capita			Agricultural land			Rates of change in yield as % (weighted mean)		Potential area in ha, and as %					
	2000 (thousand)	Change in % up to		2000 (grain equivalent)	Change in % up to		2000 2) (thousand ha)	Change in % up to		2000 - 2010	2010 - 2020	2000	%	2010	%	2020	%
		2010	2020		2010	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
Great Britain	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/Luxembourg	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
Slovakis	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						240.269,667					15.309.601		34.011.526		66.038.076	

1) doesn't correspond to the balance from countries in all columns, due to different data sources, and inexactness of data; 2) average over three years

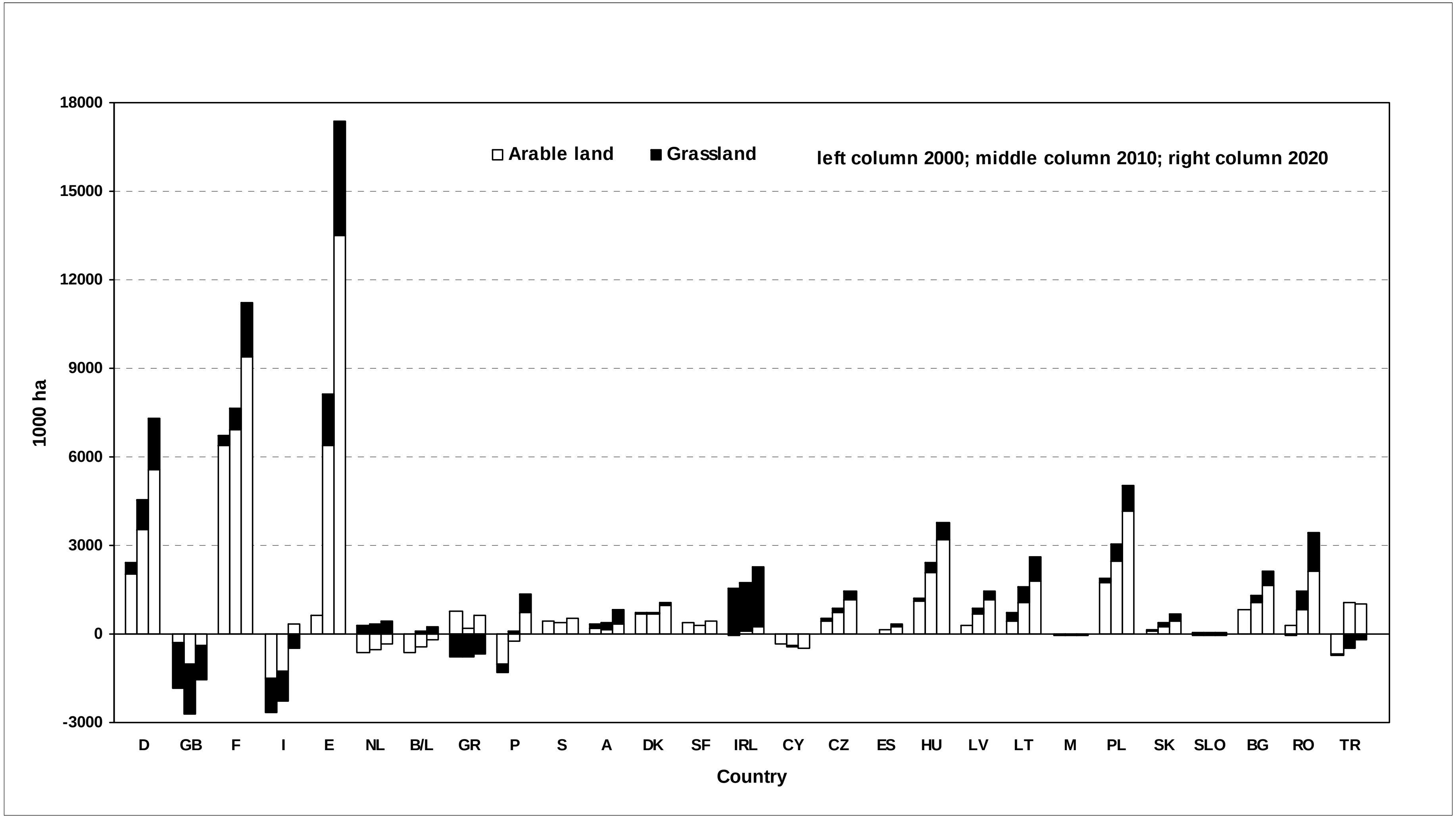

Figure 14: Technical potential for bioenergy sources in ha of area in member states and acceding countries (2000 – 2010 – 2020)

Results for other member states

- Unlike Germany, Great Britain has no potential for bioenergy sources in the basis or in projections for 2010 and 2020. In the basis, this was due to lower availability of fallow land and overall deficit self-sufficiency with the exception of cereals. In the projection for 2010 and 2020, a continuing increase in population, temporarily increasing per capita consumption and considerable redesignation of land despite substantial increases in yield result in larger food supply deficits, which will not drop until after 2010.

- The opposite is true in France. Due to the large amount of agricultural land, as in Germany, there is considerable fallow land that must be set aside and substantial surpluses of all market regulation crops, which are exported and would potentially be available for bioenergy sources. Continuing increases in yield and moderate increases in population and food consumption result in similar potential for bioenergy sources as in Germany in percentage terms. This potential is much higher in absolute terms, however.

- Italy, the Netherlands, Belgium-Luxembourg and Greece are less important for biomass potential.

- Spain is another special case with especially high potentials for land to be made available for bioenergy sources even though there was almost no available potential in the basis. This is due to stagnating population growth and a sharp increase in expected yields. Reported increases in yields in Spain the past few years, which are the same in all statistics, can be compared to the average yield of cereals of 3.2 t/ha. In absolute terms, annual increases in yield are as high as in Germany with growth of only 1.5 compared to 3% per year. Figures for Spain show that 58% of land or 17.4 million ha can be made available for bioenergy sources in 2020. Even such high figures seem plausible. In 2020 the average cereal yield in Spain will have climbed from 3.2 to around 5 – 5.5 t/ha, whereas the average yield in Germany will be around 7.5 t/ha. In the basis 40 million people are fed from just less than 30 million ha of agricultural land in Spain while 82 million people were fed from 17 million ha of agricultural land in Germany with a similar degree of self-sufficiency. In 2020, Germany will still require around 10 million ha to feed 82 million people, and in Spain 12 million ha will be available for less than half of the population of Germany. At 3.3 million ha, the existing fallow land in the basis is especially high in Spain. This is due to the current difficult natural conditions and the mandatory amount of land that must be set aside, which is over 1 million ha in Spain. Aside from stronger competing aims of nature conservation in future, we can assume that a considerable share of this fallow land can technically be made usable for bioenergy sources if all logical alternatives for extensive use including afforestation are considered.

- Denmark also has a comparatively high level of potential land for bioenergy sources. In the basis, a relatively high amount of agricultural land (2.6 million ha) is available for a small population (5.3 million people). By reducing surpluses in milk production, Denmark could free up an overproportional amount of land for bioenergy sources. If almost 40% is made available for bioenergy sources in 2020 and only 60% or 1.6 million ha of agricultural land is sufficient for feeding just over 5 million people, we can see once again the relationship between the amount of land required for agricultural use to produce food and the population, as demonstrated in Germany and other industrialised countries in the EU.

- The calculations for Ireland also show extremely high potentials. Ireland has the highest agricultural surpluses in relative terms based on the population. It produces primarily subsidised animal products, which are considered potential area for bioenergy sources in our method. If we project for 2020 that around 50% of the available agricultural area from the basis could be redesignated to use by bioenergy sources and just 50% is required for food supply, 2.2 million ha would still be available to feed 4 million people, which is not surprising given the excellent climate and high productivity of the agricultural sector.

- The results for the EU-15 countries, which only record exports to non-EU countries, reflect the partial results of surplus and deficit countries. If the exchange of goods within the EU does not change, an additional potential for biomass production of over 10 million ha is available in the basis, around 22 million ha in 2010 and around 45 million ha in 2020. In particular the arguments listed in the discussion of results for Germany and the particularities for the individual countries, which show arguments both for an underestimate and for an overestimate, help put this estimate into relative terms. Even if there are arguments pointing to a considerable amount of agricultural land in the period under consideration being redesignated in full to nature conservation, if 10% is redesignated in 2020, there would still be potential land of over 30 million ha for producing bioenergy sources, for set-asides, for subsidised exports or for use in the domestic market.

- Of the new member states the potentials in the small countries of Cyprus and Malta cannot be explained in full without further research, but the potentials of these countries are irrelevant for the absolute potentials.

- The potential land that can be made available for bioenergy sources is noticeably high in the Baltic countries and Hungary, which show high yield growth rates and a low absolute level of yield, decreasing population and a comparatively large area with agricultural land. Even in Lithuania where 3.5 million ha of agricultural land was available for feeding 3.5 million people in the basis, around 900,000 ha will still be available in 2020 for preparing food products, which is still a large amount of area when compared to other countries.

- The large amount of potential land for bioenergy sources in Poland is also of note. This is due to the large areas that became fallow in the transformation process. Trends show this land being put back into production due to direct payments following EU accession. The statistics show comparatively high yield progress in the final phase of the transformation process, which results in more land being made available for bioenergy sources. The estimated 5 million ha of potential land in 2020 is therefore a cautious figure. Whether all of the fallow land in the basis should be considered as technical potential for biomass in the calculations can be questioned, given the comparatively high value as nature conservation areas in some cases.

- Of the candidate countries Turkey does not have any important potential for bioenergy sources given its strong population growth and the expected increase in per capita consumption over the long term. As agricultural countries with decreasing populations, Bulgaria and Romania show greater potentials for bioenergy sources, especially following EU accession.

The potential available land for bioenergy sources in the different EU member states and candidate countries consists of different proportions of grassland and arable land. As the data in Table 23 show, in countries where agricultural land use dominates, the area that can be made available for producing bioenergy sources is almost exclusively arable land.

For example, the grassland that can be made available in Germany is comparatively low both in relative and absolute terms. This also applies for France, Spain and Denmark. In countries where grassland dominates, in some cases more than two-thirds of the potential land that can be made available for bioenergy sources consists of grassland, for which only limited production alternatives exist. These countries include Ireland, Austria, the Netherlands and Great Britain.

Table 23: **Grassland made available for bioenergy sources and total by country**

Country	Land release and grassland share for bioenergy sources					
	Basis		2010		2020	
	total ha	thereof grassland ha	total ha	thereof grassland ha	total ha	thereof grassland ha
Germany	2.409.302	353.178	4.543.325	998.927	7.300.886	1.745.618
Great Britain	-1.841.626	-1.564.700	-2.703.560	-1.704.503	-1.568.179	-1.176.368
France	6.722.083	332.236	7.629.654	704.716	11.214.504	1.850.498
Italy	-2.652.431	-1.136.467	-2.280.070	-1.031.078	-132.652	-465.587
Spain	652.192	18.032	8.145.458	1.764.751	17.363.878	3.879.522
Netherlands	-308.240	311.124	-198.557	343.867	70.630	424.691
Belgium/Luxembourg	-620.472	-8.330	-307.198	110.958	54.895	231.060
Greece	-26.126	-777.158	-604.295	-782.900	-37.576	-674.569
Portugal	-1.312.674	-311.703	-112.259	116.567	1.335.635	587.219
Sweden	389.115	-23.192	346.555	-22.019	508.645	-4.483
Austria	347.843	168.773	409.372	268.641	817.048	484.123
Denmark	737.888	76.685	726.583	69.080	1.063.183	85.010
Finland	388.344	6.290	306.668	6.401	429.084	7.539
Ireland	1.492.239	1.543.352	1.747.281	1.666.733	2.253.293	2.022.054
EU-15[2)]	**10.737.522**	**867.728**	**21.943.932**	**4.227.585**	**45.027.911**	**11.176.923**
Cyprus	-329.446	-129	-411.437	-742	-481.882	-1.333
Czech Republic	528.230	106.145	890.254	184.553	1.446.831	281.858
Estonia	-1.094	12.104	164.797	43.697	326.307	67.034
Hungary	1.187.649	68.709	2.406.215	313.636	3.751.584	539.677
Latvia	152.965	15.897	745.455	193.791	1.337.538	332.127
Lithuania	703.491	281.743	1.614.814	550.245	2.621.052	826.796
Malta	-46.590	0	-50.028	0	-52.200	0
Poland	1.898.375	160.678	3.050.733	579.147	5.054.230	878.267
Slovakia	132.973	59.914	380.209	138.328	659.883	212.196
Slovenia	-14.623	43.287	-32.570	34.067	-21.122	40.897
EU-25[2)]	**14.445.153**	**747.682**	**30.009.163**	**5.009.717**	**59.249.232**	**13.159.127**
Bulgaria	817.886	-14.418	1.304.019	224.099	2.120.113	476.137
Romania	285.104	-26.626	1.434.611	615.795	3.424.658	1.272.361
Turkey	-742.840	-89.048	570.522	-488.892	823.172	-173.535

1) positive number indicates release of land for bioenergy sources, negative number indicates additional area requirement for food production
2) doesn't correspond to the balance from countries in all columns, due to different data sources, and inexactness of data

For the EU-15 countries, the proportion of grassland made available is 8% in the basis, around 20% in 2010 and around 25% in 2020.

In the new member states, the share of grassland made available for bioenergy sources is overproportionally high in the Baltic countries of Latvia and Lithuania. Of the acceding countries the share of land that can be made available for bioenergy sources made up by grassland is comparatively high in Romania.

Sensitivity analysis

As already mentioned in other sections, the methodology used for estimating bioenergy potentials contains several assumptions. Some of the assumptions have a considerable effect on the results. They are therefore analysed for sensitivity in the following. The results of the sensitivity analysis are listed in detail for all variants in appendix E. This section only comments on the results using the following. See also Figure 15.

Table 24: **Total land made available for bioenergy sources and grassland portion in different scenarios[1)]**

Scenario Country	Land release and grassland share for bioenergy sources					
	Basis		2010		2020	
	total ha	thereof grassland ha	total ha	thereof grassland ha	total ha	thereof grassland ha
Standard Model						
Germany	2.409.302	353.178	4.543.325	998.927	7.300.886	1.745.618
EU-15	10.737.522	867.728	21.943.932	4.227.585	45.027.911	11.176.923
EU-25	14.445.153	747.682	30.009.163	5.009.717	59.249.232	13.159.127
Increasing potential						
I 1: cereals, rapeseed, sunflower and beet need not be extended to the point of self-sufficiency						
Germany	2.720.167	353.178	4.854.190	998.927	7.611.751	1.745.618
EU-15	11.729.724	867.728	22.936.134	4.227.585	46.020.113	11.176.923
EU-25	15.119.556	747.682	30.683.567	5.009.717	59.923.636	13.159.127
I 2: as for 1; milk and beef need not to be extended to the point of self-sufficiency						
Germany	2.720.167	353.178	4.854.190	998.927	7.611.751	1.745.618
EU-15	11.729.724	867.728	22.936.134	4.227.585	46.020.113	11.176.923
EU-25	15.558.738	747.682	31.122.749	5.009.717	60.362.818	13.159.127
I 3: as for 2, increased/decreased food production only applies to the share of self-sufficiency in production						
Germany	2.720.167	353.178	4.810.931	998.927	7.572.491	1.745.618
EU-15	11.729.724	867.728	24.219.126	4.227.585	47.422.596	11.176.923
EU-25[2)]						
Reducing potential						
II 1: potential release of fallow land reduced by 30%						
Germany	2.150.805	353.178	4.284.828	998.927	7.042.389	1.745.618
EU-15	8.305.273	867.728	19.511.682	4.227.585	42.595.662	11.176.923
EU-25	11.271.064	747.682	26.835.074	5.009.717	56.075.143	13.159.127
II 2: as for 1; yield increase only applies to agricultural land						
Germany	2.150.805	353.178	3.493.643	241.157	5.460.020	230.080
EU-15	8.305.273	867.728	8.780.235	-2.963.663	19.348.062	-4.401.522
EU-25	11.271.064	747.682	14.284.488	-3.728.798	29.064.877	-5.647.135
II 3: as for 2; 2010 5%, 2020 10% redesignation of agricultural land as nature conservation areas						
Germany	2.150.805	353.178	2.814.065	241.157	3.421.284	230.080
EU-15	8.305.273	867.728	4.486.880	-2.963.663	6.270.761	-4.401.522
EU-25	11.271.064	747.682	8.299.432	-3.728.798	10.853.282	-5.647.135
Combination						
III: increased/decreased food production only applies to the share of self-sufficiency in production [3)]; potential release of fallow land reduced by 30%; yield increase on grassland 50%; 2010 2,5%, 2020 5% redesignation of agricultural land as nature conservation areas						
Germany	2.150.805	353.178	3.489.480	620.042	5.159.161	987.849
EU-15	8.305.273	867.728	11.512.174	631.961	22.001.116	3.387.700
EU-25	11.271.064	747.682	15.661.217	640.459	29.362.210	3.755.996

1) positive number indicates release of land for bioenergy sources, negative number indicates additional area requirement for food production

2) Calculation not possible due to lack of data from new member countries

3) not for the new member countries and EU-25

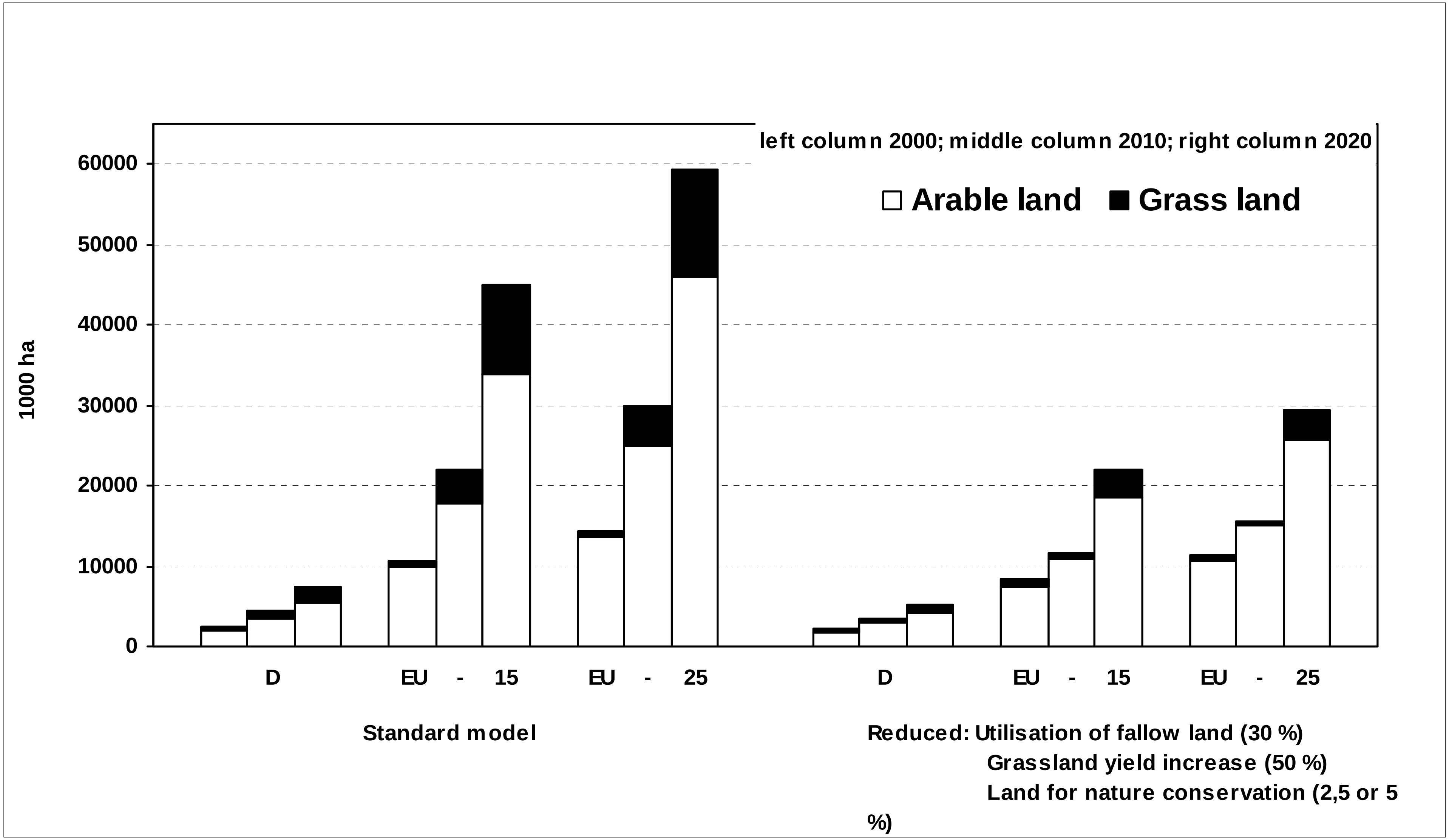

Figure 15: **Technical potential for bioenergy sources in ha of area in Germany, EU-15 and EU-25 countries (2000 – 2010 – 2020)**

Variants that increase potential:

- **Variant I.1**: Countries importing sunflower and rapeseed are not forced to expand production to become self-sufficient. These products will continue to be imported. Compared to the standard variant, which reports around 2.4 million ha of land that can be made available in Germany and 10.7 million ha in EU-15 countries in the basis, this variant shows a slight increase in potential to 2.7 and 11.7 million ha. The change is small because the EU-15 countries' imports of market regulation products are comparatively insignificant. Potential land that can be made available for bioenergy sources increased to the same degree for 2010 and 2020. This variant has greater effects on the potentials of Spain and Portugal to make land available because these countries import considerable amounts of these market regulation products.
- **Variant I.2**: Countries that import milk, dairy products and beef are not forced to extend production to become self-sufficient. They will continue to import these products. The results of this variant have an even lower effect on potentials for bioenergy sources for Germany and for the EU as a whole because imports of milk, dairy products and beef are largely offset for the EU. EU member states with a high import demand for milk, dairy products and beef such as Great Britain and Italy show a notable increase in land available for bioenergy sources.
- **Variant I.3**: In the standard variant, the rates of change in food consumption and in agricultural production through 2010 and 2020 were balanced without considering the self-sufficiency degree. This is only correct for 100% self-sufficiency. Unlike in the standard variant, the rate of change of area in variant 3 is calculated taking the degree of self-sufficiency of food production of the respective country into account (the share of domestic production covered by domestic consumption). In countries with an agricultural surplus, this results in greater amounts of land that can be made available for bioenergy sources than in the standard variant. In countries that import, less land can be made available for bioenergy sources.

Variants that decrease potential:

- **Variant II.1**: Fallow land (only the land set aside due to annual rotation) is calculated as potential land for bioenergy sources at 70% instead of at 100%. This should roughly take into account that leaving fallow land out of rotation results in higher yields for the first and even subsequent crops and that land is taken out of rotation for sites with lower yield. The results of the calculations in the basis are very different than those in the standard variant as the considerable potential land that can be made available for bioenergy sources in the basis consists primarily of fallow land used for production. In this variant the amount of land available for bioenergy sources decreases by around 2.5 million ha to 8.3 million ha. In 2010 and 2020 the potential is also around 3 million ha less than in the standard variant. The amount of grassland made available does not change.

- **Variant II.2**: The increases in yield derived from the crops of arable land, which also apply to permanent grassland in the standard variant, are applied to agricultural land with the result that no increases in yield are assumed for permanent grassland. The results of the sensitivity analysis show that this very pessimistic assumption results in much lower potential land for bioenergy sources in 2010 and 2020 compared to the standard variant. The potential for the EU-25 countries drops from around 30 million to 14 million ha in 2010 and from around 60 million ha to 29 million ha in 2020. The amount of grassland made available for bioenergy sources is lower as expected.
- **Variant II.3**: By 2010 5% of agricultural land and by 2020 10% of the total agricultural land will be taken out of agricultural production for nature conservation and other purposes. This variant assumes no yield for food and bioenergy production for this area. Further redesignation of agricultural land to nature conservation and other purposes considerably reduces the amount of land that can be made available for bioenergy sources with the result that in 2010, adding all assumptions that would result in decreased potential, only around 4.5 million ha is reported for bioenergy sources and in 2020 only 6.3 million ha.

In all, the sensitivity analysis shows that the above variants that would increase potential compared to the standard variant show only a comparatively slight increase in potential for bioenergy sources. The variants that would result in lower potential, however, have a much greater affect on the potential for bioenergy sources. The assumption that fallow land could only contribute 70% of the potential of average land reduces the total potential for bioenergy sources only by just under 4% in Germany compared to the standard variant but by just under 6% in the EU-15 countries. The greatest influence on potential for bioenergy sources results from the assumption that grassland yields cannot increase at all due to the natural potential, demand for milk and beef and bans on redesignating grassland. Compared to the variant discussed earlier, the potential for bioenergy sources in Germany is reduced by almost 30%

from around 7 to 5.5 million and by much more than half from 42.6 million to 19.3 million in the EU-15 countries. Just as important is the assumption that by 2010 5% and by 2020 10% of arable land could be redesignated to nature conservation areas, which would assume zero yield for food and energy production for the redesignated land. Similarly this potential for redesignation would be sufficient to compensate for 25–30% organic farming by 2020. As a result, the potential for bioenergy sources in Germany would drop by an additional 60% compared to the previous variant and from 19.3 to 6.3 million ha for the EU-15 countries. In short, potential ranges from 7.6 million ha to 3.4 million ha for Germany and from 47 million to 6 million ha for the EU-15 countries.

3.3.4 Scenarios of realistic potential development

To limit the results to a realistic range, we examine the assumptions taking into account the probability of their occurrence. The aim is to define two realistic end point scenarios between which future development will likely occur. These end point scenarios are described as the Current Policy (CP) and Environmental scenario (E+) in the following.

3.3.4.1 Current Policy scenario (CP)

The Current Policy scenario is the standard variant (Table 24). It applies for the conditions already defined by agricultural and energy policy, as they are used to calculate estimates of the technical potential through 2020.

If, contrary to the CP assumptions, demand for bioenergy sources in individual EU member states or in the entire EU domestic market were to increase, the countries would not switch over to producing products that they had previously imported and that are traded on the global market for which they do not have a comparative cost advantage. The trend would actually be to increase imports of these products. Scenarios that would increase potential are thus not illusory but not possible under CP assumptions.

3.3.4.2 Environmental scenario (E+)

The scenarios that would decrease potential assume that fallow land in rotation could not be evaluated at 100% potential for bioenergy sources. The assumption in variant II.1 that it would be counted as area for bioenergy sources at 70% is rather pessimistic, however. It is highly unrealistic that yield would only increase on arable land. Particularly the large number of countries that will have to rely on intense use of grassland in future due to increases in population and demand for milk and beef will have to anticipate increasing yields. As in variant II.3, the assumption that up to 10% of arable land will be redesignated for nature conservation and more extensive use by 2010 is not realistic. It may be plausible for some member states or regions within member states but seems unlikely for the entire EU. The E+ scenario is a more likely scenario as the minimum for technical potential.

These considerations along with a combination of different variants have let us quantify an expected Environmental scenario that is highly probable. We have assumed variants I.3 and II.1, the increase in grassland yield of 50% of agricultural land from variant II.2, and the redesignation of 2.5% of available agricultural land by 2010 and 5% redesignation by 2020 from variant II.3. The results (Table 24, variant III) show that a considerable potential for bioenergy sources can be expected under these assumptions: over 5 million in Germany, 22 million in the EU-15 countries and almost 30 million ha in the EU-25 countries in 2020. Grassland accounts for 1 million ha of the land made available in Germany, 3.4 million in the EU-15 countries and approximately 3.8 million in the EU-25 countries. The results for the individual countries are shown in detail in Table 25 in the following.

Table 25: Grassland made available for bioenergy sources and total by country, E+ variant[1]

Country	Released area and grassland share for bioenergy sources					
	Basis		2010		2020	
	total ha	thereof grassland ha	total ha	thereof grassland ha	total ha	thereof grassland ha
Germany	2.150.805	353.178	3.489.480	620.042	5.159.161	987.849
Great Britain	-1.852.641	-1.564.700	-4.595.956	-2.103.854	-5.188.396	-2.174.746
France	6.333.756	332.236	6.234.044	152.863	7.859.289	551.399
Italy	-2.853.961	-1.136.467	-3.483.572	-1.249.493	-2.529.965	-1.011.624
Spain	-342.532	18.032	3.062.570	694.582	7.510.622	1.739.183
Netherlands	-316.680	311.124	-273.563	300.552	-133.353	316.403
Belgium/Luxembourg	-629.081	-8.330	-414.636	53.688	-178.076	116.520
Greece	-167.520	-777.158	-1.855.162	-872.350	-2.136.137	-898.194
Portugal	-1.481.489	-311.703	-1.089.644	-91.909	-278.940	170.266
Sweden	309.629	-23.192	157.823	-51.938	129.841	-66.467
Austria	316.135	168.773	235.945	172.771	407.809	244.449
Denmark	680.755	76.685	670.954	59.883	856.823	62.018
Finland	327.301	6.290	190.656	5.121	186.056	4.339
Ireland	1.486.473	1.543.352	1.609.961	1.425.595	1.861.984	1.538.443
EU-15[2]	**8.305.273**	**867.728**	**11.512.174**	**631.961**	**22.001.116**	**3.387.700**
Cyprus	-331.666	-129	-403.786	-622	-465.883	-1.091
Czech Republic	494.936	106.145	697.452	139.380	964.787	168.926
Estonia	-10.012	12.104	108.272	24.097	199.067	27.834
Hungary	1.095.457	68.709	1.947.544	154.689	2.776.610	221.784
Latvia	261.251	15.897	706.261	112.584	1.092.640	169.714
Lithuania	655.738	281.743	1.450.866	404.182	2.245.652	534.671
Malta	-46.665	0	-50.441	0	-53.261	0
Poland	1.331.628	160.678	1.752.479	343.001	2.563.167	369.007
Slovakia	129.703	59.914	277.921	97.927	385.596	111.196
Slovenia	-14.820	43.287	-63.081	13.002	-89.358	-3.245
EU-25[2]	**11.271.064**	**747.682**	**15.661.217**	**640.459**	**29.362.210**	**3.755.996**
Bulgaria	676.742	-14.418	955.075	135.142	1.403.417	253.745
Romania	119.644	-26.626	712.786	368.335	1.715.639	653.710
Turkey	-742.840	-89.048	-1.462.446	409.197	-4.018.479	754.740

1) Positive number indicates release of land for bioenergy sources, negative number indicates additional area requirement for food production
2) Doesn't correspond to the balance from countries in all columns, due to different data sources, and inexactness of data

In Germany and in the EU-15 and EU-25 countries as a whole, the potential in the different scenarios can differ by up to 50%.

3.4 Economic potential for bioenergy sources under given and future expected conditions

The term “economic potential for bioenergy sources” in the following refers to the part of the technical potential that can be produced economically under given agricultural policy conditions. The additional supply of agricultural products compared with the basis is estimated for 2010 and 2020. The supply can be used to cover additional food demand, used as bioenergy sources, subsidised for export or used for domestic applications. The following section first estimates trends in the supply of agricultural products under agreed policy conditions and taking into account continuing progress in yield, changing competitiveness of production methods and related substitutions. The results of this supply projection are based on the production structure in the basis in 2000 and show its change following implementation of agricultural policy in 2010 and 2020. To enable these results to be compared with the previous estimates of technical potential for bioenergy sources, changes in food demand, land redesignation and improved feed conversion included in the technical potential estimate are taken into account exogenously.

3.4.1 Methodology for determining the economic potential for bioenergy sources

The estimate of economic supply potentials from agriculture is currently limited to the EU-15 countries due to the availability of data. It is based on models of representative operations. It is based on current legal and policy conditions and specifies the agricultural reform resolutions that must be implemented for operations aiming to maximise profits. The results refer to the end of the reform period around 2010 and to 2020 by extrapolation. Five-year averages (1998 – 2002) of operating results from returning holdings are used for the reference period. The estimate takes into account increases in yields that are used in policy evaluation models (CAPSIM). Increases are between 1.0 and 2.0% and on average not as high as the yield increases assumed for the estimate of technical potential. The economic potential estimate scenario assumes that current agricultural policy, which focuses almost exclusively on food supply, will be continued. In addition to energy yield, numerous quality parameters apply that will reduce the quantity of yields. In contrast, the technical estimate of potential assumes that the share of agricultural area used for bioenergy sources will be utilised systematically for selected cultivars and species that would result in much higher energy yields.

Prices for agricultural products are specified according to agricultural reform resolutions, and direct payments will be eliminated completely or partially by 2010 and 2020 according to national implementing regulations of the member states. Price increases for resources are based on past trends and on average correspond to the inflation rate. For future sugar market regime reforms, we have assumed that the current proposals of May 2005 will be implemented by 2010.

The model data[16] consist of a sample from returning holdings. The sample covers around 1 – 3% of the operations. Contribution margins for all production methods of crops are integrated for each sample operation. Each individual operation is formulated as an operating model. For each change in prices or quantities, a comparison of the contribution margin determines the new production assuming the aim is to maximise profit. Production methods can only be expanded or restricted to a certain extent by defining crop rotation limits. As a result, a single cultivar cannot take up more than 70% of the agricultural land. This applies to wheat and maize only. Beets and rapeseed combined cannot take up more than 33% of the agricultural land. As competition for energy crops, speciality crops are limited in scope by demand quantities and other restrictions. Demand for potatoes is inelastic and changes in most EU-15 countries only in as much as the population changes. Consequently, if potato yield continues to increase, land redesignation must be adjusted to demand, especially as potatoes can be used to some extent as bioenergy sources but are not competitive with other energy crops. The operating model definition specifies that energy crops can only be replaced with other crops that have the same high level of soil and climate demands. As Grandes Cultures are expanded, land that is set aside must also be expanded. We have assumed 10% of land to be set aside for 2010 in line with agricultural reform decisions.

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[16] The sugar market regime passed on 24 November 2005 will result is slightly different prices for sugar and sugar beets than those proposed by the Commission, which are used in the calculations. This has no significant effect on the results.

3.4.2 Supply potentials for bioenergy sources in light of changing policy conditions

The methods for estimating potential described above are based on the given technical conditions (technical potential) or the given policy conditions and clearly defined policy conditions for the future for the given technology (economic potential). They do not take into account the supply potentials mobilised for bioenergy sources if for example policies promoting energy crop cultivation or technical innovations in the use of bioenergy cause price increases for potential energy crops due to demand under equal political conditions. The supply-side reaction for bioenergy sources is demonstrated in the following using selected case studies for a quantitative estimate of these types of potential.

These types of examinations are not theoretical exercises. Recent developments have shown that policy decisions supporting introduction of renewable energies onto the market has also increased the demand for certain agricultural products, stabilising or increasing prices and encouraging production. An example is the cultivation of rapeseed for producing biodiesel and silage maize, which is a co-substrate for producing biogas. The following section analyses three measures:

- ➢ eliminating mandatory set-aside of land
- ➢ systematic promotion of ethanol beet cultivation
- ➢ systematic promotion of all energy crops

The analysis assumes each measure is applied for the EU as a whole.

A decision by the EU Council of Ministers would eliminate compulsory set-aside and could be implemented over the short term.

Targeted promotion of ethanol beet cultivation can be implemented in the context of the sugar market regime. According to the EU decisions, a production levy of €126.40 per t sugar (in 2006/07, €173.30 per t and €113.30 per t in the following years), will be charged for sugar production for the food market by all producers in the EU-25 countries. Sugar companies can claim a one-time payment for ceasing production of €730 per t sugar (€625 or €520 per t) from this fund. Sugar companies can redesignate entire factory sites or parts of sites for ethanol production and depending on the geographical location, produce ethanol from sugar beets around 100 days per year and from cereals the rest of the year. The non-marketing premium of €730 per t sugar, which is equivalent to around €104 per t of sugar beets, offers a high incentive to convert to ethanol production. This would enable positive employment effects, prevent destruction of capital when factories close and create economic advantages for sugar companies in the CO_2 certificate trade. According to the sugar industry, producing ethanol from sugar beets can achieve utilisation of around €10 – 15 per t of beets. A difference of €5 – 10 per t of sugar beets would have to be paid for the redemption price for sugar beets for sugar production (€30 per t) as a financial incentive from the EU’s structure support plan. Only under those or similar conditions would the high-energy sugar beet be preferred over cereals for ethanol production. This would also ensure that eliminating the mineral oil tax would not be at the expense of production from domestic resources and not from imported agricultural products or bioenergy sources that can be traded around the world (such as cereals and rapeseed for biofuel or bioethanol from Brazil).

A further scenario assumes that the efficiency of economic conditions for burning cereal plants (grain and straw) would be increased such that 50% of the cereal price would be offered at the local level for the energy value of straw. At a grain/straw ratio of 1:0.8 an additional €40 per 1 t of cereal grain yield would be paid for straw to enable €140 t of wheat to be paid for energy use of grain and straw at the current wheat price of €100 per t. At an average yield of 7 t of wheat per ha, this would equal an increase in returns for use of the entire plant of €280 per ha. This scenario is realistic in terms of expectations of new technologies to produce BTL and in the case of trading CO_2 certificate values on payment to the manufacturer of the bioenergy sources.

The calculation therefore assumes a 40% higher conversion yield per t of grain yield for whole plants from wheat, barley, rye, oats and maize based on the effective cereal price. The calculation permits cultivation of ethanol beets at a price of €25 per t to test whether whole plant cereals would drive ethanol beets and oleaginous fruits out of production at corresponding economic use.

3.4.3 Results of estimates of economic potential

The results of the comprehensive calculations refer to the production volumes by sector in FAO statistics (not to those of the selected operations). The tables show only crops that can be used as energy sources. Crops are aggregated using the area and production volume with individual crops weighted according to the grain equivalent definition. Volumes of cereal types and protein crops are multiplied by 1, oleaginous fruits by 1.7, beets by 0.25 and potatoes by 0.2. We can expect production to increase under the expected economic conditions by comparing results from the basis to 2010 and 2020. Unlike in 2010, yield trends and resource prices are extrapolated for 2020, and we assume that the policy conditions for agricultural production will not change at all after 2010 due to a lack of information. Interpretations of the data for 2020 must take these deficiencies into account.

3.4.3.1 Germany

The first scenario examines production development that would be expected if no measures increasing biomass were taken. The data in Table 26 (with compulsory set-aside) clearly indicate that wheat cultivation in Germany will continue to become more competitive and increasingly displace barley due to overproportional increases in yield. Rye will become more competitive at better sites, and grain maize will become predominant in favourable areas. Rapeseed will reach its limits in favourable areas. Sugar beet cultivation must be adjusted to the provisions of the future sugar market regime, and potato area will be adjusted in line with demand due to the continuing increase in yields. Compulsory set-aside will vary according to the scope of cultivation of market regulation crops.

The supply volume, expressed in grain equivalents, will continue to grow under the given policy conditions from around 59 to 69 million t from the basis to 2010, or by around 1.7% per year. This trend will continue at about the same rate when we extrapolate the results for 2020.

Table 26: **Potential of area and production volumes for bioenergy source**
Scenario: compulsory set-aside 10%

Country	Ø 1998 - 2002		2010		2020	
	Area thousand ha	Quantity thousand t	Area thousand ha	Quantity thousand t	Area thousand ha	Quantity thousand t
Germany						
Wheat	2.856,87	21.016,00	3.121,14	27.175,83	3.253,93	33.534,13
Rye	816,52	4.411,31	1.109,00	7.232,25	1.148,18	9.038,52
Barley	2.108,70	12.468,39	1.338,70	9.006,89	1.304,37	9.985,91
Oats	247,08	1.174,54	205,32	1.178,18	228,74	1.584,35
Grain maize	373,58	3.321,08	645,20	6.991,89	680,49	8.989,22
Pulses	178,84	595,74	58,10	220,23	57,17	246,55
Rapeseed	1.143,58	3.853,06	1.390,11	5.382,31	1.282,77	5.707,52
Sunflower	28,76	70,36	76,81	195,57	64,76	171,59
Land set-aside[1]	749,29	0,00	745,82	0,00	752,02	0,00
Ethanol beet	0,00	0,00	0,00	0,00	0,00	0,00
Sugar beet	470,33	26.751,83	326,47	20.512,29	283,99	19.710,17
Potato	295,36	12.169,15	252,22	12.299,36	212,48	12.264,07
Total	**9.268,90**	**85.831,44**	**9.268,90**	**90.194,80**	**9.268,90**	**101.232,01**
Total in grain equivalent		**58.778,63**		**68.875,62**		**80.753,52**

1) according to FADN

Source: FAOSTAT; own calculations

If the calculation results are compared assuming that land does not have to be set aside (Table 27), almost all of the land that had to be set aside in the reference period is used for production in 2010. It would be used primarily for cultivating wheat, rye and grain maize. This results in an increase in supply in 2010 of 15.85 million t of grain equivalents over the basis in 2000, which is equivalent to annual growth of around 2.7%. The supply potential could be increased considerably if future conditions of the sugar market regime would create an additional financial incentive to cultivate ethanol beets. The incentive would have to be high enough to enable a price of €25 per t of ethanol beets and operations that previously did not cultivate beets to convert to ethanol beets (Table 28). In 2010 German agriculture would be able to cultivate up to 1.3 million ha of ethanol beets in addition to 324,000 ha of beets for sugar production, reaching crop rotation limits in many areas where beets are cultivated. Around 80 million hl of ethanol could be produced from 80 million t of ethanol beets, which would be three times the target of 5.75% petrol fuel. The supply potential of German agriculture in grain equivalents would increase from 59 million in the basis to 85 million t, which is equivalent to a 44% annual increase. The estimates clearly demonstrate the potentials of domestic resources. At present, investors currently consider using cereal to produce ethanol or using ethanol from sugar cane from abroad as more economical. The calculations show that ethanol beets are economically efficient even at a €20 per t at many sites for approximately 1 million ha, while at €30 per t ethanol beets reach their limits at 1.7 million ha.

Table 27: Potential of area and production volumes for bioenergy sources
Scenario: without set-aside

Country	Ø 1998 - 2002		2010		2020	
	Area thousand ha	Quantity thousand t	Area thousand ha	Quantity thousand t	Area thousand ha	Quantity thousand t
Germany						
Wheat	2.856,87	21.016,00	3.121,14	27.175,83	3.253,93	33.534,13
Rye	816,52	4.411,31	1.109,00	7.232,25	1.148,18	9.038,52
Barley	2.108,70	12.468,39	1.338,70	9.006,89	1.304,37	9.985,91
Oats	247,08	1.174,54	205,32	1.178,18	228,74	1.584,35
Grain maize	373,58	3.321,08	645,20	6.991,89	680,49	8.989,22
Pulses	178,84	595,74	58,10	220,23	57,17	246,55
Rapeseed	1.143,58	3.853,06	1.390,11	5.382,31	1.282,77	5.707,52
Sunflower	28,76	70,36	76,81	195,57	64,76	171,59
Land set-aside[1]	749,29	0,00	745,82	0,00	752,02	0,00
Ethanol beet	0,00	0,00	0,00	0,00	0,00	0,00
Sugar beet	470,33	26.751,83	326,47	20.512,29	283,99	19.710,17
Potato	295,36	12.169,15	252,22	12.299,36	212,48	12.264,07
Total	**9.268,90**	**85.831,44**	**9.268,90**	**90.194,80**	**9.268,90**	**101.232,01**
Total in grain equivalent		**58.778,63**		**68.875,62**		**80.753,52**

1) according to FADN
Source: FAOSTAT; own calculations

Table 28: Potential of area and production volumes
Scenario: without set-aside, cultivation of ethanol possible for sugar beet operations at €25 per t

Country	Ø 1998 - 2002		2010		2020	
	Area thousand ha	Quantity thousand t	Area thousand ha	Quantity thousand t	Area thousand ha	Quantity thousand t
Germany						
Wheat	2.856,87	21.016,00	2.831,73	24.655,89	2.910,66	29.996,47
Rye	816,52	4.411,31	1.063,55	6.935,87	1.151,28	9.062,88
Barley	2.108,70	12.468,39	1.208,39	8.130,11	1.133,24	8.675,75
Oats	247,08	1.174,54	218,68	1.254,85	245,47	1.700,24
Grain maize	373,58	3.321,08	615,90	6.674,29	657,56	8.686,30
Pulses	178,84	595,74	62,33	236,25	61,75	266,32
Rapeseed	1.143,58	3.853,06	1.321,04	5.114,87	1.260,63	5.609,01
Sunflower	28,76	70,36	61,76	157,24	53,43	141,58
Land set-aside[1]	749,29	0,00	19,82	0,00	25,37	0,00
Ethanol beet	0,00	0,00	1.289,42	81.014,04	1.276,29	88.579,00
Sugar beet	470,33	26.751,83	324,08	20.361,90	280,74	19.484,56
Potato	295,36	12.169,15	252,22	12.299,36	212,48	12.264,07
Total	**9.268,90**	**85.831,44**	**9.268,90**	**166.834,67**	**9.268,90**	**184.466,19**
Total in grain equivalent		**58.778,63**		**84.653,73**		**97.632,69**

1) according to FADN
Source: FAOSTAT; own calculations

If we assume even cereals and grain maize can be fully used for bioenergy sources (using both grain and straw), which increases product prices by 40% based on grain yield, we have the production effects shown in Table 29. Cultivation of ethanol beets (price base €25 per t) will be limited considerably by the competitive cereals wheat, rye and grain maize. Rapeseed would also become less competitive, and land for rapeseed would be reduced. Total production in grain equivalents, not including the use of straw for energy use since it is recorded in the residue balance, increases only slightly compared to the alternatives without a price increase with cultivation of ethanol beets. We can therefore conclude that the supply potential of agriculture in this scenario is largely exhausted due to the policy measures.

Table 29: **Potential of area and production volumes**
Scenario: without set-aside, cultivation of ethanol possible for sugar beet operations at €25 per t, cereal price + 40%

Country	Ø 1998 - 2002		2010		2020	
	Area thousand ha	Quantity thousand t	Area thousand ha	Quantity thousand t	Area thousand ha	Quantity thousand t
Germany						
Wheat	2.856,87	21.016,00	3.457,56	30.104,99	3.604,86	37.150,66
Rye	816,52	4.411,31	1.181,46	7.704,83	1.290,92	10.162,13
Barley	2.108,70	12.468,39	1.432,02	9.634,75	1.322,34	10.123,48
Oats	247,08	1.174,54	248,11	1.423,70	281,64	1.950,81
Grain maize	373,58	3.321,08	714,29	7.740,55	794,86	10.500,03
Pulses	178,84	595,74	25,62	97,11	24,85	107,16
Rapeseed	1.143,58	3.853,06	556,49	2.154,65	517,16	2.301,03
Sunflower	28,76	70,36	33,20	84,53	23,08	61,14
Land set-aside[1]	749,29	0,00	6,51	0,00	7,69	0,00
Ethanol beet	0,00	0,00	1.089,29	68.440,38	975,08	67.673,97
Sugar beet	470,33	26.751,83	272,12	17.097,61	213,95	14.848,72
Potato	295,36	12.169,15	252,22	12.299,36	212,48	12.264,07
Total	**9.268,90**	**85.831,44**	**9.268,90**	**156.782,44**	**9.268,90**	**167.143,17**
Total in grain equivalent		**58.778,63**		**84.356,90**		**97.093,43**

1) according to FADN
Source: FAOSTAT; own calculations

The results of the scenario calculations for Germany show that systematically promoting certain bioenergy sources results in considerable substitutions that can noticeably increase supply potential. The results must be qualified: only part of land used to cultivate cereals can be used to produce whole plants for bioenergy because there would be no widespread demand due to transport sensitivity and regional supply of some important cereals must be retained.

3.4.3.2 EU-15 countries

The potentials for bioenergy sources for the EU-15 countries calculated using a similar method are shown in Table 30 through Table 33. Individual country tables are included in the appendix. In the current situation where land must be set aside, the supply potential increases from 266 million t of grain equivalents in the basis to 307 million t in 2010, where cultivated land for sugar beets and potatoes is reduced due to demand, and increases in production benefit grain maize in particular. If policy eliminating compulsory set-asides were to be introduced, the potential for bioenergy sources would increase 2.6% per year in the period to 2010. As this would only be a one-time effect, the supply would only increase by around 1.4% per year from 2010 to 2020. The land that previously had to e set aside would be used primarily for grain maize, rapeseed and rye cultivation. In the variant encouraging ethanol beet cultivation (€25 per t), sugar beet cultivation expands considerably for the EU-15 countries as a whole, from 2 million to 3.5 million ha of ethanol beets and around 1 million ha of beets for sugar production. Land would be converted to beet cultivation at the expense of barley and wheat but not grain maize or rapeseed. The scenario promoting ethanol beets and cereals as energy whole plants would further increase the overall potential for bioenergy sources. The total potential for bioenergy crops appears largely exhausted by sector. Assuming an increase in price for cereal crops, competitiveness increases enough for cereals to displace rapeseed and ethanol beets.

The results for the EU-15 countries as a whole confirm the comparatively high supply reaction to systematic promotion of selected energy crops, although with lower relative rates of change than Germany. As these types of energy scenarios cannot be assumed for all EU-15 countries, we do not need to provide further comment on the EU-15 results.

Table 30: Potential of area and production volumes **compulsory set-aside 10%**

Country	Ø 1998 - 2002		2010		2020	
	Area thousand ha	Quantity thousand t	Area thousand ha	Quantity thousand t	Area thousand ha	Quantity thousand t
EU-15 total						
Wheat	17.410,14	100.645,96	17.128,08	113.347,45	17.417,51	132.141,58
Rye	1.216,81	5.651,42	1.638,28	9.329,37	1.686,94	11.525,11
Barley	10.849,83	49.626,33	10.389,70	52.446,09	10.278,41	57.243,37
Oats	1.994,93	6.537,67	1.895,00	7.169,18	1.980,44	8.938,65
Grain maize	4.313,46	38.994,83	6.240,34	66.259,96	6.352,12	79.378,88
Pulses	1.692,70	4.783,04	1.016,53	2.921,00	978,58	2.983,64
Rapeseed	3.138,93	9.619,94	3.347,41	11.967,56	3.334,70	13.795,60
Sunflower	1.932,69	3.192,51	1.664,29	2.906,70	1.567,02	2.892,35
Land set-aside[1]	4.172,69	0,00	4.252,90	0,00	4.276,17	0,00
Ethanol beet	0,00	0,00	0,00	0,00	0,00	0,00
Sugar beet	1.953,82	115.021,91	1.247,39	82.192,36	1.088,31	79.374,34
Potato	1.329,62	47.020,73	1.185,68	48.337,73	1.045,41	49.013,37
Total	**50.005,59**	**381.094,38**	**50.005,59**	**396.877,41**	**50.005,60**	**437.286,88**
Total in grain equivalent		**266.180,03**		**306.975,00**		**350.227,00**

1) according to FADN

Source: FAOSTAT; own calculations

Table 31: **Potential of area and production volumes without set-aside**

Country	Ø 1998 - 2002		2010		2020	
	Area thousand ha	Quantity thousand t	Area thousand ha	Quantity thousand t	Area thousand ha	Quantity thousand t
EU-15 total						
Wheat	17.410,14	100.645,96	18.008,38	119.245,27	18.290,17	138.854,98
Rye	1.216,81	5.651,42	1.972,67	11.107,64	2.065,70	13.985,66
Barley	10.849,83	49.626,33	10.854,55	55.237,94	10.613,58	59.595,93
Oats	1.994,93	6.537,67	2.029,92	7.751,40	2.144,71	9.831,33
Grain maize	4.313,46	38.994,83	7.463,86	79.402,42	7.632,81	95.634,89
Pulses	1.692,70	4.783,04	903,14	2.623,66	862,18	2.667,45
Rapeseed	3.138,93	9.619,94	3.958,60	14.057,40	3.936,50	16.171,50
Sunflower	1.932,69	3.192,51	1.977,61	3.439,04	1.805,89	3.354,82
Land set-aside[1]	4.172,69	0,00	403,42	0,00	519,85	0,00
Ethanol beet	0,00	0,00	0,00	0,00	0,00	0,00
Sugar beet	1.953,82	115.021,91	1.247,76	82.214,50	1.088,80	79.405,07
Potato	1.329,62	47.020,73	1.185,68	48.337,73	1.045,41	49.013,37
Total	**50.005,59**	**381.094,38**	**50.005,60**	**423.417,00**	**50.005,60**	**468.515,00**
Total in grain equivalent		**266.180,03**		**335.333,47**		**383.418,97**

1) according to FADN

Source: FAOSTAT; own calculations

Table 32: Potential of area and production volumes
without set-aside, cultivation of ethanol beets possible for sugar beet operations at €25 per t

Country	Ø 1998 - 2002		2010		2020	
	Area thousand ha	Quantity thousand t	Area thousand ha	Quantity thousand t	Area thousand ha	Quantity thousand t
EU-15 total						
Wheat	17.410,14	100.645,96	16.440,06	108.186,13	16.500,17	124.128,96
Rye	1.216,81	5.651,42	1.719,43	9.494,30	1.841,03	12.230,53
Barley	10.849,83	49.626,33	9.991,42	49.853,84	9.809,12	54.086,68
Oats	1.994,93	6.537,67	2.001,86	7.584,75	2.118,52	9.631,73
Grain maize	4.313,46	38.994,83	7.252,84	77.164,52	7.458,46	93.333,32
Pulses	1.692,70	4.783,04	1.021,00	2.976,96	940,17	2.981,22
Rapeseed	3.138,93	9.619,94	3.545,01	12.506,16	3.647,01	14.879,86
Sunflower	1.932,69	3.192,51	1.797,40	3.114,89	1.649,41	3.061,38
Land set-aside[1]	4.172,69	0,00	344,25	0,00	444,42	0,00
Ethanol beet	0,00	0,00	3.553,11	239.102,69	3.555,24	268.597,84
Sugar beet	1.953,82	115.021,91	1.153,54	75.378,71	996,65	72.055,13
Potato	1.329,62	47.020,73	1.185,68	48.337,73	1.045,41	49.013,37
Total	**50.005,59**	**381.094,38**	**50.005,59**	**633.700,69**	**50.005,60**	**704.000,06**
Total in grain equivalent		**266.180,03**		**370.104,19**		**421.858,53**

1) according to FADN

Source: FAOSTAT; own calculations

Table 33: Potential of area and production volumes
without set-aside, cultivation of ethanol beets possible for sugar beet operations at €25 per t, cereal price +40%

Country	Ø 1998 - 2002		2010		2020	
	Area thousand ha	Quantity thousand t	Area thousand ha	Quantity thousand t	Area thousand ha	Quantity thousand t
EU-15 total						
Wheat	17.410,14	100.645,96	19.446,50	130.323,98	19.596,92	150.349,23
Rye	1.216,81	5.651,42	1.849,31	10.338,65	2.007,32	13.508,90
Barley	10.849,83	49.626,33	10.590,55	53.048,61	10.349,24	57.337,08
Oats	1.994,93	6.537,67	2.214,67	8.455,85	2.382,55	10.931,25
Grain maize	4.313,46	38.994,83	7.542,03	80.239,27	7.780,63	97.466,00
Pulses	1.692,70	4.783,04	612,28	1.514,53	536,46	1.481,09
Rapeseed	3.138,93	9.619,94	1.542,93	5.356,85	1.669,27	6.676,54
Sunflower	1.932,69	3.192,51	819,21	1.267,49	704,54	1.185,96
Land set-aside[1]	4.172,69	0,00	129,39	0,00	173,30	0,00
Ethanol beet	0,00	0,00	3.102,74	211.619,39	2.970,99	228.988,59
Sugar beet	1.953,82	115.021,91	970,31	64.636,42	788,98	58.737,52
Potato	1.329,62	47.020,73	1.185,68	48.337,73	1.045,41	49.013,37
Total	**50.005,59**	**381.094,38**	**50.005,60**	**615.138,81**	**50.005,60**	**675.675,56**
Total in grain equivalent		**266.180,03**		**373.913,81**		**426.174,03**

1) according to FADN

Source: FAOSTAT; own calculations

3.4.4 Comparison of economic and technical potentials for bioenergy sources from agriculture

We have selected the following method to enable the comparison of the results of both estimation procedures, which differ in their methods, for determining the potentials of bioenergy sources from agriculture:

The results of the estimate of economic potential for the periods to 2010 and 2020, which are based on the standard variant (Current Policy), are adjusted using the changes that are included in the estimate of technical potential but not in the estimate of economic potential. These changes include:

- Increased (-) or decreased (+) food consumption
- Land redesignation (-)
- Potentials made available from improvements in feed conversion in pork and poultry production (+)
- The additional production potentials from the economic estimate of potential are expressed as the proportion of additional potentials for bioenergy sources from the statistical estimation method.

A quantitative supplemental calculation for determining the proportion of the technical potential for bioenergy sources covered by the economic potential is shown in Table 34 for Germany under the current conditions and 10% set-aside. It assumes production of the economic potential to increase 17.2% to 10.1 million t of grain equivalents from 2000 to 2010 and 20.2% to 11.9 million t of grain equivalents by 2020. After adjusting for changes in food consumption, land redesignation and improved feed conversion, the overall economic potential equals 14.6% in 2010 and 20.6% in 2020 compared to the basis or 35.2% over the entire period. Based on the available agricultural area used for the recorded production (9,268,900 ha) in the basis, around 1.35 million ha could be made available between 2000 and 2010 and around 1.9 million ha between 2010 and 2020, or a total of 3.26 million ha. In comparison, the statistics-based estimate of the technical potential for the same periods returned 2.134 million and 2.76 million ha. The proportion of the technical potential covered by the economic potential is 63% in the first period, 70% in the second and 67% overall.

Table 34: Germany: Estimate of the proportion with **10% set-aside**

	Unit	Change and Balance Period 2000 -2010	 2010 -2020	 2000 - 2020
Total production in grain equivalent	t	68.875.620	80.753.520	
Increased production in grain equivalent	t	10.096.990	11.877.900	21.974.890
	%	17,2	20,2	37,4
Increase/decrease in food consumption	%	-2,8	0,3	-2,5
Land redesignation		-0,5	-0,5	-1,0
Saving due to improved feed conversion	%	0,6	0,6	1,3
Increase in economic potential	**%**	**14,6**	**20,6**	**35,2**
	ha	**1.349.342**	**1.909.596**	**3.258.938**
Increase in technical potential	ha	2.134.023	2.757.561	4.891.584
Share of economic potential in technical potential	**%**	**63,2**	**69,2**	**66,6**

If new tools for promoting bioenergy sources are introduced during the period under consideration, the economic potential will account for a greater share of the technical potential. The same calculation assuming land does not have to be set aside, which is shown in Table 35, shows production increases of 15.9 million t of grain equivalents by 2010 and of 13.1 million t of grain equivalents in 2020. After adjusting the potential estimate, 24.4% of land could potentially be made available by 2010 and 22.7% by 2020. Based on the agricultural area taken into account in the basis, around 2.26 million ha of land could potentially be made available for bioenergy sources by 2010 and around 2.11 million ha between 2010 and 2020, or 4.37 million ha in all. The economic potential in 2010 is even 6% (123,257 ha) greater than the estimated technical potential for bioenergy sources. This occurs because the estimate of technical potential does not account for the substitution of high-yield energy crops for traditional crops. In 2020 the economic potential accounts for around 76% of the technical potential. Around 90% of the technical potential is provided over the entire period.

Table 35: Germany: Estimate of the proportion **without set-aside**

	Unit	Change and Balance Period		
		2000 -2010	2010 -2020	2000 - 2020
Total production in grain equivalent	t	74.633.300	87.769.420	
Increased production in grain equivalent	t	15.854.670	13.136.120	28.990.790
	%	27,0	22,3	49,3
Increase/decrease in food consumption	%	-2,8	0,3	-2,5
Land resedignation	%	-0,5	-0,5	-1,0
Saving due to improved feed conversion	%	0,6	0,6	1,3
Increase in economic potential	**%**	**24,4**	**22,7**	**47,1**
	ha	**2.257.280**	**2.108.007**	**4.365.287**
Increase in technical potential	ha	2.134.023	2.757.561	4.891.584
Share of economic potential in technical potential	**%**	**105,8**	**76,4**	**89,2**

Assuming that in addition to eliminating set-aside, sugar beet cultivation for ethanol production is subsidised enabling a redemption price of €25 per t of sugar beets, the agricultural supply increases by 44% over the basis by 2010 and by an additional 22% from 2010 to 2020 for a total of 66% over the entire period (Table 36).

By substituting sugar beets for cereals and rapeseed, which results in the highest energy productivity per ha, the economic potential accounts for 80% of the technical potential in 2010 but remains 76% in the period from 2010 to 2020.

If we also assume that the whole plant can be used for all cereal types, which would result in increased economic efficiency of cereal cultivation, the technical potential can not be increased further.

The data in Table 37 indicate that the supply potential of the agricultural sector is practically exhausted under the assumed beneficial economic conditions for energy crops in the last scenarios discussed.

Table 36: Germany: Estimate of the proportion **without set-aside, ethanol beets at €25 per t**

	Unit	Change and Balance		
		Period		
		2000 -2010	2010 -2020	2000 - 2020
Total production in grain equivalent	t	84.653.730	97.632.690	
Increased production in grain equivalent	t	25.875.100	12.978.960	38.854.060
	%	44,0	22,1	66,1
Increase/decrease in food consumption	%	-2,8	0,3	-2,5
Land redesignation	%	-0,5	-0,5	-1,0
Saving due to improved feed conversion	%	0,6	0,6	1,3
Increase in economic potential	**%**	**41,4**	**22,5**	**63,9**
	ha	**3.837.418**	**2.083.224**	**5.920.642**
Increase in technical potential	ha	2.134.023	2.757.561	4.891.584
Share of economic potential in technical potential	**%**	**179,8**	**75,5**	**121,0**

Table 37: **Germany:** Estimate of the proportion without set-aside, **ethanol beets at €25 per t, cereal price +40%**

	Unit	Change and Balance		
		Period		
		2000 -2010	2010 -2020	2000 - 2020
Total production in grain equivalent	t	84.356.900	97.093.430	
Increased production in grain equivalent	t	25.578.270	12.736.530	38.314.800
	%	43,5	21,7	65,2
Increase/decrease in food consumption	%	-2,8	0,3	-2,5
Land redesignation	%	-0,5	-0,5	-1,0
Saving due to improved feed conversion	%	0,6	0,6	1,3
Increase in economic potential	**%**	**40,9**	**22,1**	**63,0**
	ha	**3.790.610**	**2.044.995**	**5.835.606**
Increase in technical potential	ha	2.134.023	2.757.561	4.891.584
Share of economic potential in technical potential	**%**	**177,6**	**74,2**	**119,3**

The potentials for the EU-15 countries calculated using the same methods, (Table 38 to Table 41) results in around 41% of the technical potential being used for economic purposes in the period from 2000 to 2010. This is equal to around 3.6 million ha. In the period from 2010 to 2020, 38% of the technical potential can be used economically, which corresponds to around 6.7 million ha of area being made available. We can assume that economic potential would account for around 39% of the technical potential for the EU-15 countries. If no land were set aside (Table 39) the technical potential increases considerably. Without setting aside land and with an ethanol beet price of €25 per t, the technical potential can be tapped even further (Table 40).

Table 38: EU-15: **Estimate of the proportion** with 10% set-aside

	Unit	Change and Balance		
		Period		
		2000 -2010	2010 -2020	2000 - 2020
Total production in grain equivalent	t	306.975.000	350.227.000	
Increased production in grain equivalent	t	40.794.970	43.252.000	84.046.970
	%	15,3	16,2	31,6
Increase/decrease in food consumption	%	-6,0	-0,6	-6,5
Land redesignation	%	-2,6	-2,6	-5,3
Saving due to improved feed conversion	%	0,5	0,5	0,9
Increase in economic potential	**%**	**7,2**	**13,5**	**20,7**
	ha	**3.585.010**	**6.748.420**	**10.333.430**
Increase in technical potential	ha	8.688.976	17.896.547	26.585.523
Share of economic potential in technical potential	**%**	**41,3**	**37,7**	**38,9**

Table 39: EU-15: **Estimate of the proportion** without set-aside

	Unit	Change and Balance		
		Period		
		2000 -2010	2010 -2020	2000 - 2020
Total production in grain equivalent	t	335.333.470	383.418.970	
Increased production in grain equivalent	t	69.153.440	48.085.500	117.238.940
	%	26,0	18,1	44,0
Increase/decrease in food consumption	%	-6,0	-0,6	-6,5
Land redesignation	%	-2,6	-2,6	-5,3
Saving due to improved feed conversion	%	0,5	0,5	0,9
Increase in economic potential	**%**	**17,8**	**15,3**	**33,1**
	ha	**8.912.540**	**7.656.459**	**16.568.999**
Increase in technical potential	ha	8.688.976	17.896.547	26.585.523
Share of economic potential in technical potential	**%**	**102,6**	**42,8**	**62,3**

Table 40: EU-15: **Estimate of the proportion** without set-aside, ethanol beets at €25 per t

	Unit	Change and Balance		
		Period		
		2000 -2010	2010 -2020	2000 - 2020
Total production in grain equivalent	t	370.104.190	421.858.530	
Increased production in grain equivalent	t	103.924.160	51.754.340	155.678.500
	%	39,0	19,4	58,5
Increase/decrease in food consumption	%	-6,0	-0,6	-6,5
Land redesignation	%	-2,6	-2,6	-5,3
Saving due to improved feed conversion	%	0,5	0,5	0,9
Increase in economic potential	**%**	**30,9**	**16,7**	**47,6**
	ha	**15.444.699**	**8.345.701**	**23.790.401**
Increase in technical potential	ha	8.688.976	17.896.547	26.585.523
Share of economic potential in technical potential	**%**	**177,8**	**46,6**	**89,5**

Table 41: EU-15: **Estimate of the proportion** without set-aside, ethanol beets at €25 per t, cereal price +40%

	Unit	Change and Balance		
		Period		
		2000 -2010	2010 -2020	2000 - 2020
Total production in grain equivalent	t	373.913.810	426.174.030	
Increased production in grain equivalent	t	107.733.780	52.260.220	159.994.000
	%	40,5	19,6	60,1
Increase/decrease in food consumption	%	-6,0	-0,6	-6,5
Land redesignation	%	-2,6	-2,6	-5,3
Saving due to improved feed conversion	%	0,5	0,5	0,9
Increase in economic potential	**%**	**32,3**	**16,9**	**49,2**
	ha	**16.160.389**	**8.440.738**	**24.601.127**
Increase in technical potential	ha	8.688.976	17.896.547	26.585.523
Share of economic potential in technical potential	**%**	**186,0**	**47,2**	**92,5**

The analysis of the economic potential shows that subsidising ethanol beets in all member states results in 5 million ha of sugar beets instead of 2 million ha as would otherwise be the case. This would require, in addition to using existing overcapacities in existing factory sites, that seasonal capacities be expanded and a significant number of new sugar factories be built. Supply would increase by 40% in the first period and by 20% in the second period. If we take into account changes in food demand, land redesignation and feed conversion, around 16 million ha would become available between 2000 and 2010, which greatly exceeds the estimated value of the technical potential due to the effects of substituting sugar beets, which are a productive energy crop, for crops. The area made available from 2010 to 2020 is well below the technical potential with 8.4 million ha compared to 16.2 million ha. The economic potential would be almost 25 million ha over the entire period, which is equivalent to around 92% of the technical potential being used economically.

Compared to the current situation (no subsidies for productive energy crops), the alternative calculations show that most important factors for utilising technical potential are to eliminate compulsory set-asides and replace less productive bioenergy sources with highly productive bioenergy sources. As demonstrated in the ethanol beet example, similar effects would be expected if new breeds of energy crops were more widespread. As these bioenergy sources as a rule replace crops with a lower energy yield, the effects could increase the economic and technical potential even more than calculated in this study.

3.5 Potentials for product groups (energy crops)

The technical fuel potential is relevant for putting the agricultural biomass potential for energy use into perspective. The technical fuel potential comprises the energy content of the product groups that can be prepared on agricultural areas. These product groups (energy crops) are annual or perennial crops that are cultivated on agricultural areas exclusively for energy use. The estimate of the potential is based on the technical potentials of agricultural area, which is defined in section 3.3.4.

3.5.1 Methodology

The potential of energy crops is based on the potential of the agricultural area. Specific cultivation regimes are assumed for these areas, and yields are estimated such that the mass potentials of energy crops can be calculated. The potential of bioenergy sources is calculated using these masses and the general procedure described in section 3.1.

The estimate of cultivated crops and intensities is important for energy crop production. Crops can be traditional food (starch crops, sugar crops, oil crops, etc.), special energy crops (such as energy maize, perennial grasses) and a special energy crop cultivation regime (such as a two-crop system).

The procedure selected here attempts to control the conceivable variety of products (energy crops) and cultivation systems using two basic assumptions, thus ensuring transparent and reproducible calculation of potential for all EU-28 countries:

1. The cultivation mix of cereals, oil crops, etc. that has been optimised over decades in the individual countries for food production should serve as the base for the energy crop mix. In other words, in countries with a high proportion of cereal cultivation, energy cereal cultivation is also important. In countries with large areas dedicated to maize silage, cultivation of energy maize is promising.

2. The new cultivated crops and systems are shown using established systems, not examined individually. In other words, energy cereal cultivation will also represent cultivation of perennial lignocellulose biomasses in the following, as these biomasses have a similar yield and at least in theory similar site requirements, meaning they could also be produced on the area used to produce cereals.

This method also applies the two land release scenarios in section 3.3). The conditions of each scenario are described briefly below:

<u>CP scenario</u>

- 100% of fallow land is available for energy crop cultivation.
- Surplus production of market regulation products is reduced, and areas are made available for energy crop cultivation (except pork and poultry).
- Production deficits for rapeseed and sunflowers reduce the technical potential.
- The area for bioenergy sources is not adjusted for deficit self-sufficiency of soya.
- Food demand is covered according to population growth and per capita consumption.
- Area is redesignated: municipalities, traffic, nature conservation.
- Crop and animal production yields increase.

<u>E+ scenario</u>

- No self-sufficiency for rapeseed and sunflowers.
- No self-sufficiency for milk or beef.
- Consumption trends are based on the degree of self-sufficiency.
- Only 70% of fallow land is cultivated.
- Yield for grassland is 50% less compared to the CP scenario.
- 2.5% (2010) and 5% (2020) of arable land is redesignated to nature conservation (which assumes that the yield of these areas would then be zero).

Cultivation of the following energy crops is examined on the potential area calculated in Table 24:

- Oil crops (rapeseed, sunflower)
- Cereals (wheat, rye, barley, grain maize, triticale)
- Sugar beets
- Maize silage and alfalfa

Cultivation of renewable raw materials and bioenergy sources must be integrated into existing agriculture. In other words, all qualities of each area (such as climatic and soil conditions) must be taken into account. If we assume that the land qualities of existing cultivation systems have been optimised over many years, renewable raw materials and bioenergy sources can be integrated easier the closer they come to the existing crop mix. The following assumes that the cultivation systems on the land available for bioenergy sources have the same distribution as agricultural area for food and feed production (for example, if 40% of agricultural land in a country is planted with wheat, we assume that 40% of additional available land will be planted with wheat). The crops under consideration are a majority of the main crops cultivated in Europe whose share of agricultural land has remained relatively stable over the last decade (Figure 16).

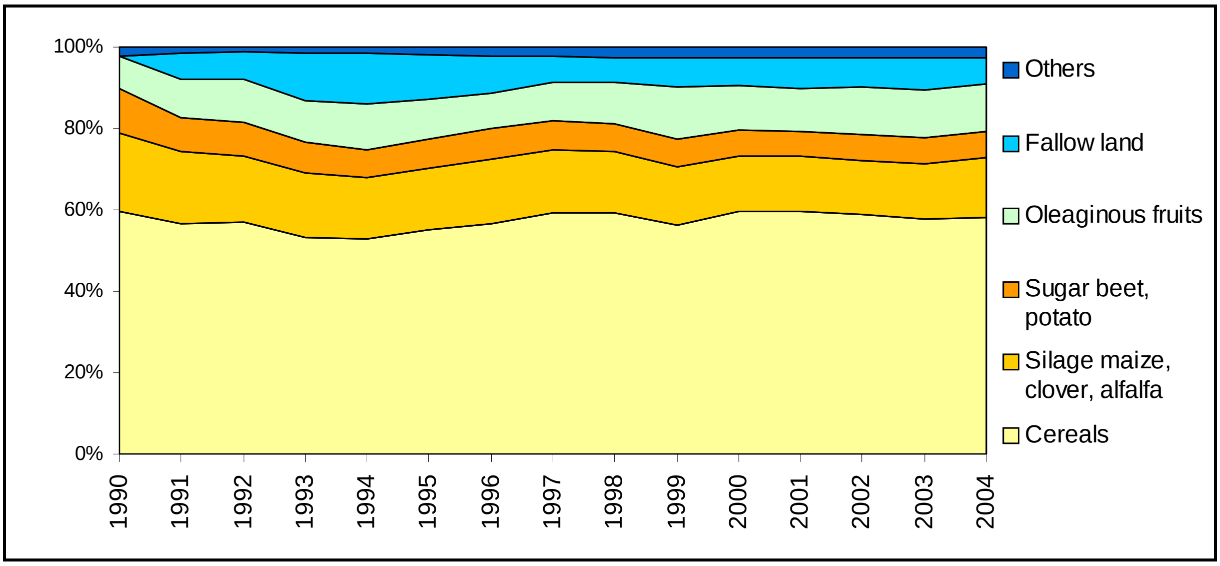

Figure 16: **Trends in the proportion of agricultural land allocated to the main crops in Germany Source /118/**

To take the area deficits of different countries (food production shortage) reported during calculation of the land potentials into account, we also assumed that the countries with surplus land offset these deficits proportionately (supply is offset within the EU). The calculation of fuel potential from energy crops for the EU-28 countries is based on the respective cultivated areas and yields of the crops in consideration from EUROSTAT. We calculated 5-year averages (1998 to 2002) to offset fluctuations in yield due to climate. Increases in yield for the EU-15 countries to 2020 were calculated based on the model assumptions from CAPSIM. An average increase in yield of 1.5% was defined for the new acceding and candidate countries. The development of agricultural land distribution until 2020 was taken into account as in section 3.4.3. The biomass produced can be used as solid fuel, to produce liquid bioenergy sources or as a substrate for producing biogas.

3.5.1.1 Technical assumptions

Solid fuels

The target area-specific dry mass yields and heating values are essential for determining the resulting energy source potentials for solid fuels. Only cereal plants are considered potential solid fuels. Due to the enormous importance of cereal cultivation in Germany and Europe, cereal crops represent the greatest biomass potential of energy crops.

This process does not explicitly analyse innovative cultivation systems such as short rotation wood (poplar and willow) and energy grasses (miscanthus), as their expected energy yield and cost are comparable to those of cereal plants (Table 42). The assumed area potentials for producing solid fuels are equivalent for different potential crops and can thus be interchanged.

Table 42: Technical fuel potential of energy crops for solid fuel production
Source: /28/

Crops	Dry mass yield	Heating value	Energy source potential
	[t_{DM}/(ha·a)]	[MJ/kg_{DM}]	[MJ/ha]
Cereal crops	10[a]	17	170
Energy grasses	12	17.6	211
Short rotation plantations	9	18.5	165

[a] Weighted mean of crops

See Table 43 for the assumptions for calculating the potentials. We have assumed that if the entire plant is used, 100% of straw can be used to produce energy.

Table 43: **Characteristics of energy crops for solid fuel production**
Source: /179/

Crops	Dry mass yield	Heating value	Energy source potential
	[t_{DM}/(ha·a)]	[MJ/kg_{DM}]	[MJ/ha]
Cereal crops	10[a]	17	170
Energy grasses	12	17.6	211
Short rotation plantations	9	18.5	165

[a] Weighted mean of crops

See appendix H for a detailed overview of the calculated potentials.

Biodiesel production

We assumed cultivation of rapeseed and sunflowers to determine the potential of biodiesel production. The amount of energy comes from the energy content of the vegetable oil, the meal remaining following oil extraction or the press cake left after pressing. The energy potential of rapeseed and sunflower straw is not included in the potential calculation to compensate for fossil fuel input in biodiesel production.

To calculate the potential, we assume a yield of 0.41 t of rapeseed oil and 0.59 t of meal for each t of rape seeds and a heating value of 32.65 MJ/kg for biodiesel and of 15.8 MJ/kg for meal (15% water content).

For sunflowers, we assume a yield of 0.42 t of sunflower oil and 0.58 t of meal for each t of rape seeds and a heating value of 32.65 MJ/kg for biodiesel and of 15.8 MJ/kg for meal (15% water content) /180/.

See appendix H for a detailed list of the calculated potentials.

Bioethanol production

Bioethanol can be produced from starch crops such as wheat, rye, barley, maize and potatoes and sugar crops such as sugar beets. This means that the uses of starch crops – bioethanol production and solid fuel production – are in direct competition with each other. As these crops cannot be clearly assigned due to technical restrictions, they are considered as in section 5.3 under the assumption of different scenarios. The potential of starch crops is defined in this section as pure energy source potential based on the characteristics of solid fuel.

The amount of energy from cultivating these energy crops results from the energy content of the bioethanol that can be produced and the energy content of the residues (i.e. wheat straw used as a solid fuel). Like biodiesel, mash produced is not included in the energy potential calculation to compensate for fossil energy input for bioethanol production.

An ethanol yield of 440 $l_{Ethanol}/t_{Wheat}$ is assumed for wheat, 437 $l_{Ethanol}/t_{Triticale}$ for triticale and 430 $l_{Ethanol}/t_{Rye}$ for rye and barley. An average bioethanol yield of 310 l/t is assumed for bioethanol production from lignocellulosic biomass. Bioethanol yields are always given per ton of dry mass /181/.

An ethanol yield of 107.5 $l_{Ethanol}/t_{Beets}$ is assumed for bioethanol production from sugar beets. For the use of residues for biogas production, we used assumptions for biogas potential for beet leaf (root/leaf ratio 1:0.8), treacle and beet pulp (36.5 kg of treacle and 76.5 kg per t sugar beets) from Table 44 /179//180/.

See appendix H for a detailed overview of the calculated potentials.

Biogas production

The cultivation of maize silage and alfalfa is assumed for land with energy crops as a substrate for biogas production. Grassland made available from reducing milk and beef surplus production (section 3.3.3) would be available to produce plant cuttings. For the calculated grassland, we assume that a maximum of 50% of the area or volume can be used to produce energy. We used the values from Table 44 for the calculations.

Table 44: Characteristics of energy crops and residues for biogas production
Source: /199/

Crops	oDM content	Biogas yield	Methane content
	[%]	[m³/kg oDM]	[%]
Plant cuttings	95	0.5	52
Alfalfa	89	0.45	52
Silage maize	88	0.58	55
Beet leaf	77.5	0.48	54.5
Beet pulp	66	0.60	70

3.5.2 Results

The following sections show and discuss the technical potential of energy crops for Germany and for the EU-28 countries as a whole. See appendix H for detailed results for all countries.

3.5.2.1 Germany

The calculated potentials for energy crop groups in Germany are shown in Figure 17 for the reference year 2000 and for 2010 and 2020. The E+ scenario, i.e. assuming agricultural and environmental policy is oriented toward sustainability criteria, shows a potential of around **100 PJ p.a.** in Germany for the reference year. Assuming all arable land that becomes available – as is the case in the CP scenario – the available potential for Germany is **175 PJ p.a.**

Due to additional agricultural land that was previously used for food production being made available for energy crop cultivation, the potential in the E+ scenario is **185 PJ p.a.** in 2010 and **486 PJ p.a.** in 2020. A much higher increase of the potentials available for energy crop production can be expected in the CP scenario. The energy crop potential increases to **560 PJ p.a.** in 2010 and to **1 274 PJ p.a.** in 2020. Given the different amounts of land made available, the two scenarios differ by a factor of 2 to 3 by 2020 (Table 45).

If the cultivation structure for food production on land made available is continued, the potential for energy crops consists primarily of cereal cultivation. Wheat is the primary cereal cultivated in Germany followed by barley and rye. As a substrate for producing biogas, silage maize has the second largest potential after cereal in Germany. Because the cultivation structure is retained, rapeseed cultivation is relatively unimportant. The development of cultivation structure over the coming years is relatively open in this scenario, however. A sharp increase in demand for rapeseed could shift the cultivation volume accordingly. Rapeseed, however, cannot be cultivated at will due to crop rotation restrictions[17].

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[17] Rapeseed and sunflowers cannot be cultivated as monocultures. The upper limit is a share of 25% of arable land (4-year crop rotation). /231/

If perennial crops are cultivated on these areas (miscanthus, short rotation plantations), yields similar to cereal cultivation can be expected (Table 42) yet with other economic and environmental effects (section 5.4).

Table 45: Energy source potential of energy crops in Germany in 2020

	Energy source potential in PJ p.a.	
	E+ scenario	**CP scenario**
Oil energy crops (dry)		
Sunflower	2	5
Rapeseed	31	83
Starchy energy crops (dry)		
Wheat	172	458
Triticale	26	69
Rye	61	163
Barley	56	150
Grain maize	49	131
“Wet” energy crops		
Silage maize	53	141
Alfalfa	0	1
Sugar beets	14	38
Plant cuttings	20	36
Total	**486**	**1,274**

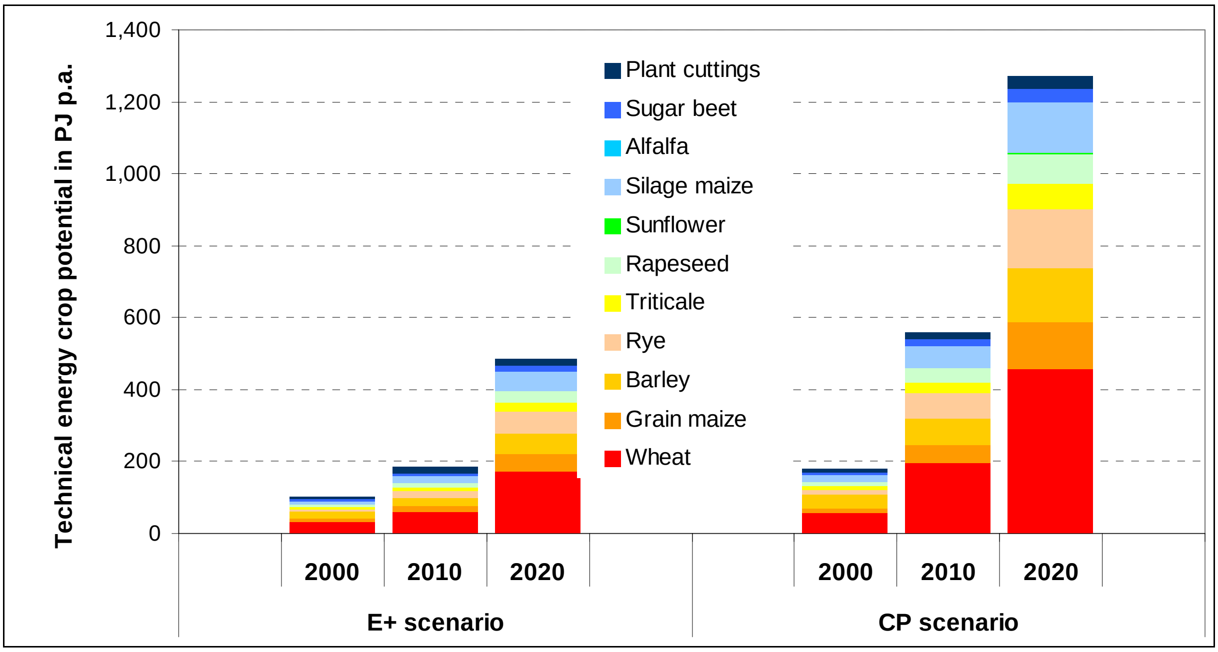

Figure 17: **Energy source potential for energy crops in Germany in the E+ and CP scenarios in PJ p.a.**

3.5.2.2 EU-28 countries

The energy crop potentials calculated for the reference year 2000 and for 2010 and 2020 in the EU-28 countries are described in the following (Figure 19 and Figure 18).

Along with France and Spain, Germany has the most important energy crop potentials in Europe. This is due in large part to considerable potential land if fallow land that must be set aside were made available and to the large surpluses of almost all market regulation crops. The increase in the potential of energy crops can also be traced to increases in yield.

The new EU acceding countries, led by Poland and Hungary also have a notable potential for energy crops. These countries are in the final phase of the transformation process. Given the decreasing population rates and comparatively high rates of yield increase, these countries have a relatively large potential for cultivating energy crops.

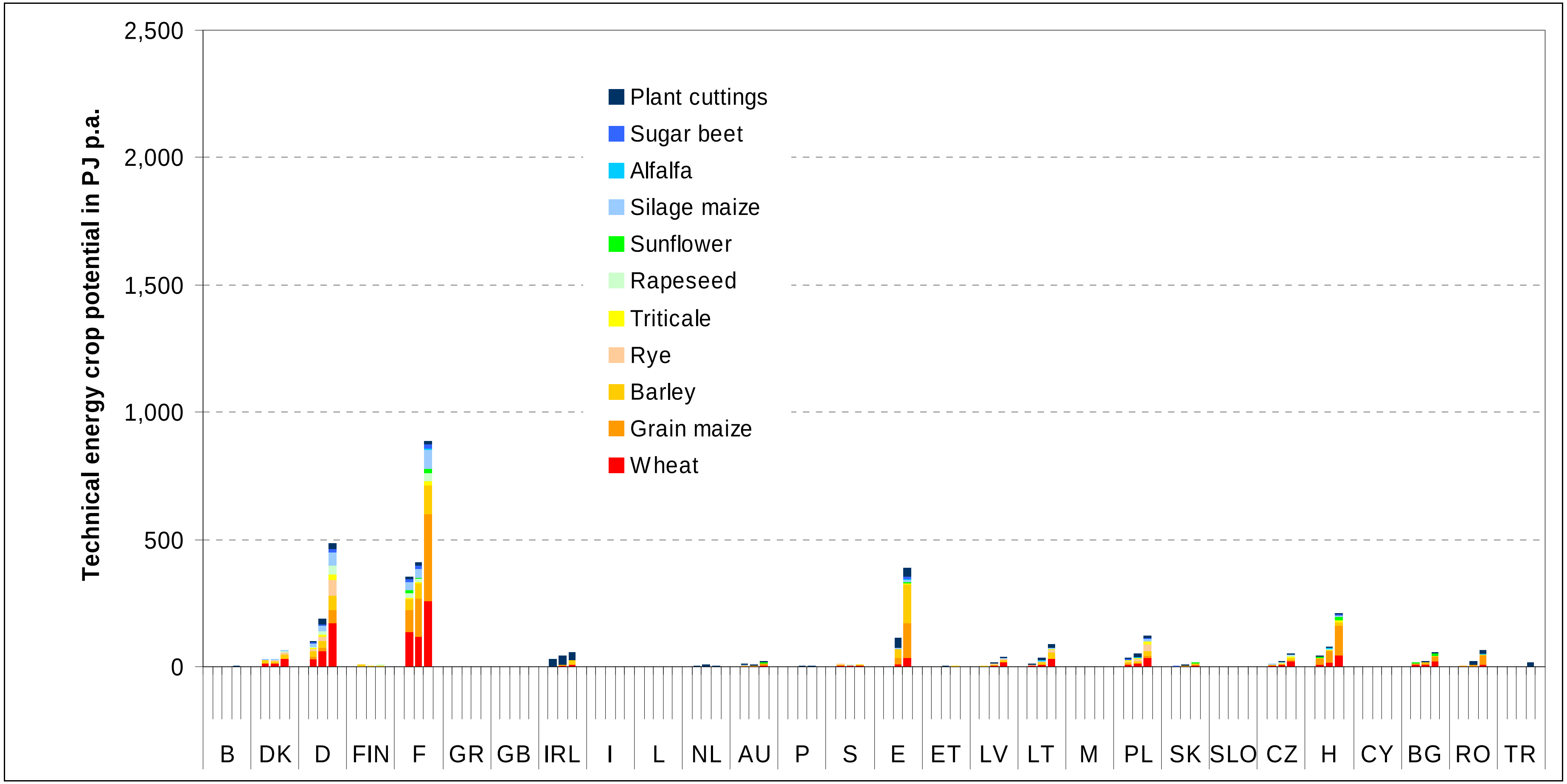

Figure 18: **Energy source potential for energy crops in the EU-28 countries in the E+ scenario (2000 – 2010 – 2020)**

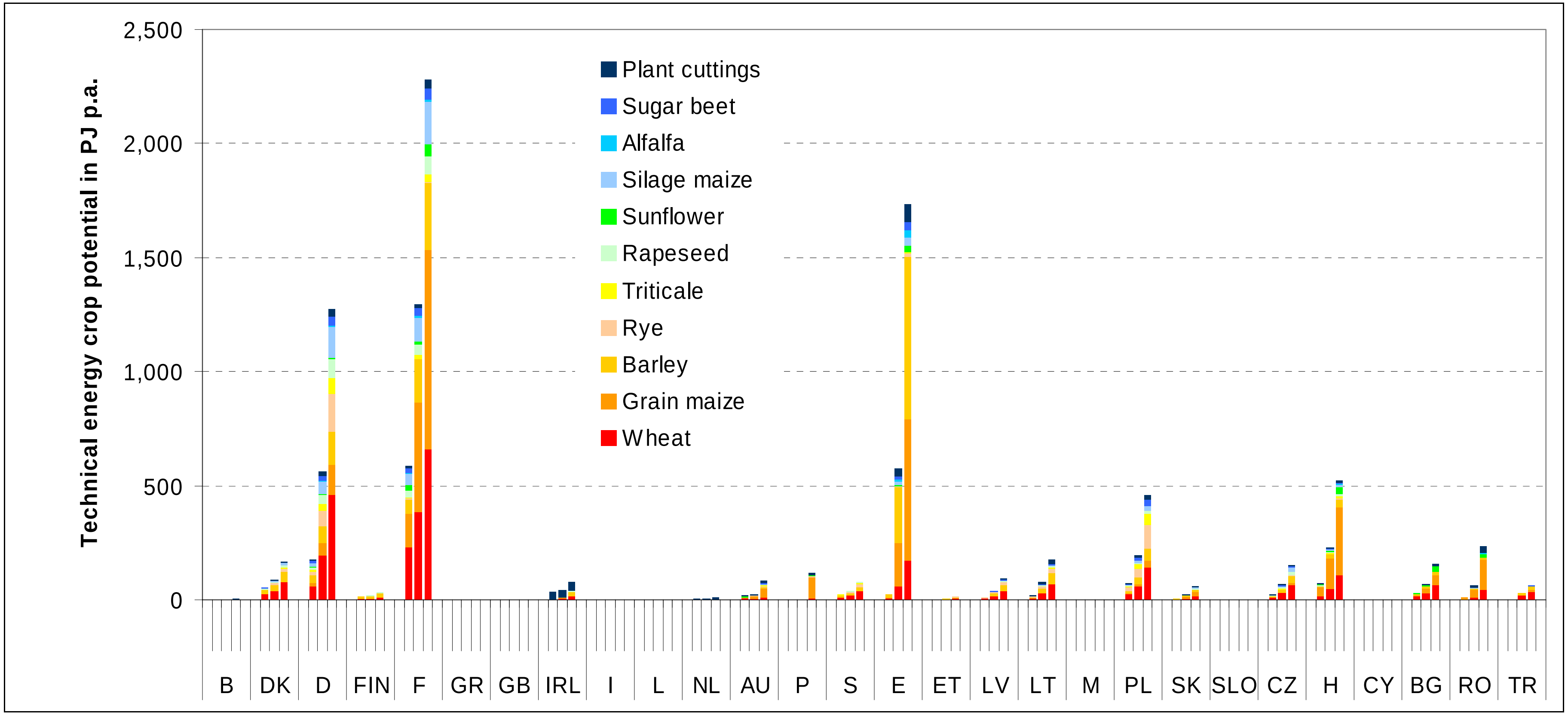

Figure 19: **Energy source potential for energy crops in the EU-28 countries in the CP scenario (2000 – 2010 – 2020)**

The option of cultivating energy crops is not available in all European countries. Some countries such as Finland, Greece, Great Britain, Italy, Slovakia and Turkey show comparatively low potentials in both scenarios through 2020. This is primarily due to low availability of fallow land and overall deficit self-sufficiency of food.

Due to different trends in making land available, the two scenarios differ by a factor of 2 to 3.

In the E+ scenario, the EU-28 countries have a potential of **690 PJ p.a.** in the reference year 2000. In the CP scenario, the EU-28 countries have a potential of **1,180 PJ p.a.** in the reference year.

Due to more land being made available, the potential for energy crops in the E+ scenario increases to **1,075 PJ p.a.** for 2010. The potential quadruples to **2,614 PJ p.a.** by 2020. In the CP scenario, the potential for energy crops increases to **3,465 PJ p.a.** for 2010 and **7,792 PJ p.a.** for 2020. The potential for 2020 is almost three times as high in the CP scenario as in the E+ scenario.

Given that cultivation structures are retained, cereals are also the most important crop cultivated in the EU-28 countries accounting for over 80% of the potential. Grain maize is the leading cereal crop followed closely by wheat. The potential of oil energy crops in the EU-28 countries, which compared to Germany consists increasingly of sunflowers, plays a less important role. The EU-28 cultivation structures could change given the increasing demand for oil energy crops.

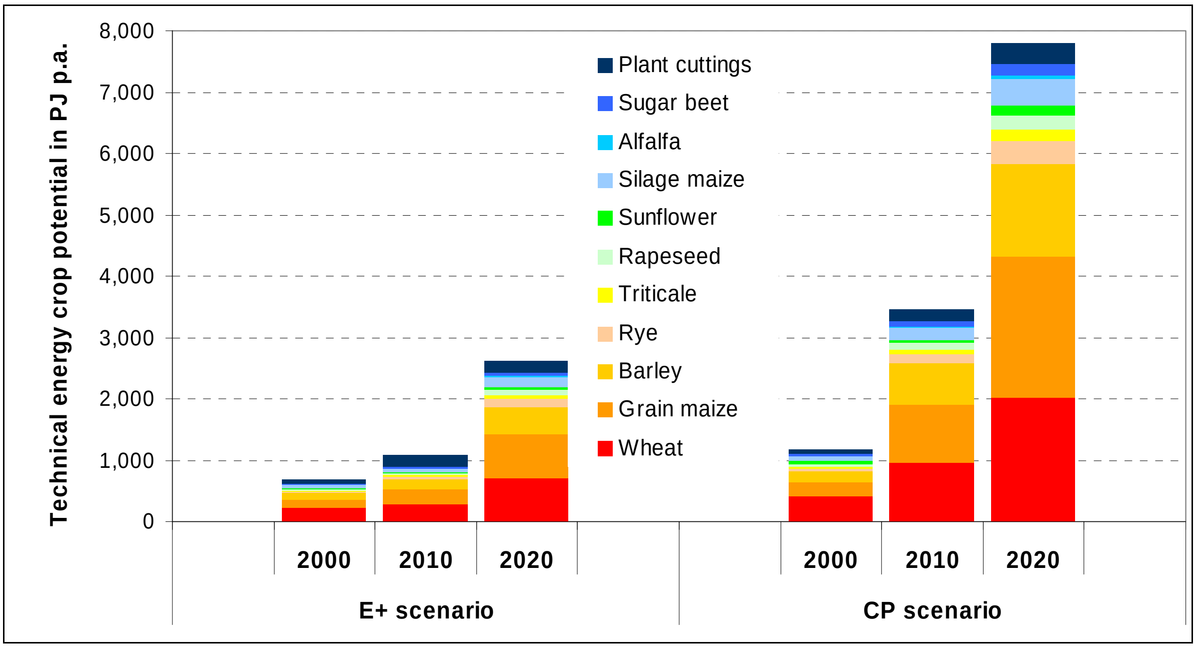

Figure 20: **Energy source potential for energy crops in the EU-28 countries in the E+ and CP scenarios in PJ p.a.**

Table 46: **Energy source potential of energy crops in the EU-28 countries in 2020**

	Energy source potential in PJ p.a.	
	E+ scenario	**CP scenario**
Oil energy crops (dry)		
Sunflower	54	165
Rapeseed	83	224
Starchy energy crops (dry)		
Wheat	704	2,024
Triticale	67	194
Rye	120	364
Barley	451	1,517
Grain maize	717	2,293
"Wet" energy crops		
Silage maize	155	428
Alfalfa	16	58
Sugar beets	62	191
Plant cuttings	185	334
Total	**2,614**	**7,792**

3.6 Potential from residues

3.6.1 Methodology

Residual material includes residues, by-products and other waste that results from agriculture, wood and food processing and at the end of the production chain. The biomass that is not intended for use as material and/or cannot be used as a material is available. The following section describes the procedure for determining each potential from residues for 2000 and extrapolating it for 2010 and 2020. The section also describes the available statistics. The potential of waste wood, pruning from agriculture, commercial and industrial waste, sewage sludge and organic municipal waste including landfill gas are assumed unchanged for 2010 and 2020.

3.6.1.1 Woody residues

Wood processing industry by-products and residues

By-products and residues from the wood processing industry (referred to as “industry by-products” in the following) include all residues, by-products and waste resulting from wood preparation, production of derived timber products, wood products and wood processing. This wood is generally converted for use as a material or used to produce energy on site or delivered to processing companies. Some of the industry by-products are waste wood resulting from conversion and disposal. These volumes are counted twice if necessary but are disregarded in the following as they are immaterial. The following section includes industry by-products from the sawmill industry (sawmill by-products and bark), wood materials industry (production residues and bark) and wood pulp industry (bark). Residue wood from the wood furniture industry, other wood processing industries (e.g. manufacturing wood packaging) and the wood processing trade are not included because it has limited commercial importance and is not produced at a single central location.Extrapolation of the potential of industry by-products for 2010 and 2020 is based on the EFSOS[18] trends in roundwood

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[18] EFSOS: European Forest Sector Outlook Studies by UN/Economic Commission for Europe (UN/ECE) and FAO

(material use only). The percent changes in roundwood volume compared to the reference year 2000 are applied to industry by-products accordingly. This method assumes that trends in the timber industry will be the same for all areas (sawmills, wood materials industry, wood pulp industry).

Sawmills

The potential of industry by-products in the sawmill industry (based on sawmill by-products, i.e. wood shavings, edgings/slabs and wood chips) was derived from the production volume taking into account the specific wood residue factor/timber yield. The potential is derived based on timber production in 2000 /65/. The calculations use primarily values for Germany that are different for softwood and hardwood /64/.

The energy potential of industry and sawmill by-products in the sawmill industry takes into account the competition between material and energy use and is calculated from total wood residues minus the volume used for material in 2000, taking into account foreign trade /71/. The total demand for raw wood and the proportion of sawmill residues in the wood materials and wood pulp industries is calculated based on the results of the balance of wooden raw materials for Germany /64/, different timber association statistics /69//70/ and other studies /60/. The use of sawmill by-products for other material purposes was also taken into account (e.g. wood shavings/sawdust from horsekeeping). Due to major uncertainties in the estimate of the demand for sawmill residues for material use and the external trade of sawmill residues, the results only permit initial conclusions on the scope of material use and total energy potential. If, based on the above balance, major data errors would result in negative values for the remaining potential energy uses for individual countries, a flat rate of 10% of the total occurring wood residues would be considered energy potential. Energy potential for Finland and Sweden, the two countries with the by far largest amount of wood residues, is calculated primarily based on domestic data bases /73//74/.

In addition to sawmill by-products, sawmill waste includes bark, which can also be used to produce energy and already do so to a great extent. The total occurrence is derived for all EU countries under consideration based on the present detailed data, which are categorised by softwood and hardwood for Germany /64/. We have assumed that 80% of bark can be used to produce energy.

Wood materials industry

Wood processing industry residues from the wood materials industry in the individual European countries can be derived roughly based on the scope of production of wood materials (chipboards, fibreboards, oriented strand boards) and the specific occurrence of residue wood. Production for 2000 is taken from UN data /65/. For specific residue wood, results calculated for Germany as part of an environmental assessment were used for all EU countries under consideration /67/:

- In chipboard production approximately 82 kg_{bdt}/m^3 of wood residues result from the production of 1 m^3 boards (approximately 5 kg_{bdt}/m^3 protection boards, scantlings, slats, approximately 8 kg_{bdt}/m^3 other scrap, approximately 69 kg_{bdt}/m^3 sanding dusts) /67/. Protection boards, scantlings, slats and other scrap re-enter the production process (material use) and are thus not available as potential energy sources. Only sanding dusts have potential for energy use.
- MDF production (which by far dominates fibreboard production and whose specific factors are used to calculate the total residue wood for fibreboards) results in just under 300 kg_{bdt} residue wood for the production of 1 m^3 of boards. Around 225 kg_{bdt}/m^3 of protection boards, scantlings and other scrap and approximately 74 kg_{bdt}/m^3 of sanding dusts are produced /67/. Residue wood from MDF production cannot generally be (re-)used because the quality is insufficient. At sites that produce chipboards in addition to medium densified fibreboards (MDF), which is common, all residue wood is used as a material, and only sanding dusts are used to produce energy. Only sanding dusts are included in the potential calculation.
- In OSB production, around 70 kg_{bdt} of specific wood processing industry residues are assumed for 1 m^3 of boards produced. Residue wood is created from scrap wood and from grooves and tongues and equals around 50 kg_{bdt}/m^3. Around 20 kg_{bdt}/m^3 of sanding dusts are produced /67/. Residue wood from OSB production is generally not used as to produce material because the quality is insufficient. Instead it is usually used as a material in nearby chipboard facilities, as is the case with MDF production. Therefore, only sanding dusts have potential as an energy source.

Bark from the volume of processed industrial wood also has potential as an energy source /64/. We assume that 80% of bark can be used to produce energy.

Wood pulp industry

Industrial wood occurs as bark in the wood pulp industry. The amount of bark is derived from the amount of industrial wood used and the specific occurrence of bark, as is the case in the wood materials industry. The total demand for raw wood was derived using data for Germany /64/ and the proportion of industrial wood according to statistics from the European Pulp and Paper Association /69/. We assume that 80% of all bark is available as energy potential.

Black liquor

In the pulp production process, the non-cellulose substances in cellulosic materials (usually wood in Europe) are dissolved or isolated using different pulping procedures, and the cellulose structure is retained. The contents of wood are bonded chemically primarily by hydrogen bonds or ether bonds, which can be broken enabling the wood to decompose. This process involves heating wood chips in specific chemical solutions under pressure. Resins, lignin and other wood components are dissolved, and the cellulose is retained. The cellulose is then washed and bleached. There are different pulping processes used (especially sulphite and sulphate pulping). The sulphate pulping is the main process used in Europe because it is less harmful to the environment. Waste liquors (e.g. black liquor) are by-products of this process and are composed of the dissolved lignin, hemicelluloses, different process-related chemicals and water. The chemicals are recovered in a chemical recovery process and are reused as resources. The liquors are thickened and then burned in special liquor recovery boilers to generally produce combined heat and power and less often exclusively for process heating /82/.

The energy potential of black liquor is derived based on two current studies for Europe on the different potentials of biomass in 2000, which also contain detailed data on black liquor /83//84/. The plausibility of the results, which differ to some extent, was checked using the cellulose production volume in 2000 /69//65/ and the average values for black liquor per ton of cellulose produced. In some cases minor corrections were made. The value for Turkey was derived directly using this method as no potential data was available. For countries with high cellulose production volumes and thus a high amount of black liquor /87//88//88//89/ detailed country-specific publications on the amount of energy use of black liquor in 2000 were used as the basis for deriving the potential. Potential equals use in this case as in general all of the black liquor produced can be used to produce energy.

The potential of black liquor for 2010 and 2020 is calculated using the estimate of trends in the pulp industry (based on EFSOS data for roundwood for 2010 and 2020). Percent changes over the reference year 2000 are applied accordingly to the amount of black liquor produced.

Waste wood

Waste wood consists of used wood (used products of wood, wood materials or compounds consisting primarily of wood) and wood processing industry by-products and residues that are considered waste. Used wood results in places where wood is discarded from the usage process, for example in construction (building demolition, new buildings, renovations) and at the end of the service life of certain wood products (old furniture, packaging).

Only general waste statistics (e.g. amount of municipal waste) are available for the European level but not any specific statistics on the amount of waste wood. The potential of waste wood in 2000, which was calculated in detail for Germany at 97 kg per inhabitant per year[19], is therefore applied to the individual countries /25/. To account for material use of waste wood in the chipboard industry, we assume that 75% (around 73 kg/(E·a)) of waste wood can be used to produce energy.

There are a variety of factors that affect the amount of waste wood that results (including the economic situation in the construction market and consumer behaviour), and they are difficult to predict. In addition, population figures are not expected to change significantly by 2020. Consequently, we are assuming the potential will not change for 2010 and 2020.

Pruning from agricultural production

Pruning from agricultural production includes all wood left over from vineyards and fruit and olive orchards. These quantities have not been recorded for Germany or other European countries. We are therefore using the cultivated areas and specific yields of these areas to calculate prunings. Fruit-growing is limited to citrus fruits only.

We considered cultivated areas for 1998 to 2000 as recorded by FAOSTAT /26/. The largest cultivated areas are in southern and south-eastern European countries. Some estimates of prunings are known for these countries /76/ and can be used to derive the following area-

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[19] Waste wood amounts are calculated from the proportion of individual waste types (commercial waste, bulky waste, construction waste etc.) accounted for by waste wood.

specific factors: 0.5 to 1.7 t_{DM}/(ha·a) for citrus fruits, 0.2 to 0.4 t_{DM}/(ha·a) for olive orchards. The potential calculation assumes that biomass from vine pruning in vineyards remains at the vineyard to form humus. In addition to vine pruning, wood residues are created when vineyards are cleared. Converted area-specific amounts equal 0.8 to 3 t_{DM}/(ha·a).

We assume that around 80% of the different types of pruning can be used to produce energy (H_u=18 MJ/kg_{bdt}).

We assume that the potential of pruning from agricultural production will remain unchanged from 2000 to 2010 and 2020.

3.6.1.2 Herbaceous residues

Straw that results consists of wheat, barley, rye, oats, grain maize, rapeseed, sunflowers and legumes (peas and beans). We assume 20% of all straw can be used to produce energy to take into account different recovery rates, weather and material use (horticultures, litter, etc.).

The amount of straw for 2000 is calculated using harvest quantities and a specific grain/straw ratio for each type of cereal. Data on harvest yields are taken from FAO harvest statistics. The arithmetic mean of the crop years 1999 – 2002 is used to account for annual deviations (due to crop rotation, weather etc.) /26/.

The extrapolation of straw potential for 2010 and 2020 is based on the estimate of country-specific food consumptions for this time span (see section 3.3.2). Population growth is also taken into account. We also assume that an increase in yields will change the grain/straw ratio in favour of grain by 8% on average in 10 years (trend according to /63/). Each rate of change is applied as a percent to cereal, rapeseed, sunflower and legume yields.

3.6.1.3 Other residues

<u>Excrements and litter</u>

To determine the energy potential of biogas from excrements and litter, we take cattle, pigs, chicken and turkeys into account. The calculations assume a total of 68% housing for cattle, chickens and turkeys (85% housing during the 4 winter months and 60% during the rest of the year) and 100% for pigs. The calculations also assume that litter is provided for 15% of animals but do not take into account that some of the straw used for litter is eaten by the animals. Other farm animals such as sheep, goats, horses, geese and ducks are not included because they are normally kept outdoors or produce little manure.

Quantities of excrements and litter for 2000 were calculated from animal stocks. Animal stock statistics were taken from 2000 FAO statistics /27/.

The estimates of the energy potential for biogas for 2010 and 2020 assume that the amount of excrements and litter for pigs, chickens and turkeys remains unchanged. The change in demand for beef and milk (see section 3.3.2) is taken into account in the amount of excrements and litter for cattle. The rates of change are applied to the entire cattle stock as percentages (reference year 2000).

Other agricultural harvest residues

In addition to straw, beet and potato leaves are the primary harvest residues from agriculture that can be used to produce biogas. Calculations assume that 25 to 50% of beet leaves and 17 to 33% of potato leaves are available for producing energy /28/.

The amounts of beet and potato leaves for 2000 are calculated using harvest quantities (FAOSTAT; arithmetic mean of crop years 1998 to 2002 /26/) and a specific root- (or tuber-) to-leaf ratio.

The extrapolated biogas potential of beet and potato leaves for 2010 and 2020 is based on the estimate of country-specific food consumption (see section 3.3.2). The specific root- (or tuber-) to-leaf ratio is assumed to remain constant.

Other agricultural residues

The entire cereal harvest cannot be used as food or feed. Depending on the weather (reduced growth, mycotoxins), 2 to 5% of cereals are not suitable for food or feed. The following potential calculation assumes that 3% of crops are affected. These cereals are available for energy production (combustion, biogas production).

Brewing residues

Brewing residues that can be used to produce biogas include spent grain, yeast and hot wort and cool wort. We assume that 25 to 40% of these residues can be used to produce energy to account for the portion that is used as a material, such as livestock feed /29/.

The volume of beer brewed is calculated from hops processing, as there are no brewing data available for the individual European countries. The quantity of hops processed is calculated from hops cultivation, if available (FAOSTAT, mean value of 1998 to 2002 /26/), and the balance of hops imports and exports[20] (EUROSTAT 2000 /30/). Although the amount of land under hops cultivation in the EU-15 countries declined by over 20% in the past 10 years, beer production increased due to better technology and fewer bitter beers. Calculations assume 100 g hops/hl beer[21].

The potential of brewing residues is assumed to remain constant for 2010 and 2020.

Residues from grape pressing

Pomace (skins, seeds, stems, etc.) left over from grape pressing can be used to produce biogas. It is also used to produce pomace brandies and wine due to its relatively high sugar content and acidity. Pomace can also be used as fertiliser and feed in agriculture. We therefore assume that only 10 to 20% of pomace is actually available for biogas production /29/.

The amount of pomace is calculated from wine production statistics (EUROSTAT 2000 /31/). Around 25 kg of pomace are produced per hectolitre of wine.

The potential from grape pressing residues is assumed to remain constant for 2010 and 2020.

Residues from fruit juice pressing

Residues in the form of peels, cores, etc. and pomace are created during the juicing process. Parts of the residues are used as feed, to produce pectin and as a raw material for alcohol production. These residues can in theory also be used to produce biogas. Due to insufficient data (only production volumes of processed juice concentrates are available at the European

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[20] Given as hop umbels equivalent: 100 kg of ground hops = 110 kg of hop umbels.

[21] The quantity of hops used can vary between 35 and 185 g hops/hl beer depending on the type of beer and bitterness.

level) and the expected low potential (in terms of total potential), residues from fruit juice production are not included in the following potential calculation.

Residues from sugar production

Sugar production creates by-products in the form of treacle and beet pulp. Some of the beet pulp is mixed with treacle, dried and pressed into pellets, which are used as high-energy feed. Treacle is used as a syrup for livestock feed and in yeast plants and distilleries. These uses of the by-products reduce the volume available for biogas production considerably (approximately 1% of beet pulp and approximately 10% of treacle) /29/.

The potential for energy production in 2000 is calculated based on harvest quantities of sugar beets (FAOSTAT 2000 /26/) and 17% sugar content of beets, which is assumed to remain constant. Around 450 kg of beet pulp and 215 kg of treacle are produced for each ton of sugar produced.

The residues from sugar production available for biogas production are assumed to remain constant for 2010 and 2020.

Slaughterhouse by-products and meat processing residues

Certain slaughterhouse by-products resulting from slaughtering and processing can be used as substrate or co-substrate in biogas plants when legal regulations[22] are followed. Ninety percent of slaughterhouse by-products consist of stomachs and rumens, pluck and mucus and up to 10% fat. One-third to two-thirds of these by-products are assumed to be able to be used to produce energy.

Figures on slaughterhouse by-products are based on the number of slaughtered animals (FAOSTAT 2000 /27/) and specific waste quantities for each species. Potential losses (animals that expire without being slaughtered) are not taken into account.

The potential from slaughterhouse by-products is assumed to remain constant for 2010 and 2020.

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[22] Regulation (EC) No. 1774/2002 laying down health rules concerning animal by-products not intended for human consumption of 03 October 2002, updated by Regulation (EC) No. 808/2003 of 12 May 2003

Waste water from the milk processing industry

Waste water from the food and luxury food industry can be used to produce energy in a biogas plant. Only waste water from the milk processing industry is included in this study due to its relevance. Calculations assume that around 50% of waste water can be used to produce energy.

As there are no specific statistics on waste water from the milk processing industry, the ratio of cow's milk collected by dairies to waste water produced for Germany is applied to the other European countries (0.1 m^3 waste water/t cow's milk /28/). Goat's and sheep's milk (around 2% of all milk collected) are not taken into account.

The waste water volume from the milk processing industry is assumed not to undergo any significant changes for 2010 and 2020.

Sewage sludge

Waste water treatment produces sewage sludge, which can be used thermo-chemically or bio-chemically. This study assumes that at least the volume that is already used for combustion can be used to produce energy. The maximum that can be used to produce energy is the amount that is produced less the amount currently used (agricultural use and composting).

EUROSTAT provides data on the amount of sewage sludge and its current use and disposal /32/.

The amount of sewage sludge is assumed to remain constant for 2010 and 2020.

Municipal waste and landfill gas

Organic municipal waste can be used in different ways: in thermo-chemical conversion (combustion), bio-chemical conversion of the separately recorded biogenic category in special fermentation plants and bio-chemically through the use of the gas from storing waste in landfills. In the following the volume and quality of waste stored in landfills is assumed to remain constant over time. In other words, no significant changes are expected in landfill production over the years. The entire landfill gas potential of all possible stored waste of the reference year is allocated to the reference year. The potential of landfill gas from waste from earlier years is not taken into account. Combustion is considered the upper limit for energy potential and landfill gas use the lower limit for determining the fuel potential from municipal waste.

The fuel potential of municipal waste including landfill gas use is assumed to remain constant from 2000 to 2010 and 2020.

Combustion

The energy potential for the thermo-chemical conversion of the biogenic portion of municipal waste is based on the total amount of waste for 2000, which is aggregated in the statistics /33/. Separate categories (such as paper), if data are available, are not taken into account. Forty percent of all waste for all countries is assumed to be organic /111/. An average heating value of 7.9 MJ/kg is assumed. Marginal double counts (wood waste also has potential as waste wood) are not taken into account in the potential calculation.

Landfill gas production

Landfill gas is produced in landfills for domestic waste (shortly after waste is added to the landfill) by microbiological decomposition. The amount of landfill gas is determined by several factors. The landfill volume and composition have a considerable influence on the amount of landfill gas. Other factors affecting landfill gas production include the temperature, water content, structure of the landfill, conversion state of the landfill, start of degasification, gas collection rate, and type and time of surface sealing /75/. This list demonstrates that estimating the potential involves many uncertainties. The specific amount of landfill gas varies greatly and ranges between 120 to 300 m^3 of landfill gas per 1 t of domestic waste /75/.

The potential is derived in this project based on the amount of mixed municipal waste occurring in 2000 /33/. All waste is assumed to be stored in landfills and thus available 100% as landfill gas potential. An average gas formation rate of 180 m^3 landfill gas/t of municipal waste and an average gas collection rate of 50% are assumed /75/. The result is the total amount of landfill gas that can technically be used based on the volume stored in 2000. Note that the total gas volume does not occur in one single year. Instead it is distributed over a long period. The heating value of the landfill gas depends greatly on the methane content and thus varies greatly. The energy potential was calculated using an average heating value of 15 MJ/m^3 /62/.

Residues that are not taken into account

In addition to the categories already mentioned, park maintenance and landscaping create large amounts of residues. These cannot be shown satisfactorily, however, due to the variety of reserves and maintenance activities and numerous gaps in the data and the present knowledge base. Preparing these biomasses is comparatively expensive, with the result that they can only be used for targeted measures. Consequently, they are generally insignificant under present conditions.

Other residues not considered include production residues from food processing (seeds/stones, glumes, peels, etc.). These residues include inedible cereals, which are expected to increase due to increased consumer protection (mycotoxin limits). The data have thus far made it difficult to formulate quantitative conclusions for the European level.

3.6.2 Results

The potential of residues for Germany and the EU-28 countries as a whole are shown in the following. Detailed results for all countries are listed in appendix I.

3.6.2.1 Germany

The energy potential from residues for the reference year 2000 is approximately **380 to 510 PJ p.a.** for Germany. As expected, the results are in line with potentials calculated in the BMU research project “Nachhaltige Biomassenutzungsstrategien” (Sustainable Strategies for Biomass Use) /63/. A detailed description is therefore unnecessary here.

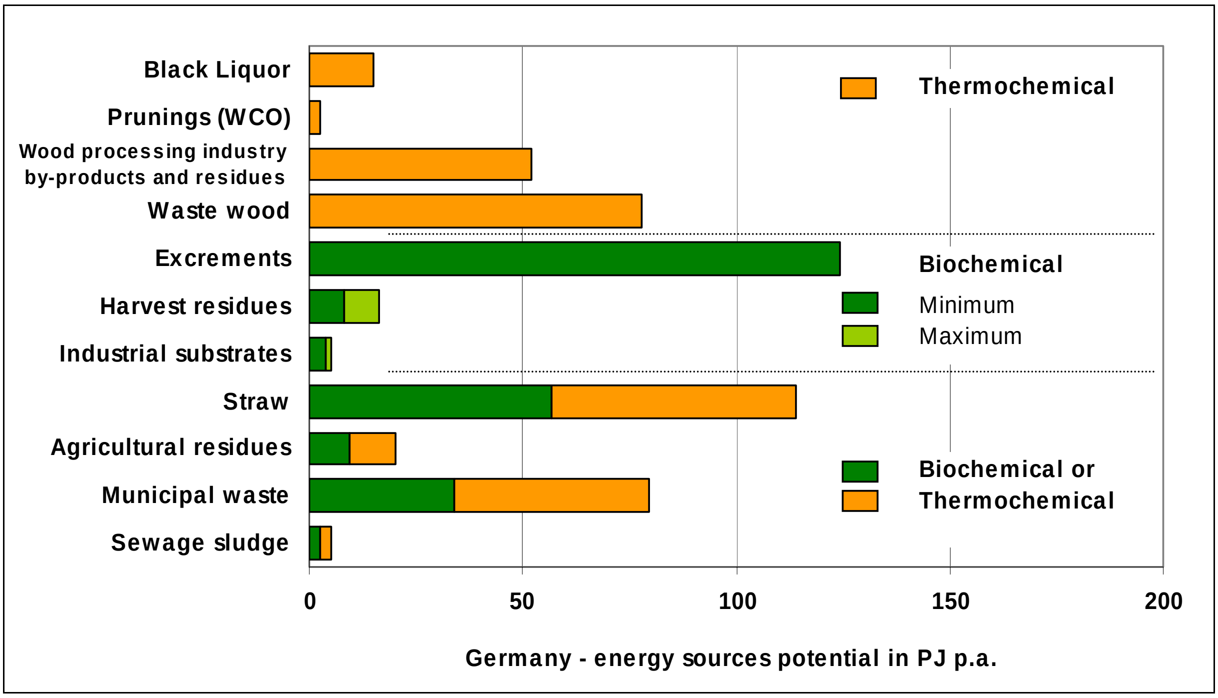
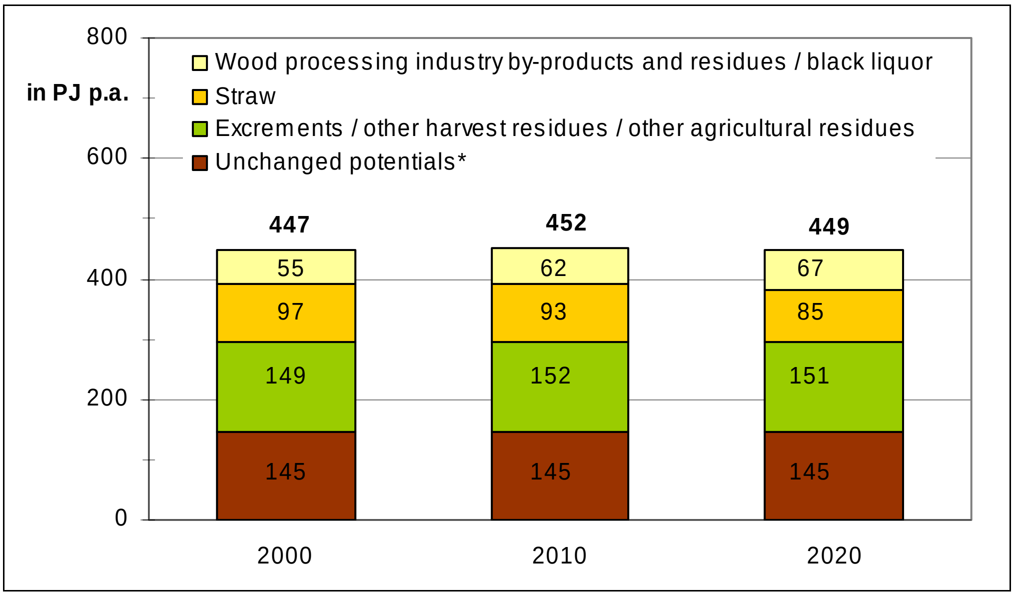


Figure 21: **Energy source potential for biogenic residues in Germany in 2020**

The biomass potentials of residues remain unchanged from 2000 to 2010 and 2020. However, each individual residue group portion of the total potential changes slightly. Whereas the potential of wood processing industry by-products and residues and black liquor increases by around 12 PJ p.a., totalling 67 PJ p.a. by 2020 due to expected increases in roundwood production capacity, the energy source potential of straw decreases by around 7 to 15 PJ p.a., totalling 57 to 114 PJ p.a. due to increases in yield (the grain/straw ratio shifts to the detriment of straw) and a slight drop in population by 2020. Changes in excrements and litter (approximately 124 PJ p.a. in 2010 and 2020), in other harvest residues (beet and potato leaves; approximately 8 to 17 PJ p.a. in 2010 and 2020) and in other agricultural residues (cereals not suitable for food or feed; approximately 9 to 20 PJ p.a. in 2010 and 2020) are less than 1 PJ p.a. The remaining potentials are assumed unchanged since 2000. The potentials of the individual residue categories for 2020 are shown in Figure 21, and the trends in potential in Figure 22.



* Waste wood, pruning, commercial and industrial waste, sewage sludge, org. municipal waste (straw, harvest residues, other agricultural residues, industrial residues, sewage sludge and municipal waste; mean values for each category are given)

Figure 22: **Trends in residue potential for Germany (2000 – 2010 – 2020)**

3.6.2.2 EU-28 countries

The residue potentials calculated for the reference year 2000 and for 2010 and 2020 in the EU-28 countries are described in the following.

Woody residues

Woody residues include wood processing industry by-products and residues, black liquor, waste wood and pruning. The total potential for the EU-28 countries in 2000 is around 1,550 PJ p.a. The extrapolated potentials for wood processing industry by-products and residues and black liquor for 2010 and 2020 is based on the estimated development of roundwood. The potential for waste wood and pruning is assumed to remain constant from 2000. The fuel potential of woody residues also increases due to the increase in roundwood used as material. In the EU-28 countries, the potential increases to approximately 1,670 PJ p.a. in 2010 and approximately 1,770 PJ p.a. in 2020. The distribution across Europe is characterised by the significant wood processing industry in Scandinavia, considerable waste wood potentials in populous countries and selective relevant occurrences of pruning in the southern countries (Figure 23).

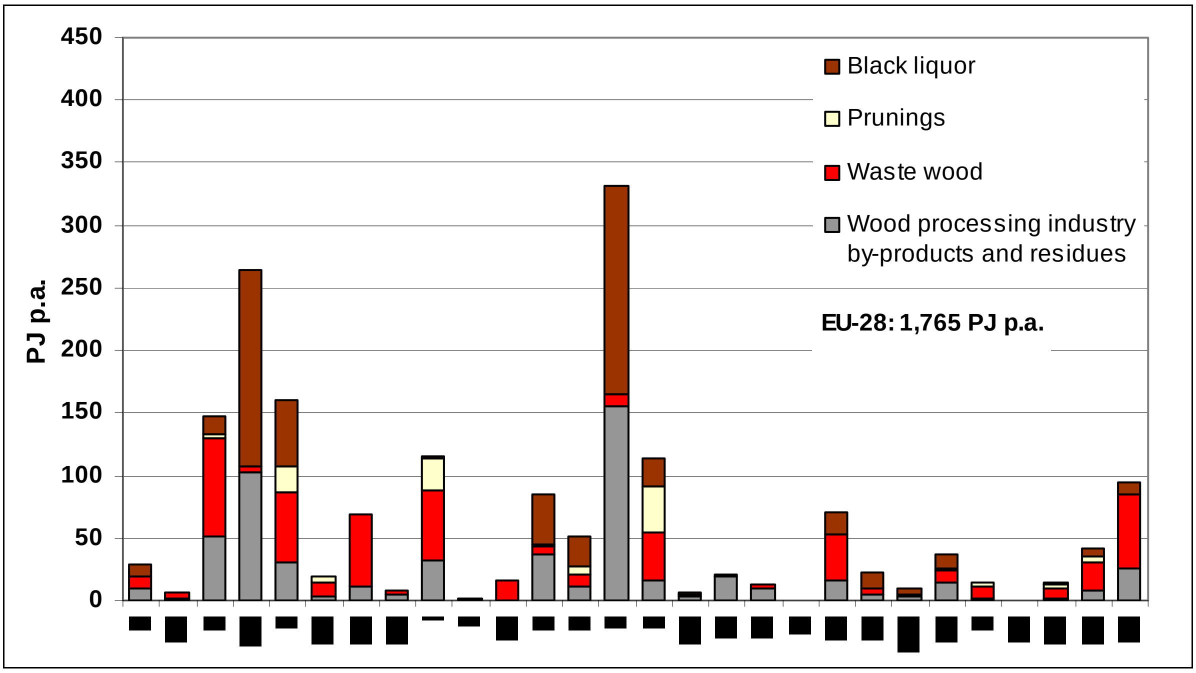


Figure 23: **Energy source potential of woody residues in the EU-28 countries in 2020**

<u>Herbaceous residues</u>

The available straw potential in the EU-28 countries in 2000 is approximately 470 to 870 PJ p.a. depending on the conversion technology. The volume and type depend primarily on the respective basic conditions for cereal cultivation. Maize straw and sunflower straw is more important in the EU-28 countries than in Germany whereas rapeseed and rye straw are much less important (Figure 24).

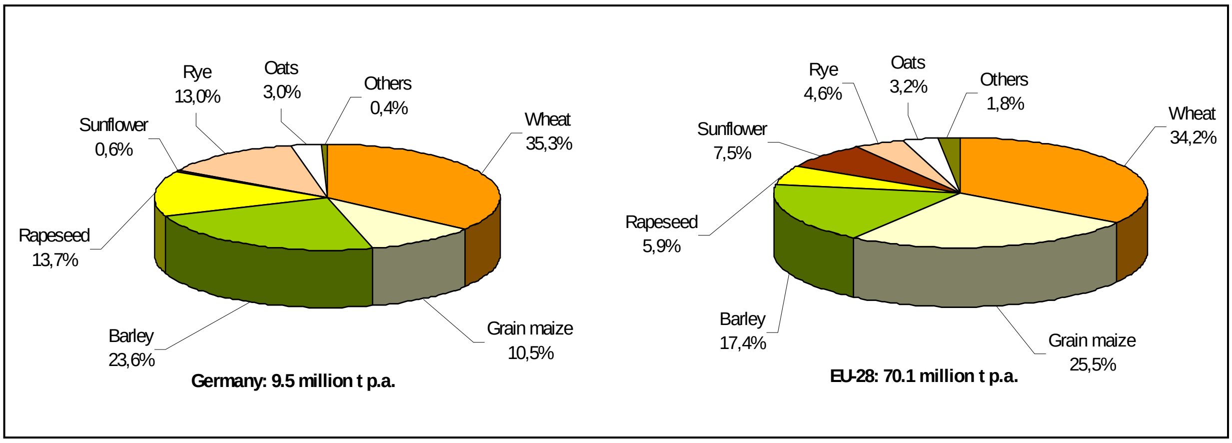


Figure 24: **Percentage of the potential of straw to be used to produce energy covered by individual straw species in Germany and in the EU-28 countries in 2000**

At approximately 460 to 870 PJ p.a., the energy potential for straw barely changes from 2000 to 2010. On the one hand, the amount of straw decreases due to increased yields and the resulting shift in the grain/straw ratio to the detriment of straw. On the other hand, however, the demand for food increases (slightly, due to increasing population in some areas), causing the amount of straw to increase. By 2020 continuing increases in yields and a relatively stable demand for food will cause the potential to drop by up to 6% to approximately 440 to 820 PJ p.a. (Figure 25).

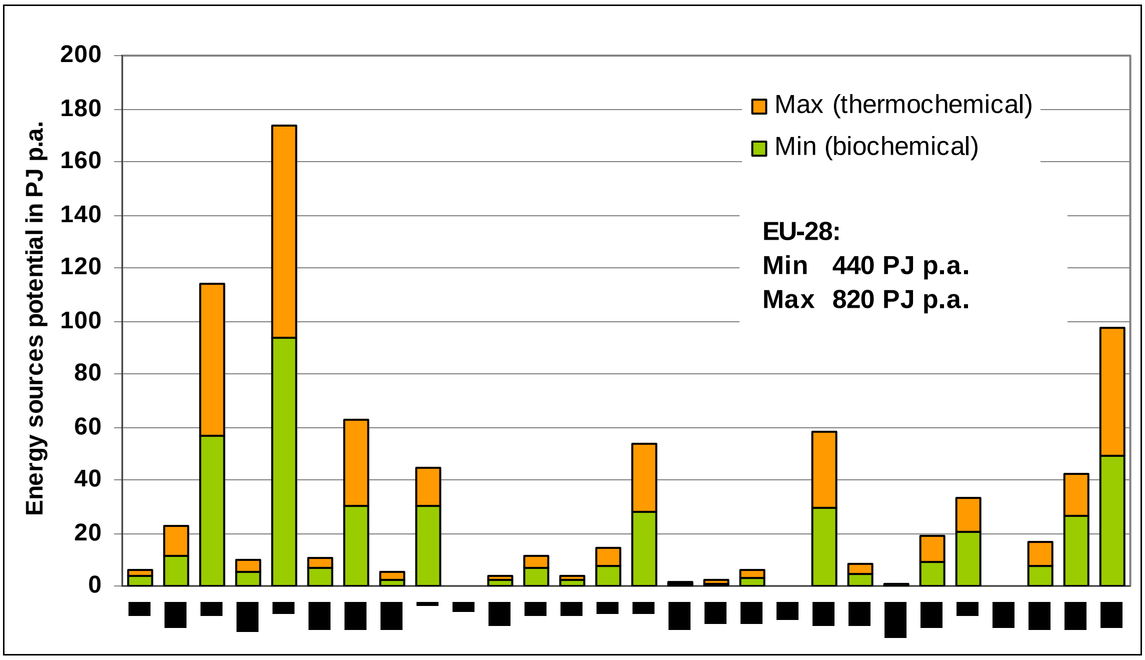
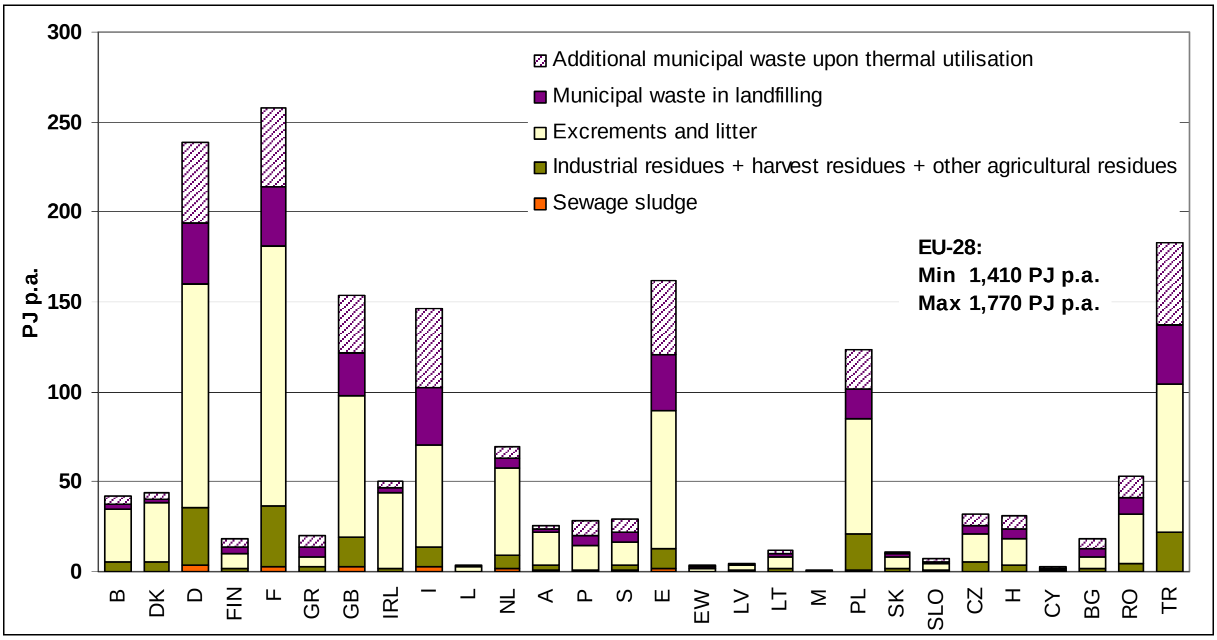


Figure 25: **Energy source potential of straw in 2020**

France and Germany have the greatest straw potential in terms of volume in the EU-28 countries. About half of the EU-28 countries also have significant potential, especially the Central and Eastern European countries with the largest area (Poland, Italy, Hungary, Romania and Turkey), as well as Spain and Great Britain.

Other residues

Other residues include excrements, other biogas substrates in the form of harvest residues, other residues from agriculture (cereals not suitable for food and feed) and industrial substrates, sewage sludge and organic waste (including landfill gas). In the reference year 2000 the energy source potential of other residues is approximately 1,350 to 1,710 PJ p.a. for the EU-28 countries. The potential for 2010 and 2020 is determined by changes in the amounts of excrements, harvest residues (beet and potato leaves) and other agricultural residues (cereals not suitable for food and feed). Other residues (industrial substrates, sewage sludge and organic waste) are assumed to remain constant from 2000. As a result of the expected increase in demand for beef, milk and other food (also in part due to an increase in population), the potential for excrements, harvest residues and other agricultural residues and thus the total potential from other residues increases to approximately 1,390 to 1,750 PJ p.a. in 2010. This trend will continue to 2020 (though to a lesser extent). The total potential of other residues in the EU-28 countries is approximately 1,410 to 1,770 PJ p.a. in 2020 (Figure 26). Throughout Europe, the energy source potential of excrements has proven the most important of the other residues. The potential of organic municipal waste is much greater if we assume largely thermal conversion of the waste. The potential landfill gas that can be used from this waste is much lower, as is expected.



(Industrial residues, harvest residues, other agricultural residues and sewage sludge; mean values for each category are given)

Figure 26: **Energy source potential of other residues in the EU-28 countries in 2020**

Total potential

The total potential of fuel from residues that can be used to produce energy (i.e. taking into account use as material, mass balance, etc.) in the EU-28 countries in 2020 is shown in Figure 27.

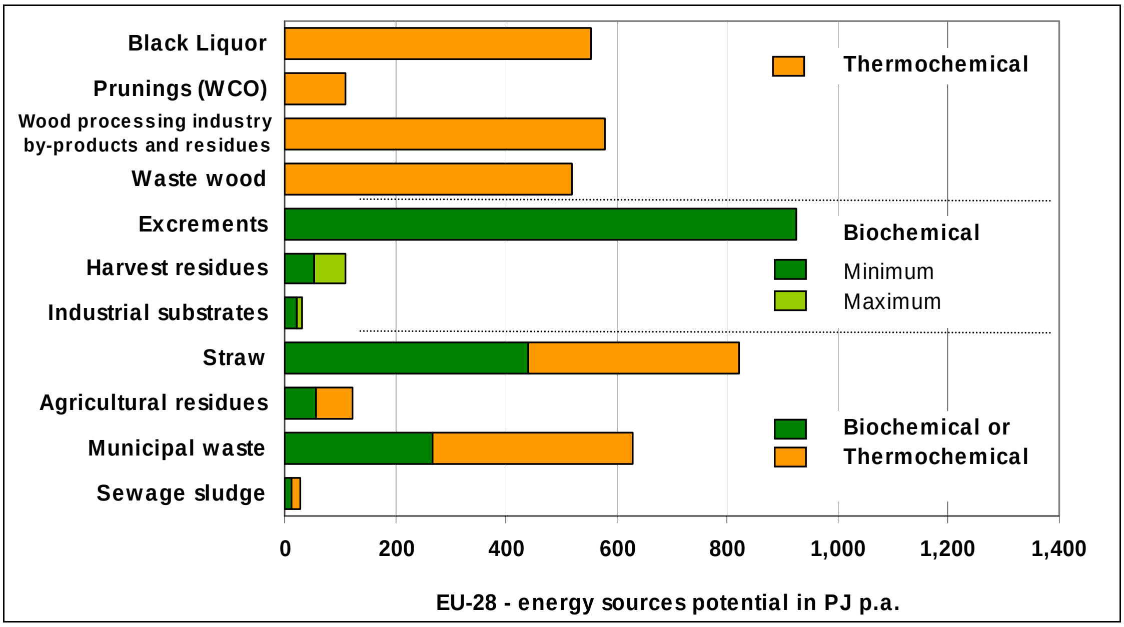


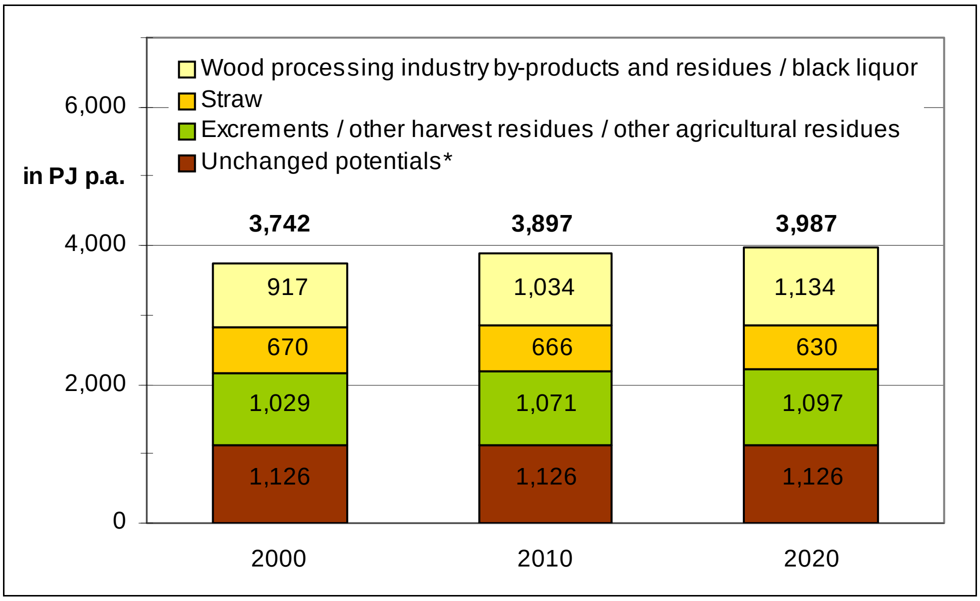
Figure 27: **Energy source potential of biogenic residues in the EU-28 countries in 2020**

Whereas the conversion processes are predetermined for woody biomass and most of the other biomass types, herbaceous biomass, sewage sludge and organic municipal waste can be converted using thermo-chemical or bio-chemical processes. The water content of the material in particular, which can vary significantly, determines which method is used. It therefore does not make sense to assign material to one of the two categories. It is important to remember that the available herbaceous material, sewage sludge and organic municipal waste can only be used once, i.e. either thermo-chemically or bio-chemically. The maximum thermo-chemical potential of residues in the EU-28 countries is approximately 3,350 to 3,380 PJ p.a. for 2020. The maximum bio-chemical potential is around 1,770 to 1,850 PJ p.a. The total potential is approximately 3,540 to 4,430 PJ p.a. depending on the conversion technology selected. Comparing the different potentials shows that woody biomasses account for the greatest proportion of residue potential by far. Agricultural residues are significant in terms of origin. Table 47 shows detailed information in the different residue categories for the EU-28 countries in 2020.

Table 47: Energy source potential of residues in the EU-28 countries in 2020

	Energy source potential in PJ p.a.	
	Thermo-chemical conversion	**Bio-chemical conversion**
Woody residues, by-products and waste		
Wood processing industry by-products and residues	579.6	—
Sawmills	372.2	—
Wood materials industry	111.6	—
Wood pulp industry	95.2	—
Black liquor	555.0	—
Waste wood	519.5	—
Agricultural pruning	111.2	—
Herbaceous residues, by-products and waste		
Straw	822.0	438.9
Cereal straw	567.7	286.9
Maize straw	115.5	113.0
Rapeseed straw	53.1	15.9
Sunflower straw	68.6	14.7
Other straw (peas, beans)	17.1	8.5
Other residues, by-products and waste		
Excrements and litter	—	924.9
Excrements	—	858.8
Litter	—	66.1
Other harvest residues	—	54.8–108.6
Beet leaf	—	35.4–70.7
Potato leaf	—	19.5–37.8
Other agricultural residues	122.4	57.7
Commercial and industrial waste	—	21.7–32.4
Brewing	—	8.0–12.7
Grape pressing	—	2.9–5.8
Sugar production	—	4.9
Slaughterhouse by-products	—	3.0–6.0
Waste water from the milk processing industry	—	2.9
Sewage sludge	10.3–43.8	4.8–20.5
Organic municipal waste (including landfill gas)	628.1	268.3
Total (maximum)	3,348–3,381	1,771–1,851

Figure 28 shows the trends in residue potential for the EU-28 countries. The fuel potential increases by about 6% from 2000 to 2020. This slight increase is due to the increase in the potential of wood processing industry by-products and residues, black liquor, excrements and litter, while the potential of straw decreases slightly.

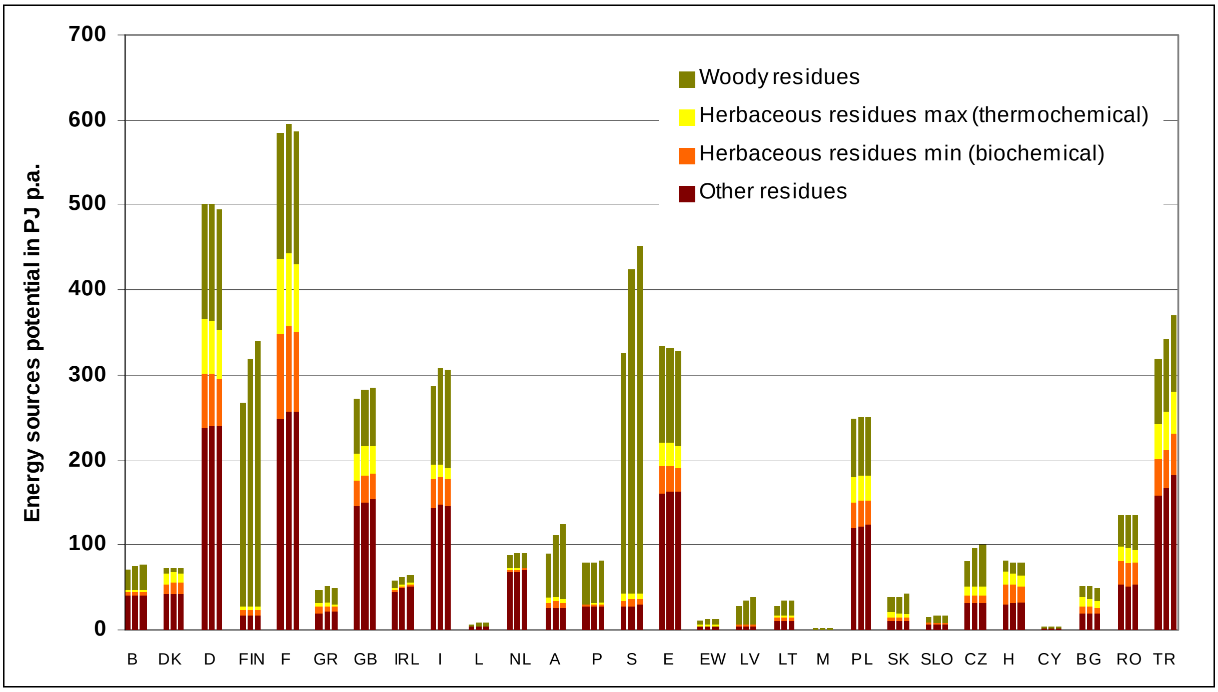


* Waste wood, pruning, commercial and industrial waste, sewage sludge, org. municipal waste

(straw, harvest residues, other agricultural residues, industrial residues, sewage sludge and municipal waste; mean values for each category are given)

Figure 28: **Trends in residue potential for the EU-28 countries (2000 – 2010 – 2020)**

Figure 29 lists the energy source potentials of residues for each EU-28 countries for 2000, 2010 and 2020. The most populous countries, France, Germany, Spain, Turkey, Great Britain, Italy and Poland, have the highest potentials from other residues. The countries with the greatest area, France and Germany, have the greatest straw potentials. Sweden and Finland, however, have the greatest potential from woody residues. It also appears that the total volume of residues is determined primarily by the EU-15 countries, while the acceding and candidate countries (except Poland and Turkey) have only low potentials.



(Industrial residues, harvest residues, other agricultural residues and sewage sludge; mean values for each category are given)

Figure 29: **Energy source potential for residues in the EU-28 countries (2000 – 2010 – 2020)**

3.7 Total potential

The following section describes and discusses the overall potential. Note that, according to the availability of data, different procedures, which do not consider aspects of economic efficiency equally, were selected for residues, forest biomass and energy crops. Consequently, the potentials of energy crops in the reference year are comparatively low, as the selected approach only considers part of fallow land for energy crop cultivation. This approach nevertheless enables a realistic estimate. The total potential is shown for the reference year 2000 and extrapolated for 2010 and 2020 for the two scenarios, CP (use of all agricultural land that is made available for energy crops) and E+ (assuming agricultural and environmental policy oriented towards sustainability criteria) (see also section 3.5.1). The scenarios assume that woody and herbaceous residues as well as other agricultural residues (cereals not suitable for food or feed), organic municipal waste and sewage sludge can be converted in full using thermo-chemical processes. The maximum possible bio-chemical conversion is assumed for residue potentials from excrements, litter, other harvest residues and commercial and industrial waste.

3.7.1 Germany

Figure 30 compares the calculated potentials for Germany. The total energy source potential for the reference year 2000 is approximately 1,075 PJ p.a. (E+ scenario) or approximately 1,150 PJ p.a. (CP scenario). It increases to 1,326 PJ p.a. or 2,150 PJ p.a. by 2020. This increase is due to additional agricultural land becoming available and thus an increase in energy source potentials from energy crops by around 400 or 1,000 PJ p.a. depending on the scenario. At the same time, the potentials from residues and forest wood drop slightly by around 100 PJ p.a.

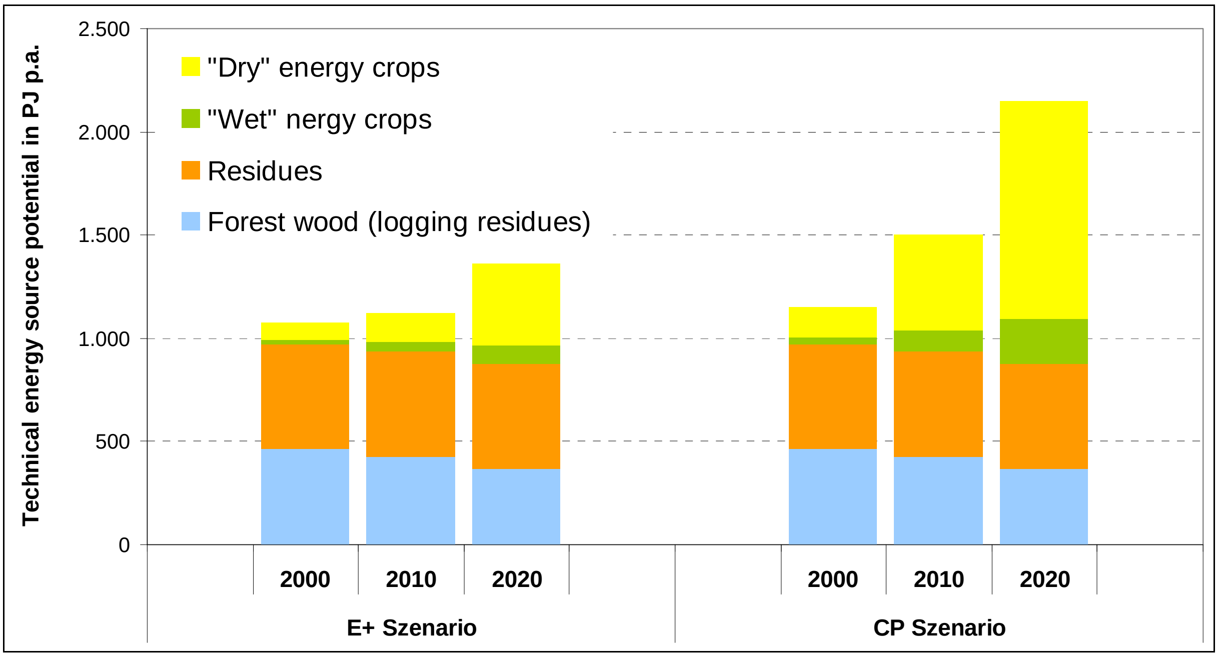


Figure 30: **Energy source potential for Germany**

3.7.2 EU-28 countries

The total energy source potential for the EU-28 countries for 2000 is approximately 7,967 PJ p.a. (E+ scenario) or approximately 8,458 PJ p.a. (CP scenario). The trend to 2020 is similar to that for Germany. While the potentials of residues and forestry wood remain relatively stable (slight decrease by about 300 PJ p.a.), the potentials of energy crops increase by approximately 2,000 or 6,600 PJ p.a. (Figure 31). The total energy source potential for the EU-28 countries in 2020 is approximately 9,550 PJ p.a. (E+ scenario) or approximately 14,750 PJ p.a. (CP scenario).

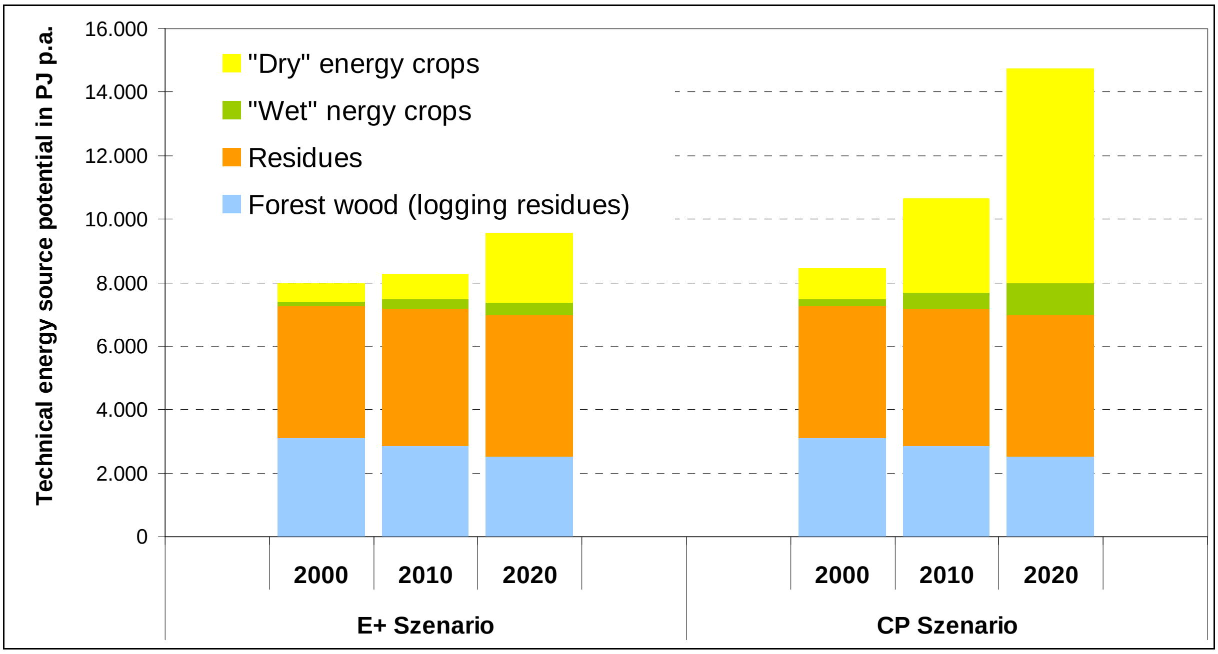


Figure 31: **Energy source potential for the EU-28 countries**

Figure 32 (E+ scenario) and Figure 33 (CP scenario) show the differences in energy source potential by country for 2000, 2010 and 2020. The countries with the greatest potential are France (around 3,200 PJ p.a. for 2020 in the CP scenario), Germany (around 2,150 PJ p.a.), Spain (around 2,200 PJ p.a.), Sweden (around 750 PJ p.a.), Poland (around 1,000 PJ p.a.) and Finland (around 480 PJ p.a.). The greatest potentials for forestry wood is in the northern European countries (Sweden, Finland), whereas the more populated countries in Central Europe (Germany, France) have higher potentials for residues. Germany, France and Spain will have the most important energy source potentials in Europe due to considerable potentials from land that is made available for energy crops.

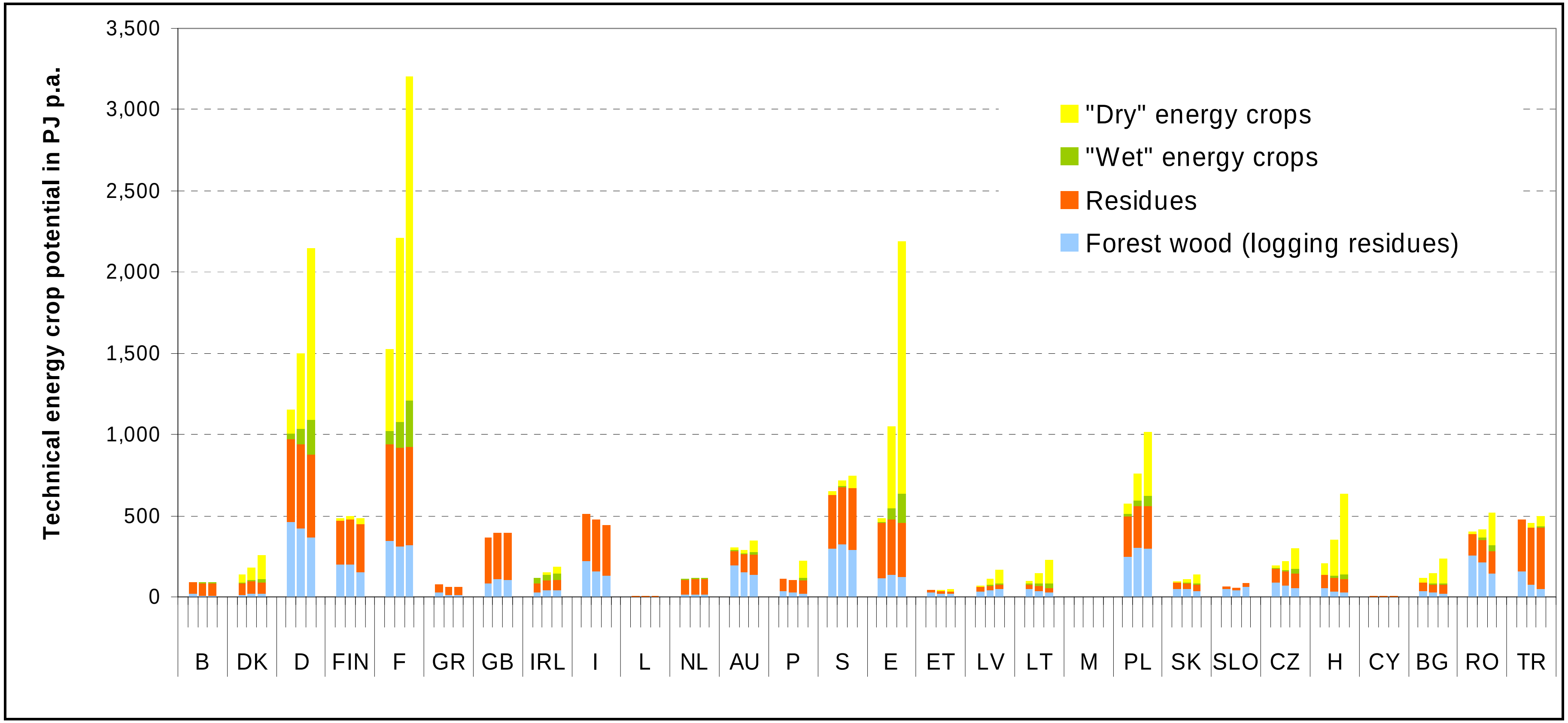


Figure 32: **Energy source potential in the EU-28 countries in the CP scenario**

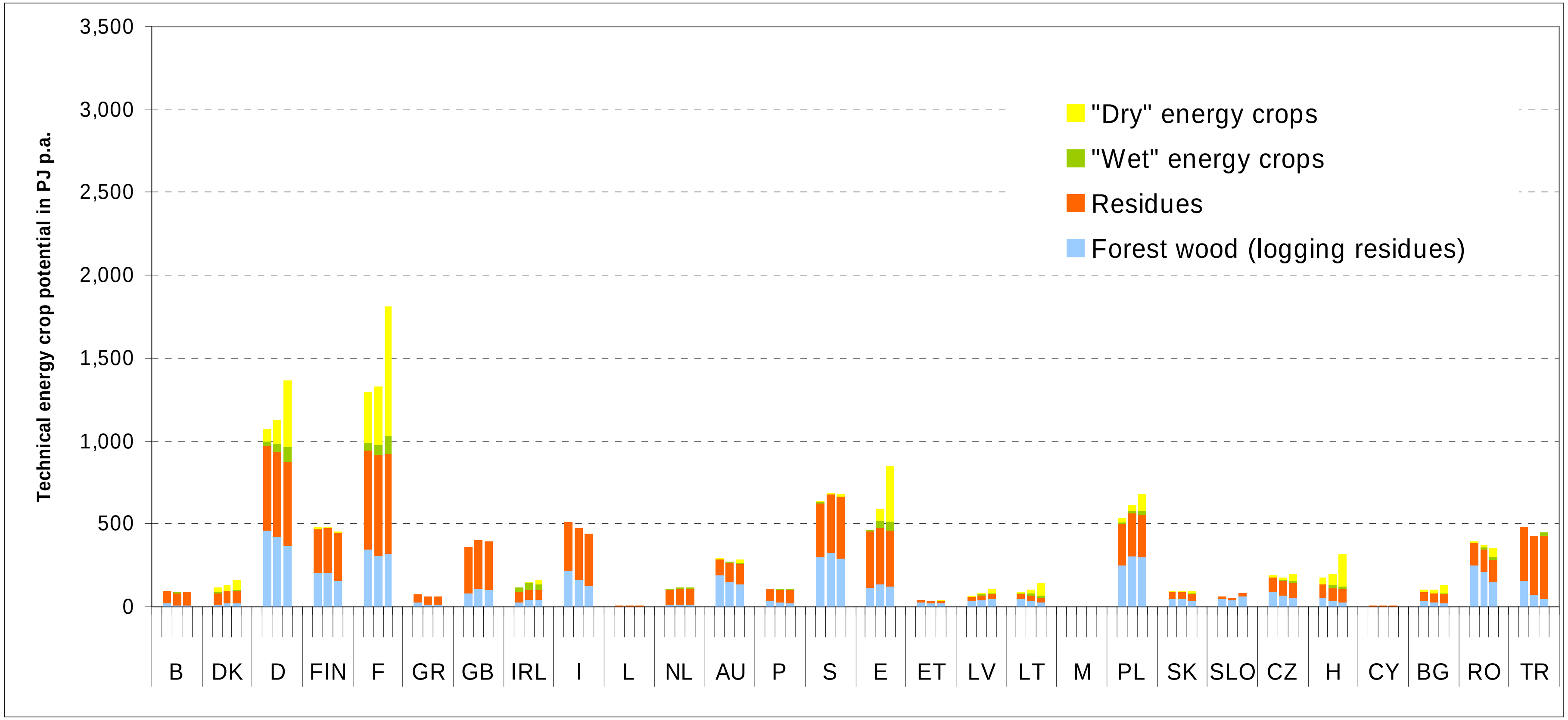


Figure 33: **Energy source potential in the EU-28 countries in the E+ scenario**

If we compare the potentials of the EU-15 countries for 2010 (6,000 PJ p.a. in the E+ scenario and 7,850 PJ p.a. in the CP scenario) to the target biomass use of 5,628 PJ p.a. for 2010 from the White Paper, we see that this target can be achieved with the potentials available, but assuming that no biomass is imported from outside the EU-15 countries, most of the potential must be tapped.

3.8 Putting potentials into perspective

We conclude this section by putting the calculated potentials into perspective. First we will compare our study to other studies (section 3.8.1). The potentials are then compared with regards to the global biomass potential for energy use (section 3.8.1).

3.8.1 Comparison of the results with other studies

The calculated potentials figure among different national and European analyses of biomass potential, which in part use very different methods producing very different results. The results of the precursor studies for Germany will be used for comparison /201//158/. They are given in Figure 34. Of the variety of scenarios, the “Environment+”, “biomass” and “basis” views are comparable and assume that important environmental and nature conservation aims will be achieved while bioenergy is expanded. As expected, the results of these three scenarios differ only slightly with the largest range of variation in energy crops. These results are determined by the agricultural land made available and yield expectations for energy crops, which vary depending on different objectives and data bases.

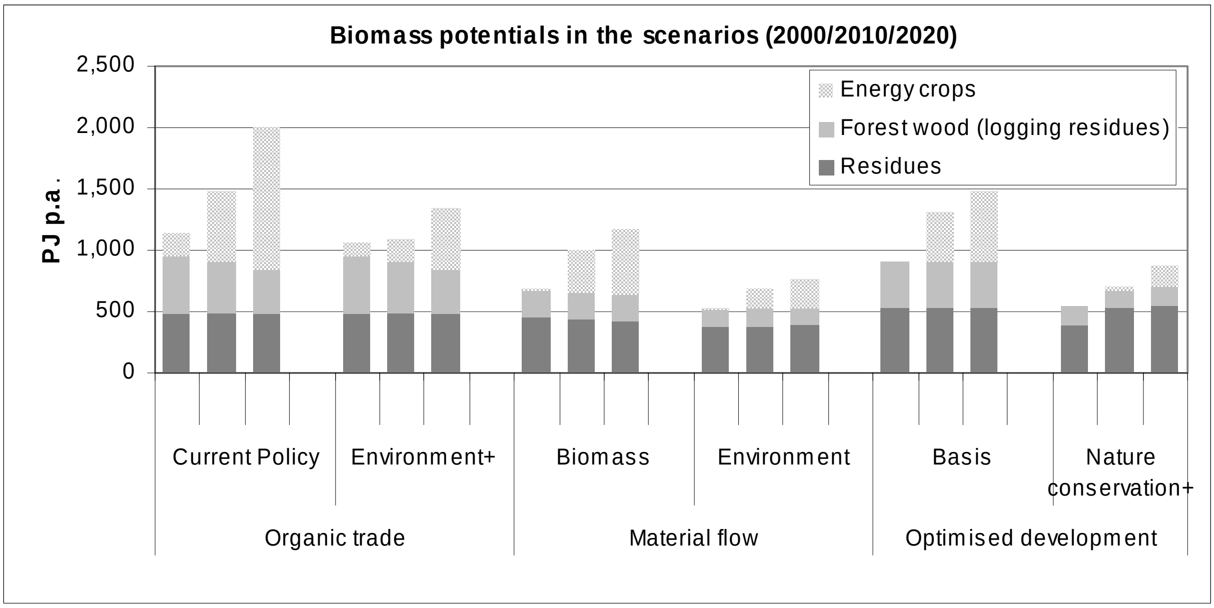


Figure 34: **Biomass potentials in different scenarios**
Source: /158//159/, plus own calculations

In the European context, the potential for energy crops was often calculated using agricultural economics models (e.g. CAPSIM). The results calculated using these models also indicate a sharp increase in energy crop potential, but the EU-10 countries (especially Poland) play a much more important role /210//202/, which is based on assumptions including that these countries are not especially competitive in food production on the liberalised agriculture markets.

3.8.2 Significance of potentials in the global context of world nutrition

With regards to the global context, we can put the European potentials shown into perspective by considering the following two questions:

- How important are Europe’s potentials in a world-wide comparison?
- Should we expect restrictions on the availability of European potentials due to global trends?

Figure 35 compares the amounts of world-wide biomass potentials. It indicates that compared to most other continents, Europe’s potentials are relatively low and account for approximately 8% of the world's potentials of around 100,000 PJ p.a. /164/. Future world-wide energy crop potentials calculated in different studies vary greatly from 10,000 to 160,000 PJ p.a. /175//176//177//178/. In most analyses, the potentials in Africa and South America exceed the present primary energy demand of these continents, enabling biomass use to provide a greater contribution to energy production in the global context than is possible in Europe /164/. As is the case for Germany and Europe, suitable conditions for environmentally friendly preparation and use must be applied to conversion. These conditions are not examined in detail here.

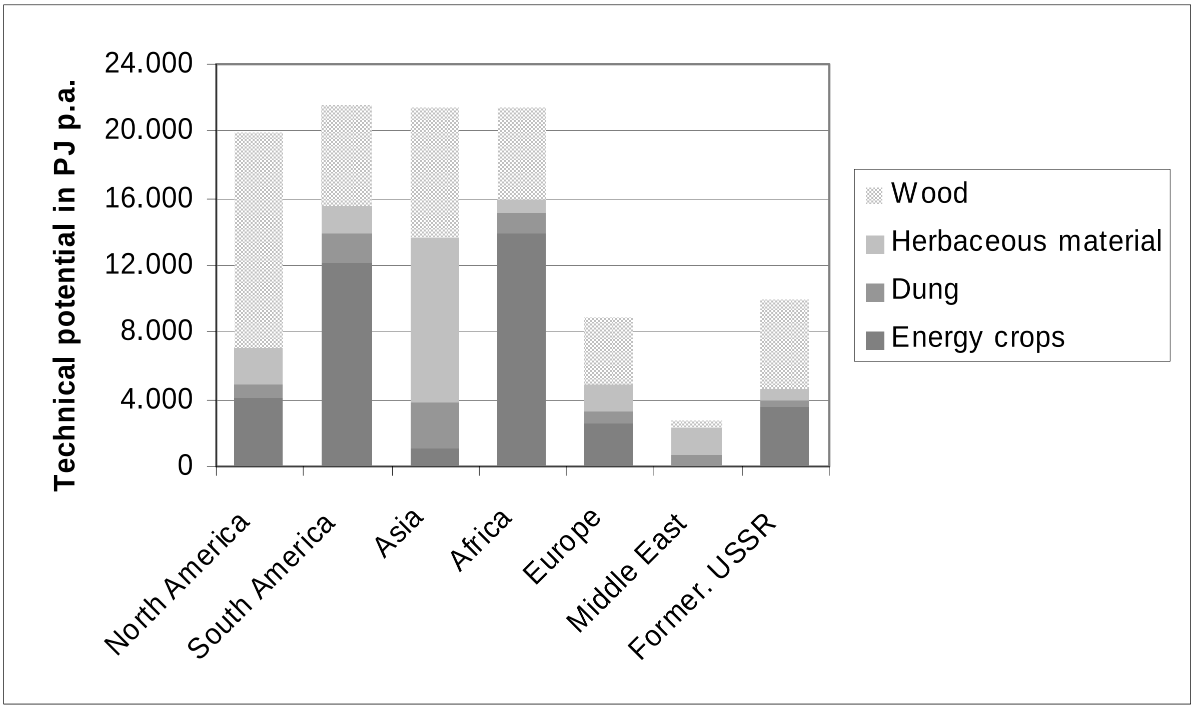


Figure 35: **World-wide technical potentials of biomass for energy use**
Source /164/

With regard to the second question, development in the world's nutrition situation is especially relevant, as it could led to Europe supplying more food, which would affect the available land and thus the potentials for energy crops. As a comprehensive analysis of expected developments would be beyond this study, this topic was the subject of an expert workshop on world nutrition and biomass use in 2030. The important results can be summarised as follows:

- In future, the world’s demand for food will continue to increase. The increase is expected to be lower than was predicted in the past. The Chinese and Indian markets are difficult to estimate, however. The supply of food is expected to come from existing agricultural areas in particular (60-80%) and additional land. New land is expected to be developed in Africa and South America in particular.

- On the supply side, the world food market was characterised by an excess supply in the past, which caused prices to drop. In future, this trend could slow due to decreased supply growth (limited availability of land and slowing advances in productivity), potentially leading to increasing global market prices. This effect would be reinforced by an additional demand for energy crops.

- The world’s fat and oil markets are already characterised by many non-food products. Demand has increased considerably in the food sector and in oleochemical and biodiesel production. The increase in demand will be covered primarily by increased production capacities for palm oil (Southeast Asia) and soya oil (Brazil and Argentina). The potentials of vegetable oil for energy production are limited throughout the world as it is in Europe.

- At 26 million ha, organic agriculture has a niche function in the world and will increase an estimated 5 to 10% per year. With regard to consumer behaviour, slight downtrends in the medium term, for example in the demand for fats and oils in industrialised countries, are expected but are not yet apparent.

- The former CIS countries are undergoing transformation and are therefore currently importing much of their food. Once the transformation is complete, yields will increase again significantly and due to the drop in population, considerable potential will be available for energy crop cultivation. Exports of energy crops and their refined products (biofuels) to the EU can be expected.

- Many developing countries also have considerable potential for growth for food supply (e.g. Sub-Saharan Africa). Whether and how technical possibilities can be made useful depends greatly on the political conditions, which must ensure access to these possibilities.

- In the global context, wood is already used primarily as a fuel with developing countries showing the fastest growth rates. A world-wide energy wood trade is unlikely due to the high logistics costs, but refined products could be transported due to the introduction of BTL technologies on the market. We also expect cultivation of firewood on plantations to increase.

- In the coming years, products will be redistributed on agricultural markets resulting in new balances. The distinction between food and energy crop markets must be questioned to encourage expansion of analyses and models of the food market.

The expected European biomass potentials must not be negatively influenced by immediate demand for food. However, a variety of market effects can result, which are decided upon based on the excellent characteristics of energy crop cultivation. Examinations of food production and bioenergy supply must be more interconnected than they are now to achieve these effects.

4 Demand for biomass

The demand for biomass and for the energy (sources) produced from biomass is steered by the framework of the energy industry. Building on the analysis of this framework provided in section 2.1, this chapter incorporates the qualitative and quantitative demand for bioenergy in Germany, and in the EU-28 countries. The current demand, how demand has developed in the past (section 4.1), and the estimated future demand for biomass (section 4.2) are all described. In addition, the options for transregional measures to meet demand are analysed and evaluated (section 4.3).

4.1 Current use

4.1.1 Germany

The use of biomass for energy has increased considerably in Germany during the last 10 years, and is traditionally characterised by a high contribution to heat generation. Overall, biomass use occurs by employing solid, liquid, and gaseous bioenergy sources, details of which are provided in the following.

Solid bioenergy sources

Biogenic solid fuels are used in the generation of electricity and heat. At the end of 2005, there were around 115 biomass (CHP) power stations, with an installed electrical capacity of around 880 MW_{el} (Figure 36) /143/. As fuel, approximately 4 – 4.5 million t of wood (85% waste wood) were used /169/. In addition, around 1.9 TWh of electricity was generated from biomass in the form of renewable waste components in waste incineration plants /143/.

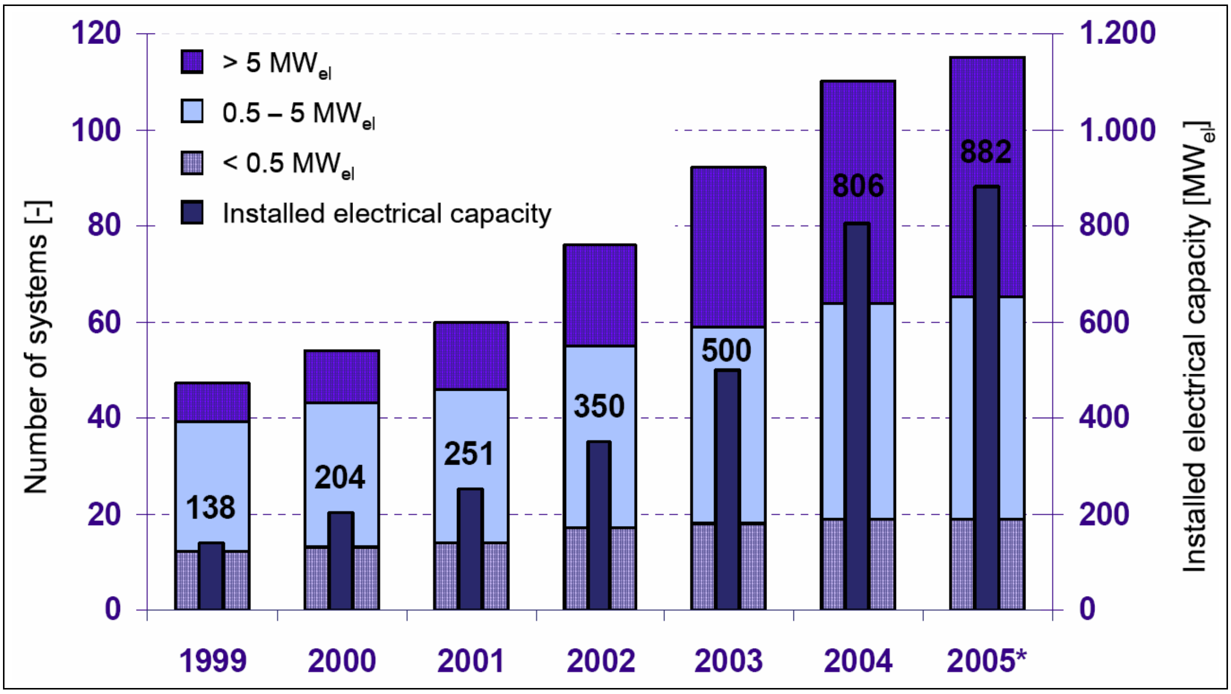


Figure 36: **Development of the total installed electrical capacity of biomass (CHP) power stations in Germany**
Source: data from /142/

It is considerably more difficult to make statements regarding heat generation from solid biomass. Currently, the total use of solid biomass for the exclusive generation of heat is estimated at around 220 to 260 PJ p.a. /156/, whereby the strongest contribution is made by the more than 130,000 boiler systems in the output range of 15 W to 1,000 kW. No notable rate of increase has been evident in the recent past. Wood is used almost exclusively; the utilisation of straw to produce energy is comparatively low.

Despite high rates of increase, the use of wood pellets is also still at a comparatively low level. In 2004, approximately 6,600 (2002: approx. 4,700; 2003: approx. 6,000) new pellet heating systems were installed. The fuel required by the approximately 26,000 pellet heating systems in operation at the end of 2004 was thus around 140,000 t p.a. The pellet production capacity in Germany climbed from 72,000 t p.a. at the end of 2002, to around 227,000 t p.a. at the end of 2004 /183/.

Gaseous bioenergy sources

Power generation from biogas has established itself among the gaseous bioenergy sources. Mid-2005, a total of around 2,300 biogas systems were in operation, with a total of around 350 MW$_{el}$ (Figure 37), whereas for the year 2005, a considerable build-up of activity isevident, so that by the end of the year 2005, well over 400 MW_{el} of installed capacity can be expected.

Furthermore, power and (to a lesser extent) heat is generated by means of the utilisation of landfill gas and sewage gas. At the end of 2003, approximately 350 landfill gas plants, with an installed electrical capacity of around 250 MW, and an estimated 1.1 TWh p.a. of generated power, were in operation /142/. In 2002, a total of 780 GWh of electricity was generated in around 700 sewage gas plants with an installed capacity of about 150 MW. A similar order of magnitude can be expected in 2005.

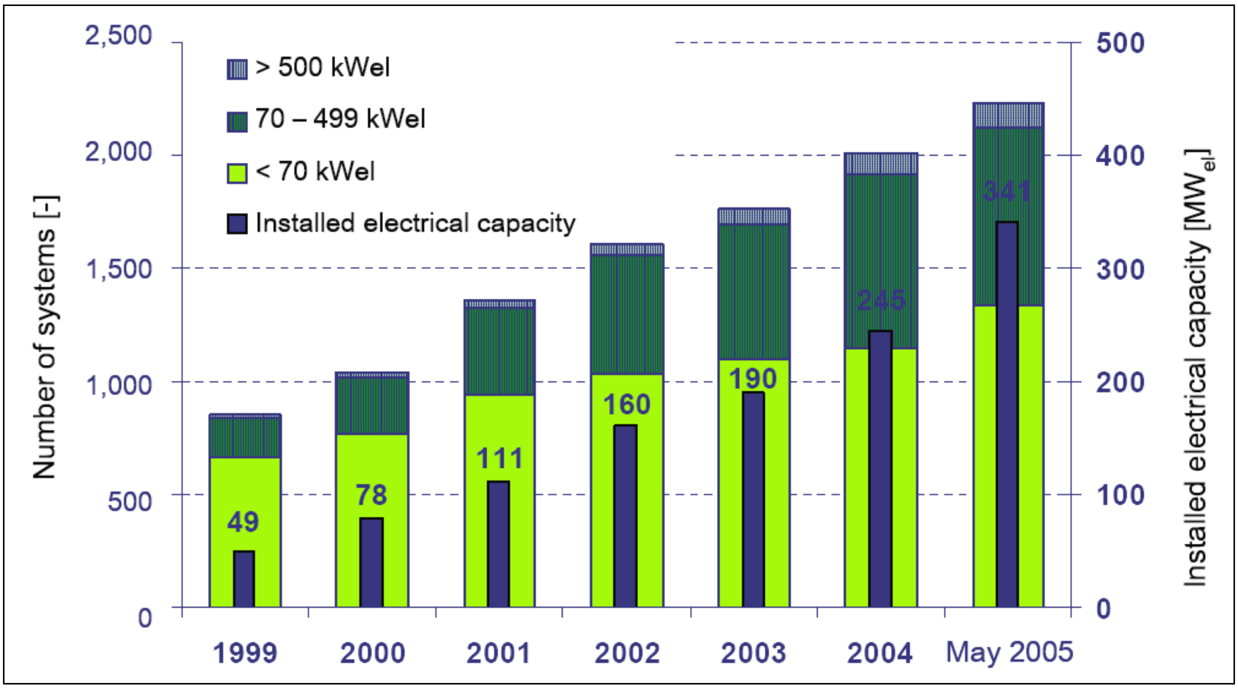


Figure 37: **Development of the number of biogas plants and installed electrical capacity in Germany**
Source: data from /143/

Liquid bioenergy sources

The biofuels in use up until the end of 2004 were almost exclusively biodiesel (rapeseed oil methyl ester – RME) and to a much lesser extent, natural rapeseed oil. The production and use of biodiesel has continued to increase in Germany since 1999, and at the end of 2004 was around 1.21 million t p.a., which corresponds to about 44 PJ p.a. (Figure 38). A further increase in biodiesel production capacities to around 2 million t is expected in 2005, and biodiesel sales of over 60 PJ are predicted /161/.

In addition, since the end of 2004, approximately 500,000 t of bioethanol can be produced annually in Germany /161/. Currently, bioethanol is mainly used by means of blending, in the form of ETBE (ethyl tertiary butyl ether), an antiknock agent with a bioethanol basis.

The sale of biofuels climbed to around a million tons in 2004, and achieved a 1.6% share of total fuel consumption in Germany (56 billion litres of diesel and petrol) /225/. Thus, the production of biofuels has increased ten-fold within 5 years. With sales of 34,000 tons, the significance of bioethanol compared to biodiesel was very low, yet capacities are on the increase. /170/

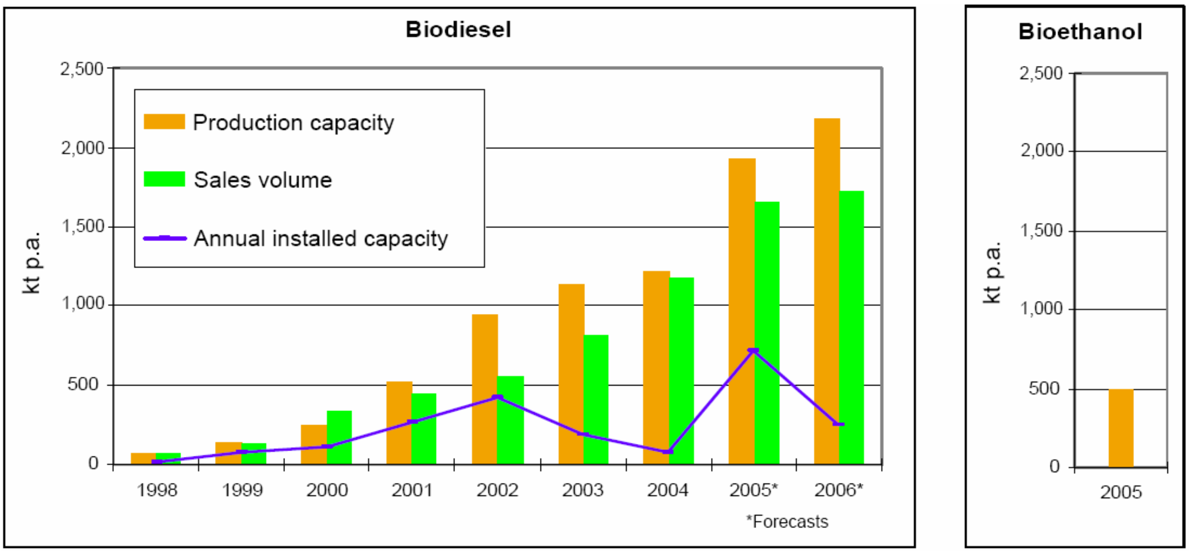


Figure 38: **Biofuel production capacities and the respective annual increase**
Source: data from /161/

Currently in Germany, renewable raw materials produced to be used for energy account for a share of just 4% of agricultural land, and only a small fraction of the multifaceted and substantial utilisation potential is being exploited.

The development of renewable raw materials over time shows that uses in the areas of technical industry and the food industry, especially of starch, sugar, and fibre plants, find only a limited sales market with stagnating demand, while the production of plant oils to be used for energy has been expanded in the last four years from 250,000 ha to around 700,000 ha Figure 39. Due to the framework of the amendment to the EEG, increased investment is expected, especially in the installation of biogas systems, which increasingly utilise agricultural raw materials, such as silage maize, grass, etc., in co-fermentation. Also in the fuels sector, the prerequisites for tapping into significantly larger potentials of agricultural biomass have been put in place (see section 2.1.1). It can be expected that agricultural mass products which are being disposed of on the global market via subsidised and non-subsidised exports, will be drawn on for future utilisation in the production of biofuels. The relevant conversion facilities are already being installed.

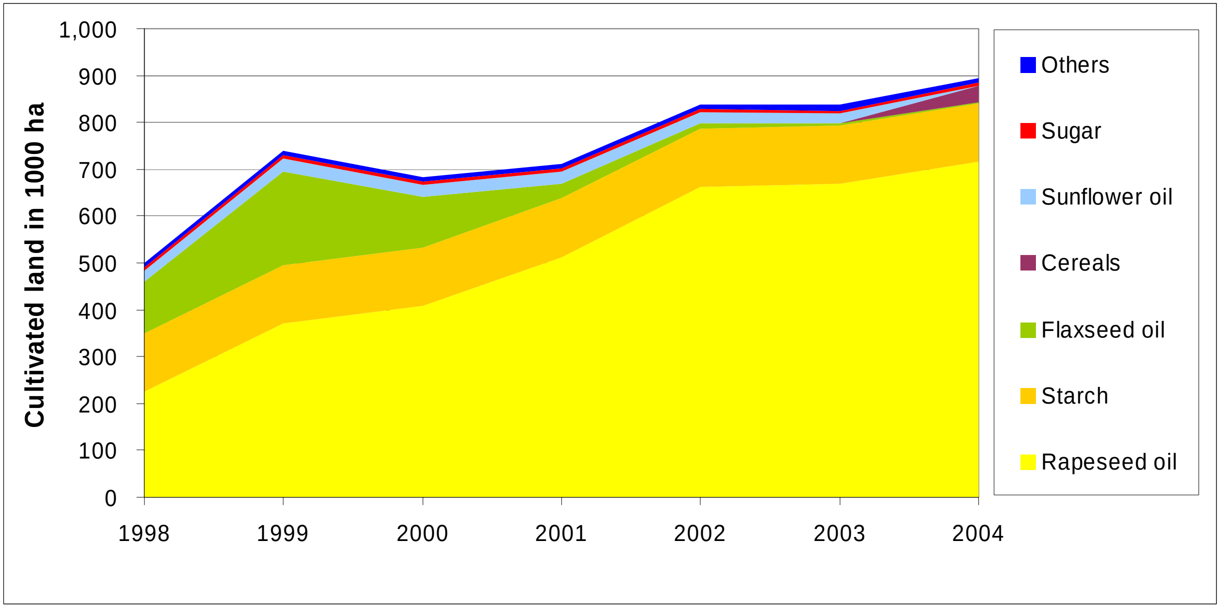


Figure 39: **Production of renewable raw materials on set-aside and non-set-aside land in Germany (in 1,000 ha)**
Source: data from /118/

4.1.2 Europe

In 2004, the supply of final energy from biomass in the EU-25 was around 2,200 PJ p.a., whereby 90% of that was accounted for by the EU-15 /171/.

The use of biomass for heat generation is also dominant Europe-wide (Figure 40). Like in Germany, the use for energy in the period from 1997 to 2002 in the EU-15 exhibits a clear upward trend in the heating sector (approx. 13%), while afterwards the production of electricity and fuel increases markedly. In the acceding countries, the heating sector also shows a considerable increase after 2002, which however may partly be due to changed data collection methods in the respective years.

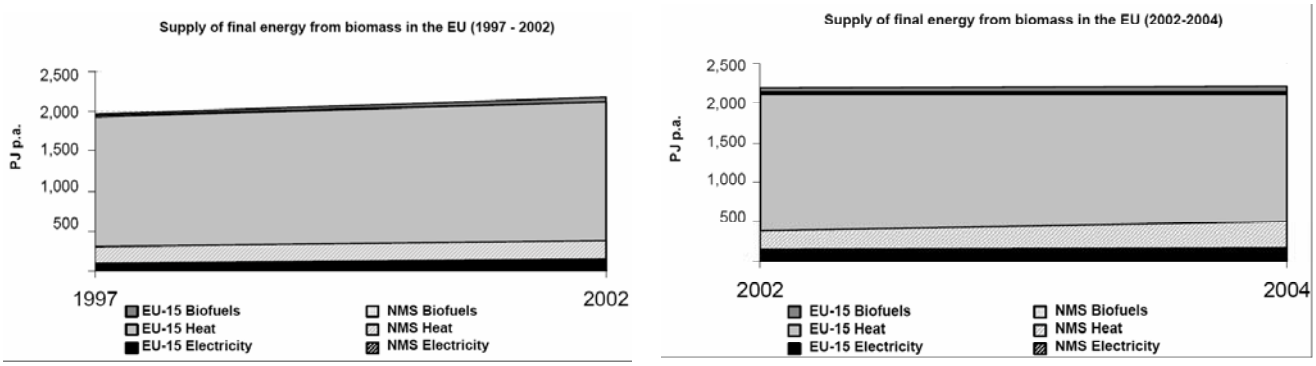


Figure 40: **Development of biomass use in the EU**
Source: figures from /171//172//173//174/

On examination of the situation in the individual countries, a very non-uniform picture emerges (Table 48). For instance, the share of the gross domestic energy consumption in the year 2000 covered by bioenergy (without waste) ranged from less than 1% (e.g. Belgium, Luxembourg, Slovakia and Cyprus) to over 25% (Latvia), but the 10% mark was only reached in a few countries. With regard to the annual growth rate, it was particularly the countries with a high bioenergy share of their gross domestic energy consumption in the heating sector which partly exhibited a declining trend (e.g. Austria, Denmark, Estonia, and Latvia), which may be due to non-sustainable supply systems, or limits in market development. Power generation shows a strong growth rate in most EU-15 countries, while in the acceding countries, there are only isolated instances of activity. During the observed period, fuel production was only notably present in a handful of EU countries. Thus, in general, the data shows a market on the move, the further developments of which are difficult to estimate on the basis of current trends.

Table 48: **Biomass use in the European Union 1997, 2002, and 2004**
Source: figures from /171//172//173//174/

	Heat production (PJ)				Electricity generation 2004 (TWh p. a.)				Fuels 2004 (PJ p.a.)			
Source:	EC		IEA / EuroObserver		EC		IEA / EuroObserver		EC		EuroObserver	
	1997	**2001**	**2001**	**2004**	**1997**	**2002**	**2002**	**2004**	**1997**	**2002**	**2002**	**2004**
Belgium	12,0	16,1	9,0	12,0	0,3	0,7	0,8	0,9	0,0	0,0		0,0
Luxembourg	1,0	1,0	1,0	1,0	0,0	0,0	0,0	0,1	0,0	0,0		0,0
Denmark	40,0	37,3	25,0	29,0	0,9	2,1	2,2	3,2	0,0	0,4	0,4	2,6
Germany	179,0	229,4	328,0	224,0	2,4	5,6	6,2	9,3	3,6	21,8	20,4	38,9
Finland	180,0	201,7	157,0	196,0	7,0	9,9	10,5	10,1	0,0	0,0		0,0
France	383,0	400,6	343,0	368,0	3,1	3,5	3,2	3,9	12,8	19,5	15,4	15,6
Greece	38,0	40,3	40,0	39,0	0,0	0,0		0,1	0,0	0,0		0,0
Great Britain	38,0	29,3	13,0	33,0	2,0	4,9	4,9	7,0	0,0	0,1		0,3
Ireland	5,0	6,1	6,0	6,0	0,1	0,1	0,1	0,1	0,0	0,0		0,0
Italy	190,0	235,0	26,0	41,0	0,7	1,8	4,9	2,6	1,9	6,8	8,2	11,9
Netherlands	14,0	13,6	5,0	10,0	1,2	2,5	2,8	3,3	0,0	0,0		0,0
Austria	106,0	99,4	112,0	129,0	1,7	2,0	1,5	1,9	0,5	1,1	1,1	2,1
Portugal	78,0	78,9	67,0	100,0	1,0	1,7	1,5	1,3	0,0	0,0		0,0
Sweden	226,0	209,1	289,0	280,0	2,8	4,0	4,1	6,4	0,0	1,7	1,7	1,4
Spain	137,0	141,6	144,0	149,0	1,1	4,0	2,5	3,5	0,0	5,0	5,0	5,7
EU-15	**1628,0**	**1739,0**	**1563,0**	**1616,0**	**24,0**	**43,0**	**45,0**	**54,0**	**19,0**	**56,0**	**52,0**	**79,0**
Estonia	22,0	16,7		6,0	0,0	0,0		0,0	0,0	0,0		0,0
Latvia	31,0	24,8		54,0	0,0	0,0		0,0	0,0	0,1		0,0
Lithuania	19,0	24,0		29,0	0,1	0,1		0,0	0,0	0,0		0,2
Malta	0,0	0,0		0,0	0,0	0,0		0,0	0,0	0,0		0,0
Poland	108,0	106,3	166,0	158,0	0,0	0,0	0,5	0,7	2,3	1,1	1,8	1,0
Slovakia	2,0	4,3		12,0	0,0	0,0		0,1	0,0	1,3		0,6
Slovenia	7,0	16,0		17,0	0,1	0,1		0,1	0,0	0,0		0,0
Czech Republic	15,0	18,1		37,0	0,5	0,6	0,0	0,7	1,9	2,5		2,2
Hungary	10,0	12,6		27,0	0,0	0,0	0,0	0,7	0,0	0,1		0,0
Cyprus	0,0	0,1		0,0	0,0	0,0		0,0	0,0	0,0		0,0
EU-10	**216,0**	**223,0**	**166,0**	**340,0**	**1,0**	**1,0**	**1,0**	**2,0**	**4,0**	**5,0**	**2,0**	**4,0**
EU-25	1844,0	1962,0	1729,0	1956,0	25,0	44,0	46,0	56,0	23,0	62,0	54,0	83,0

4.2 Future demand

4.2.1 Energy scenarios

The future demand for biomass to be used for energy will be shaped by the political objectives of the European Union and its member states, and steered by an adjusted energy industry framework. Thus, the mandatory targets of biomass use for energy can serve as a basis for estimates of future use. Due to the fact that these mandatory targets are only available to a very limited extent, such a method is not currently possible.

As the best available compromise, energy industry scenarios can be used, each of which assumes a particular political framework. In so doing, many different scenarios are conceivable, and have been calculated, however in such scenarios, biomass use is often only considered as a sideline element (e.g. /138//163/) and if it is considered, then generally on a supply-side basis, i.e. available potentials are exploited, but no import option is included (e.g. /158//159//160/). Energy scenarios to be used here as a basis must also offer Europe-wide results at the national level and, due to the dynamic development of biomass use in recent years, be highly up to date.

In the following, the modelling used in the FORRES 2020 study which was completed in April 2005 will be used as a basis /160/. The study analyses the future establishment of renewable energy sources in the EU-27 (EU-25 plus Bulgaria and Romania) up to the year 2020 within various political frameworks, on the basis of a techno-economic modelling of the market penetration of renewable energy sources, and draws conclusions for biogenic heat, biogenic electricity, and biofuels in the individual member states. To determine the final energy demand, there are on the one hand comparative quantitative analyses of the interactions between renewable and conventional energy sources in the electricity grid (via the computer models Green-X and ElGreen), and on the other hand projections of the technical growth rates of (non-grid-connected energy sources) heat and fuels with reference to econometric models. These models incorporate the effects of technological advances and economies of scale /160/.

The scenarios considered differ from each other, in that they are based on different intensities of measures employed for the introduction of renewable energy sources[23]:

The **business-as-usual scenario** (BAU) models future development based on current political developments in the promotion of renewable energy sources, and on the existing barriers and restrictions, e.g. administrative and regulatory barriers. Future political developments which have already been decided on, but not yet implemented, are also taken into account /160/. This scenario will subsequently be referred to as the **Cuerrent policy scenario** (CP).

The **policy scenario** (PS) models future development based on the best practice strategies of the individual EU countries. Here, the support measures which can be considered the most effective with regard to the implementation of renewable energy sources' share of volume are applied to all member states. This includes, for example, the German EEG, tax exemptions for biofuels, and national investment programmes similar to the MIP. Moreover, this scenario

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[23] FORRES 2020 does NOT present an authoritative model of the EC, nor of the individual member states, but rather the possible development if the framework is retained or extended in the member states.

assumes an unchanging planning horizon and retention of the current social and technical barriers /160/. Two fundamental assumptions of the FORRES models must be taken into account upon incorporation and further application of the Advanced Renewable Strategy Scenario:

- The support of renewable energy sources in the E+ scenario is not comprehensively optimised from an economic-ecological point of view[24]. Thus, when considered in economic terms, modified strategies can be advantageous in individual member states.
- The option of biomass imports is not taken into consideration, i.e. the demand for biomass is "cut off" upon exhaustion of the biomass potentials. This effect emerges in particular with this policy scenario in the year 2020 in the biofuels sector /165/.

For a representation of future trade options, the exclusion of import options seems unreasonable. For this reason, the FORRES prognoses will be supplemented here by the 2020 targets of the European Biofuels Directive currently in discussion: at present, these targets vary between 8% and 20% (/22//26//27/) and for the sake of this example will be incorporated as 15%. This example value is to provide a boundary value scenario which assumes a very far-reaching bioenergy use in Europe, and to allow a comprehensive discussion of the corresponding material flows. This scenario will subsequently be referred to as the **Environmantel + scenario** (E+).

4.2.2 Germany

Figure 41 depicts the demand for bioenergy for electricity, heat, and fuels in 2000, 2010, and 2020. As a comparison, this is juxtaposed with the results of the scenario modelling of the material flow project. This material flow project includes a REF scenario, in which the energy industry is modelled under extrapolation of the framework without active policy, a biomass scenario, comprising a supply-side examination with exploitation of maximum biomass potentials, and a sustainability scenario, comprising a supply-side examination with

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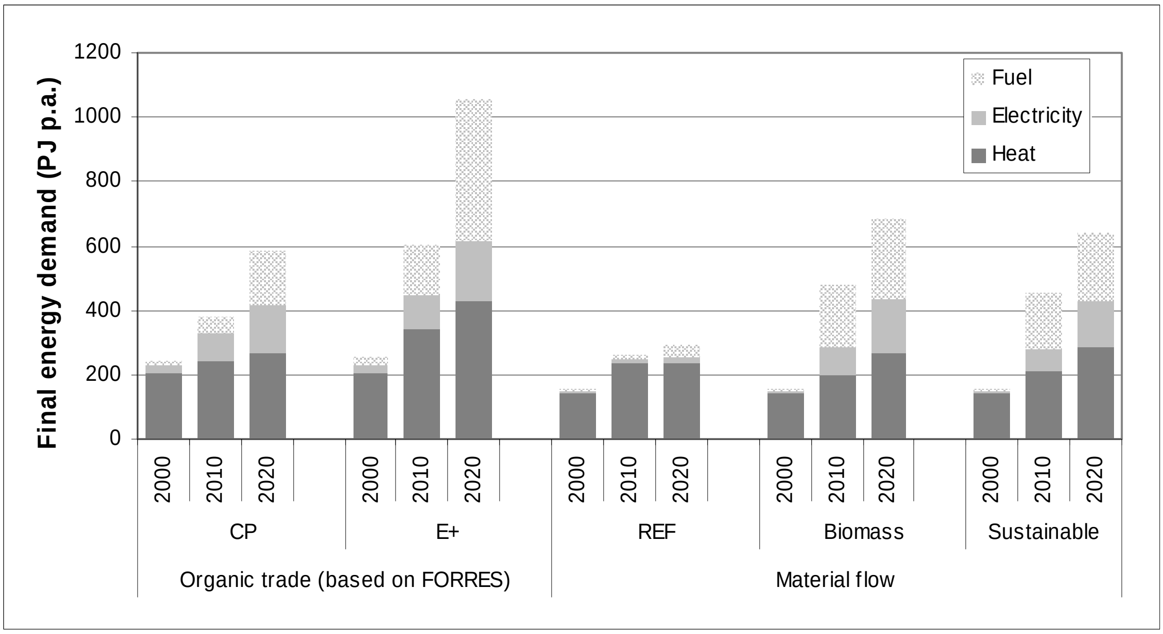
[24] This optimisation is to be examined in a follow-on project, the results of which are to be available around 2007 /165/.

exploitation of modified biomass potentials and with increased consideration of the selection of technology, and its effect on employment /159/.



Notes: "FORRES PS 2020" biofuel demand was modified; "Material Flow" biofuel demand was projected on the basis of person-kilometres

Figure 41: Demand for bioenergy sources in Germany with different scenarios
Source: data from /158//159//160/

In comparison to the material flow scenarios, the FORRES scenarios are characterised by a higher bioenergy demand, which can be explained as follows:

- As the studies took place at different times, the bioenergy use in Germany was established differently. Thus, the FORRES scenarios already take the EEG amendment and the mineral oil tax exemption for biofuels into account, whereas these had not yet been established when the other study was carried out.
- In the material flow project, a comparatively low reference value was chosen for the heating sector for the year 2000.
- Furthermore, for the examination envisaged here, the demand for biofuels in the E+ scenario was extended to incorporate import options (see section 5.3).

Thus, for various reasons, the scenarios used as a basis here indicate a higher demand for biomass, and for the energy sources which can be produced from biomass, than do the observations of biomass expansion in Germany as made at the beginning of 2004. However, this does not contradict these results, but rather, due to the variety of issues under examination, extends the examinations to incorporate further aspects.

4.2.3 Europe

The model results regarding demand for heat, electricity, and fuels in the individual member states according to the described methods are shown in the following charts (Figure 42 and Figure 43). Also shown is the significance of these results with regard to final energy demand, according to the PRIMES energy projections /163/.

For the EU, much like for Germany, the two scenarios mark out a corridor for future bioenergy demand values, where the upper value is around double the lower value. For the electricity sector, the difference between the scenarios in most European countries is more pronounced than in Germany, especially for those countries which currently only have "weak" promotion instruments.

For the fuels sector, there are considerable differences between the scenarios in countries with high fuel consumption.

The development of the utilisation of heat from biomass, on the other hand, shows a comparatively minimal difference between the scenarios, much like for Germany.

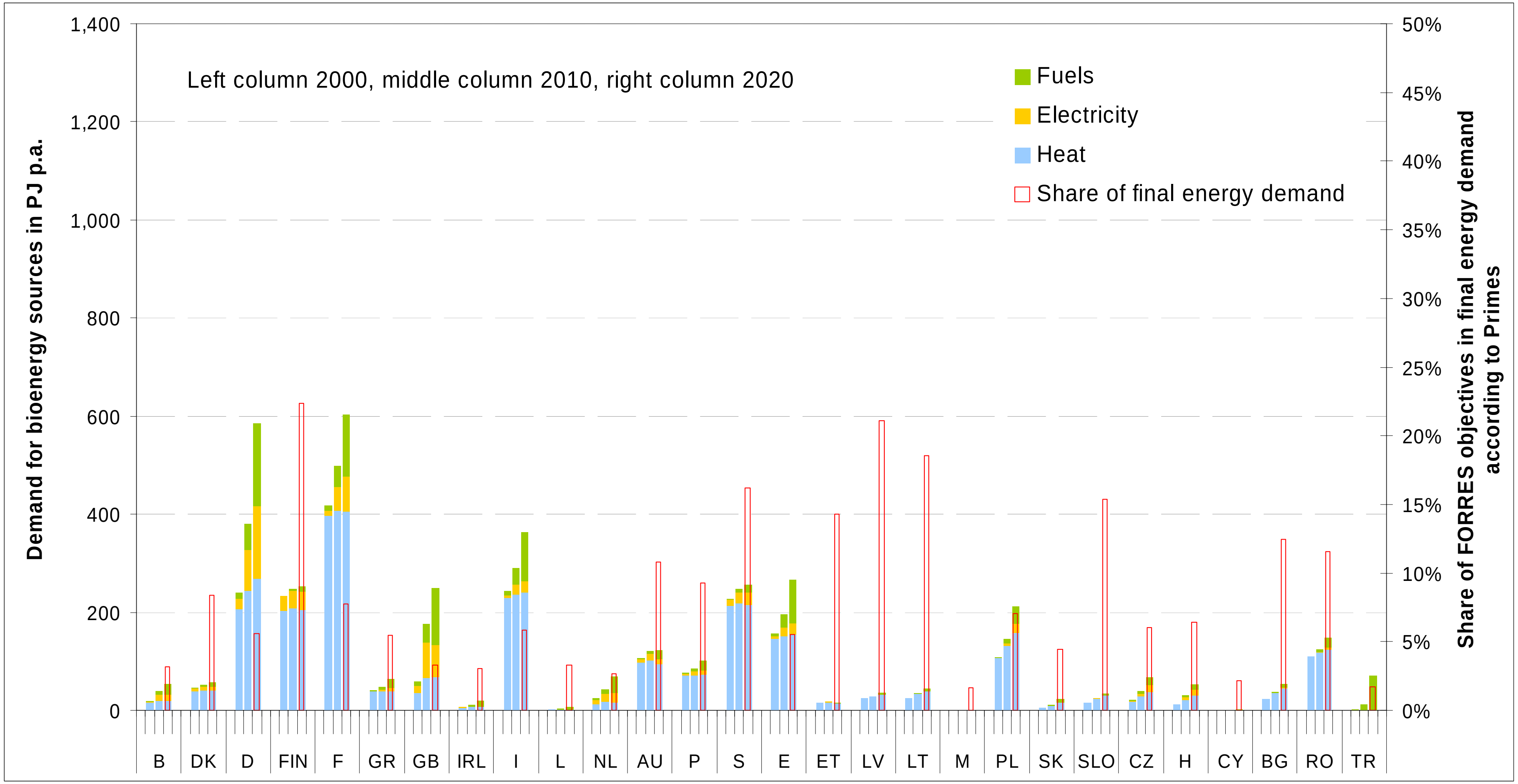


Figure 42: Demand for bioenergy sources and share of final energy demand in the EU-28 with the CP scenario
Source: data from /160//163/ (plus own calculations)

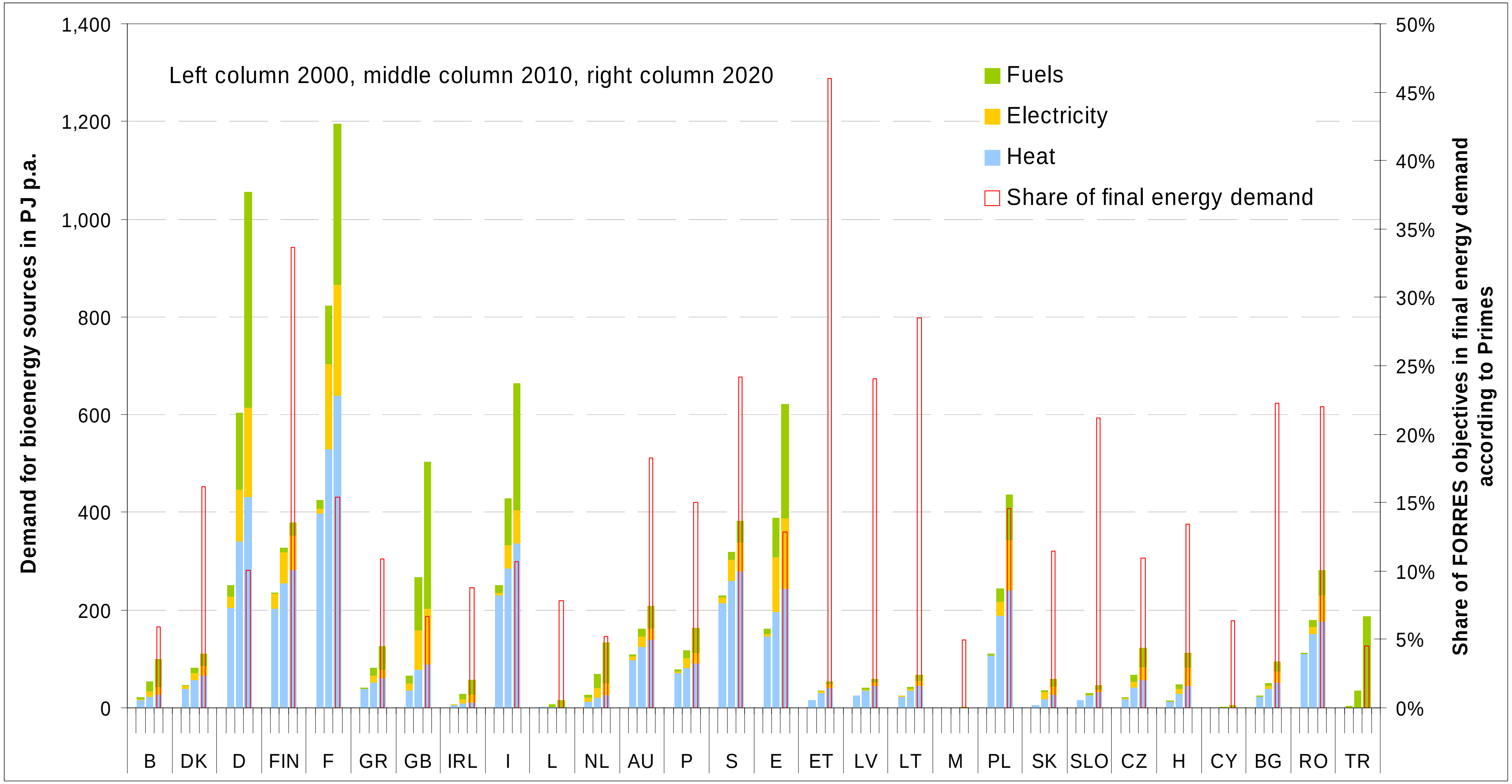


Figure 43: Demand for bioenergy sources and share of final energy demand in the EU-28 with the E+ scenario
Source: data from /160//163/ (plus own calculations)

With regard to the future demand for biomass and the energy (sources) produced from biomass, the following deductions can be made:

- In all EU countries, an increasing demand for bioenergy sources from 2000 to 2020 is indicated.
- In terms of volume, the demand for biogenic energy sources in the EU-28 is largely determined by the EU-15; at the same time, bioenergy's share of final energy consumption in the new member states (EU-10) is generally higher.
- The most significant future bioenergy demand (while only of moderate significance for the total energy consumption) comes from France and Germany, followed by Italy and Spain.
- The effects of different political frameworks (CP and E+) can be seen most clearly in the electricity and fuels sectors.
- Even in the E+ scenario, the contribution of bioenergy sources to final energy consumption up to 2020 is generally under 30%.

4.3 Options for transregional measures to meet demand

The demand for biomass, and for the energy (sources) produced from biomass can be met transregionally in the European market if the bioenergy sources are transport-worthy, i.e. if they have the following properties:

- high specific heating value
- high density
- shelf life (e.g. moderate water content)
- availability of defined quantities and qualities

If these properties are present to a limited extent, transregional supply can occur within a limited radius, e.g. trade between two neighbouring countries in areas near the border.

Table 49 provides an overview of the properties relevant to transport-worthiness for the biomasses examined in the project, and the resulting transregional supply options. It shows that these options are particularly relevant for woody biomass and seeds, as well as biofuels, whereby the latter are especially favourable due to high energy density (Figure 44). When combined with the infrastructure for fuel production and distribution, which at the same time is set up for transregional supply, it is most likely that not only European, but also global supply structures can be expected (e.g. bioethanol from Brazil).

In contrast, herbaceous biomass (straw and cereal plants) and logging residues have only limited transport-worthiness, and can therefore only be given limited consideration, e.g. for trade near borders. For waste wood, Europe-wide trade is primarily restricted by the limited potentials, while the transportability of bioelectricity is limited by the grid capacity. For the remaining biomasses, either the shelf life is insufficient, or the specific energy density is very low, meaning that no significant transregional trade can be expected.

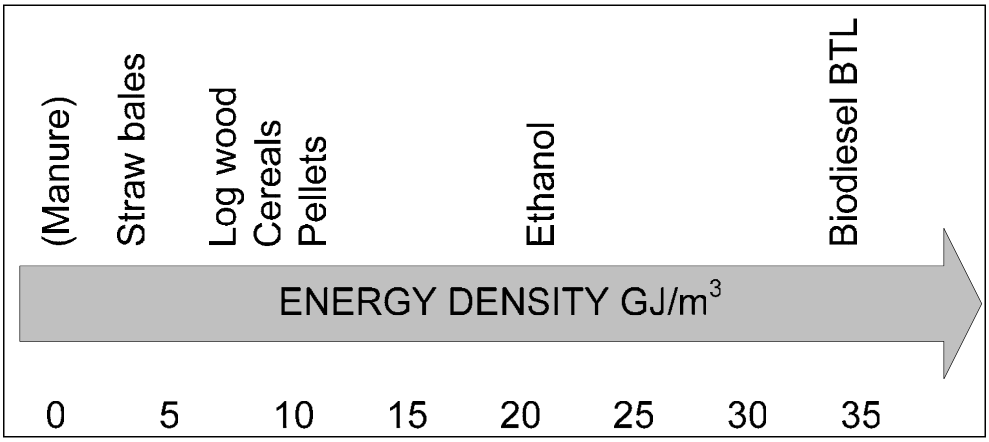


Figure 44: **Energy density in comparison**

Table 49: **Criteria for tradeability of different biomass types**

		High specific heating value	High transport density	Long shelf life	Availability of quantity & quality	Trade options		
						Untradeable	Limited tradeability	Tradeable
Woody biomass	Forest wood	x	x	x	x			x
	Logging residues / Small-dimensioned wood	x		x	x		x	
	Wood processing industry by-products and residues	x	x	x	x			x
	Wood pellets	x	x	x	x			x
	Waste wood	x	x	x			x	
	Short rotation wood	x	x	x	x			x
Herbaceous biomass	Straw	x		x	x		x	
	Energy plants (cereals)	x		x	x			x
Fruits and seeds	Cereal grains	x	x	x	x		x	x
	Rape seeds (sunflower seeds)	x	x	x	x		x	x
	Sugar beet				x	x		
Other biomass	Industrial substrates				x	x		
	Organic waste				x	x		
	Sewage sludge				x	x		
	Maize silage			x	x	x		
Bioenergy	Heat from biomass				x	x		
	Electricity from biomass	x	x				x	
	Biodiesel	x	x	x	x			x
	FT diesel	x	x	x	x*			x*
	Bioethanol	x	x	x	x			x

*in the future

5 Supply chains

The investigation of supply chains for the years 2000, 2010 and 2020 initially encompasses an analysis of major technologies and their performance data in respect of heat, electricity and fuel generation (section 5.1), as well as the allocation of typical resources (section 5.2). In a next step, biomass use scenarios for Europe will be determined for different framework conditions (section 5.3). This is followed by a supplementary economic-ecological analysis of supply chain models, which could be developed between Germany and other selected European countries (or Brazil), in respect of the effect of biomass imports to Europe (section 5.4).

5.1 Technologies

In order to describe the supply chains, an analysis will now follow of typical current and future technologies or technology groups for biomass use. This takes into account the current state of technical developments as well as classifying future technological trends. The ongoing development of existing technologies and market entry of new technologies will also be considered. This is based on the technology analysis from the material flow project /159/ and concentrates on the economic and ecological aspects of highly promising options; the data has to a certain extent been updated.

The following assumptions have been made for a Europe-wide analysis:

- ➢ common technological level: the plant technology is available across Europe and demonstrates a comparable efficiency for the given applications (efficiency, costs, emissions)
- ➢ common application of technology: the systems are used in comparable areas of application (heat, electricity, fuel), use comparable resources and have similar utilisation degrees

Regional utilisation characteristics are therefore determined by the regionally available resources, which can be exploited using a homogenous European technology basis for heat, electricity and fuel generation. This will be outlined below.

Furthermore, it has been assumed that energy crops will solely be grown as a source of energy and therefore used to the maximum degree. This permits annual and perennial lignocellulose crops to be considered as one group, i.e. the term cereal used hereinafter often also refers to miscanthus or short rotation wood. It may result in deficits for the nutrient and humus cycles in ethanol or RME production as well as for energy cereals and perennial energy crops. These must be compensated by additional measures.

5.1.1 Heat generation

Professional biomass heat generation has established itself across Europe. It may be used over a wide output range and in principle can reach high levels of efficiency (Table 50). Woody biomass in various refined variants is generally used. The use of liquid bioenergy sources for heat generation is a further technical option. This will not be given further consideration here due to its comparably high cost and the high demand from the transport sector for these types of bioenergy sources.

Table 50 Output range and net utilisation degree for relevant biomass technologies used in heat generation.
Source: data from /159/

Technologies	Output range (MW_{th})	Utilisation degree (net) (Heat (%))		
		2000[a]	2010	2020
Biomass pellet boiler	0.02 – 0.5	n.a.	88	91
Biomass wood chip boiler	0.15 – 1	85	88	91
Biomass heating station	1 – 5	83	88	91
Vegetable oil boiler	0.02 – 0.5	not considered		

a) Data from the year 2000 refers to the actual utilisation degree
n.a.: not available

5.1.2 The generation of electricity

The generation of electricity from biomass based on solid, liquid and gaseous bioenergy sources is possible using a variety of technologies with differing output ranges. The main technologies and their net efficiencies are shown in Table 51.

Biogas

Biogas CHP plants are a cost-effective and highly efficient means of biogas generation for the required output range. Alternative technologies (Stirling, micro gas turbines) are of interest for niche applications, but insignificant in terms of quantity. Heat utilisation is also insignificant at the present time. The supply of biogas into the natural gas network may be used for electricity generation with higher heat utilisation; it is expected that this will become increasingly widespread from 2010. The used resources are all biogas substrates, i.e. biogas substrates from the agriculture industry (manure, harvest residues), industrial biogas substrates, as well as energy crops with high water content (maize silage).

Biogenic solid fuels

The technologies for generating electricity from solid biomass are numerous in comparison. The main elements are biomass CHP plants with ORC and gasification processes, biomass (CHP) power stations and the additional combustion of biomass in coal-fired power stations. It should be noted that CHP systems are still in the development and market introduction phases. It is expected that these will be successfully introduced by 2010 and subsequently expanded. The use of technologies is also dependent on the specification of the biomass resources and the partially related usage structures (see section 5.2).

Table 51 Output range and net utilisation degree for relevant biomass technologies used in electricity generation.
Source: data from /140//141//142//143//144//145//146//147//148//156/ /

Technologies	Output range (MW_{el})	Utilisation degree (net) (Electricity (%) / Heat(%))		
		2000[a]	2010	2020
Biogas CHP (gas engine or similar)	0.2 – 1	23 / 3	25 / 10	28 / 15
Biogas CHP (Supply)	1 – 5	n.a.		
Biomass CHP (ORC)	0.5 – 5	n.a.	13 / 75	15 / 74
Biomass CHP (Gasification)	0.5 – 5	n.a.	27 / 30	30 / 38
Biomass (CHP) power station	5 – 50	15.7 / 23[b]	22 / 23[b]	24 / 23[b]
Black liquor heat and power station	20 – 100	35 / 60	36 / 60	37 / 60
Biomass combustion (Lignite)	very large	37.5 / 0	40.1 / 0	42.6 / 0
Vegetable oil CHP	0.02 – 5	not considered		

a) Data from the year 2000 refers to the actual utilisation degree
b) Higher when using wood processing industry by-products and residues (approx. 60%)
n.a.: not available

Liquid bioenergy sources

In principle, another available technical option is to generate electricity from liquid bioenergy sources (PME, bioethanol etc.). This will not be given further consideration here due to its comparably high cost and the high demand from the transport sector for these types of bioenergy sources.

5.1.3 Fuel production

Fuels can be supplied using a number of different technology concepts and hence a variety of related resources. Table 52 illustrates the typical output ranges and efficiencies of current and future technologies. At present, the only available options in Germany are to produce biodiesel and bioethanol from sugar and starch. Other bioenergy sources are considered to be future technologies – in the medium term it is expected that biogas, bioethanol from lignocellulose and synthetic fuels will establish themselves in the market; hydrogen is expected at the earliest in two decades /161/.

Apart from fuel production, electricity is sometimes also generated as a by-product. The following net efficiency figures relate to the use of energy plants, i.e. the straw from rapeseed cultivation (which is not used to cover one’s own energy requirements) is used e.g. to generate electricity. They are based on the following considerations:

PME

Plant methyl ester (PME) (e.g. biodiesel) is produced by the transesterification of vegetable oil. Whilst it is also possible to produce vegetable oil in very small systems, transesterification requires a minimum size of approx. 5,000 t p.a. This is realised close to the source of production in rural areas. At the same time, refineries have also recently established very large transesterification plants. This means that PME generation has a very wide output range. The implemented technologies are considered to be state-of-the-art; further advancements in technical performance are estimated to be moderate /150/.

Bioethanol

Bioethanol can be produced from feedstock containing starch, sugar and lignocellulose. Although the principle of ethanol extraction from starch and sugar is technically feasible, currently only bioethanol extraction from cereals is installed in any significant quantities in Europe (see chapter 6.5). Bioethanol extraction from lignocellulose has not yet been technically implemented on any large scale and still requires significant cost reductions in the area of lignin pulping, something which is currently being intensively researched /149/. This is expected by 2010 and could, on the one hand, increase the amount of ethanol extracted from cereal plants, whilst on the other hand permitting the use of perennial energy crops for fuel production.

BTL (synthetic fuels)

Synthetic fuels (e.g. FT diesel, methanol, DME) are produced through the synthesis of product gases from the gasification of lignocellulose. FT diesel will be considered here as a representative case. Ensuring the required product gas quality still represents a challenge, which remains to be technically proven on a large scale. The introduction of FT diesel (and other synthetic fuels) is therefore difficult to estimate at the present time; however, it is assumed that it will be established on the market by 2020. It is undisputed that production plants are only viable for very large output range applications due to the complex gasification and syntheses technology /151/. Furthermore, numerous concepts are under discussion, which produce differing levels of fuel and electricity output during synthesis. This document will consider one technology model that has largely been optimised for fuel production /152/.

Biogas

In order to use biogas as a fuel, it has to be processed and, if necessary, supplied into the regional biogas network or nationwide natural gas network. In order to keep the required technology cost-effective, larger biogas plants will be required with a range of 2-10 MW fuel (corresponds to approx. 1-5 MW_{el}). In principle the technology is already available and used abroad (e.g. Sweden, Switzerland) /154/. It is therefore possible that this technology will also be introduced in Germany from 2010.

Today it is possible to produce and use biodiesel and bioethanol from sugar and starch (technologies 2000); in future this will be supplemented by various technologies to permit the extraction of fuel from lignocellulose and use the biogas as fuel. The expected net utilisation degrees lie between 40 and 55% for liquid bioenergy sources; for biogas this even reaches around 70%. Comparably large output ranges are also expected in the area of biofuels: In particular, the very large production plants anticipated for FT diesel are expected to require nationwide catchment areas and will require the development of supply and logistics concepts /155/.

Table 52 **Output range and net utilisation degree for relevant biomass technologies used in fuel generation from plants**
Source: /149//150//151//152//154//161/

Technologies	Output range (MW_{Fuel})	Utilisation degree (net) (Fuel (%) /Electricity (%))		
		2000[g]	2010	2020
PME (RME, SME)a	5 – 200[b]	39 / 13	39 / 14	39 / 15
Ethanol from starch and sugara	50 – 200[c]	28 / 19	29 / 21	30 / 21
Ethanol from cereal plants (starch and lignocellulose)	50 – 300[d]	n.a.	48 / 0	49 / 0
Biogas (via supply)	2 – 10[e]	n.a.	65 / 0	68 / 0
BTL from lignocellulose	100 – 1,000[f]	n.a.	n.a.	35 / 15

a) simultaneous conversion of straw into electricity through joint combustion
b) corresponds to 5 - 200 million $l_{Biodiesel}$ p.a.
c) corresponds to 70 - 300 million $l_{Bioethanol}$ p.a.
d) corresponds to 70 - 440 million $l_{Bioethanol}$ p.a.
e) corresponds to 2.4 - 12 million $l_{Diesel\ equivalent}$ p.a.
f) corresponds to 80 - 900 million l_{Output} p.a.
g) Data from the year 2000 refers to the actual utilisation degree
n.a.: not available

Today it is possible to produce and use biodiesel and bioethanol from sugar and starch (technologies 2000); in future this will be supplemented by various technologies to permit the extraction of fuel from lignocellulose and use the biogas as fuel.

5.2 Allocation to application areas

5.2.1 Use of resources depending on area of application

In order to determine the use scenarios, the technologies outlined are allocated to the biomass potential of each country. The biomass use figures for 2000 are used as a starting point, whereby it is supposed that the systems established at this time will continue to remain in operation. The technologies allocated to the additional systems, which will be installed, is determined by considering the chemical-material fuel characteristics of the resources. Furthermore the currently perceived political priorities regarding the issue of heat, electricity and fuel generation are also taken into consideration.

Similar to the potential analysis, the use of resources with different technologies differentiates between the following:

- forest wood (logging residues)
- residues
- energy crops

Another similarity with the procedure used for the potential analysis is that eleven cultures are considered for the area of energy crops. This includes plants that contain oil, sugar and starch as well as plant cuttings. Perennial lignocellulose plants will not be specially investigated, however they are included as a potential substitute for cereal plants (with similar yield levels).

In principle, many biomasses can also be used in pellet form (e.g. to supply heat using wood pellets, joint combustion of wood and straw pellets, use of other pellets in biomass (CHP) power stations). These applications are expected to show strong growth in the coming years, which although difficult to quantify, will have a limited effect on the main areas of application for the resources. The use of pellets will therefore not be given special consideration in this assessment; instead they will be implicitly considered as part of each resource. The use of pellets will be most significant in the areas of wood processing industry by-products and residues as well as straw.

The resources are assigned to the technologies providing heat, electricity and fuel[25]:

Pure heat supply is only considered in the model on the basis of forest wood (logging residues) and is extrapolated from the year 2000. At this time, the EU-28 used approximately 2,200 PJ p.a.[26] for heat supply, of which over 95% was achieved by means of pure heat production plants. This corresponds to 73% of the forestry potential of 3,046 PJ p.a. in 2000. This use of primary energy for pure heat generation will be extrapolated until 2020. Improvements in efficiency will increase the generated heat from 1,864 PJ p.a. in the year

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[25] The allocation is determined by the conditions and expected developments and is not economically/ecologically optimised (see section 4.2.3)

[26] Supply of final energy: 1,962 PJ p.a., assumed CHP heat content of 1:1 from electricity production (97 PJ), assumed efficiency: 84 %

2000 to 2,020 PJ p.a. in the year 2020. Additional biomass heat will also be supplied due to increased CHP electricity generation.

The model initially considers **electricity supply** by means of residues, primarily in CHP operation. The following uses are considered:

- black liquor: used in industrial heat and power plants with high electrical and thermal efficiency
- waste wood: used in biomass (CHP) power stations
- wood processing industry by-products and residues: used in centralised and decentralised systems (equivalent)
- pruning: used in decentralised gasification and ORC systems (equivalent)
- straw: used for joint combustion in coal-fired power stations (predominant) and biomass (CHP) power stations
- manure and excrements: used in biogas plants for electricity/heat generation
- harvest residues: used in biogas plants for electricity/heat generation
- industrial biogas substrates: used in biogas plants for electricity/heat generation
- municipal waste and sewage sludge: used in plants equivalent to biomass CHP plants

In principle, these residues can also be used to produce fuel in 2020. Due to the comparably high output ranges of the fuel technologies and the decentralised availability of the residues, this option will only be tested in heavily agricultural regions where large quantities of straw are available (approx. 20% of the potential).

The **provision of fuel** is based on a limited amount of energy crop resources, i.e. rapeseed, sunflowers and sugar beet. Furthermore, cereals and lignocellulose are in principle also available. These may be used to produce ethanol from starch (year 2000) and in future scenarios (as a substitute of the lignocellulose path, i.e. as cereal plants or miscanthus/short rotation wood) for extracting ethanol and/or BTL. Furthermore, it is also possible to use straw and any forest wood (logging residues) after heat utilisation.

5.2.2 Sensitivity analysis

This will provide a certain amount of freedom in the medium term in terms of assigning all energy crops with the exception of rapeseed, sunflowers and sugar beet, as well as approx. 25% of forest wood (logging residues). Two technology scenarios will be demonstrated as borderline cases for the above (Table 53). The use of resources for the provision of heat is not affected due to the assumptions made in the model (projection based on pure heat generation).

The energy crops and available forest wood (logging residues) after pure heat usage will be converted into electricity over various paths in a so-called **Electricity scenario**.

- Silage maize, alfalfa and plant cuttings will be used in biogas plants.
- Cereal plants (wheat, rye, triticale, barley, grain maize) or perennial lignocellulose plants will be used in biomass (CHP) power stations.
- The residues of the energy crops which were sown for fuel production, namely rapeseed, sunflowers and sugar beet (e.g. rapeseed straw), will also be converted to electricity.

The various technologies available at a given time are used as thoroughly as possible in a so-called **Fuel scenario**.

- Rapeseed, sunflowers and sugar beet are used for biodiesel / bioethanol extraction, the residues (e.g. rapeseed straw) are used in joint combustion to produce electricity.
- Silage maize, alfalfa and plant cuttings will initially (year 2000) be converted to electricity in biogas plants; the corresponding utilisation path will remain until 2020 and can contribute an increased amount of heat and electricity output due to improvements in efficiency.
  The additional available potential in 2010 and 2020 will be used to produce biogas for fuel applications.
- Cereal plants (wheat, rye, triticale, barley, grain maize) will initially (year 2000) be used for bioethanol extraction, the residues (straw) will be converted to electricity; the corresponding utilisation paths will remain until 2020. The additional available potential in 2010 will be used to extract ethanol from plants; electricity production for

small output ranges will also be extended to a certain degree (30% of the additional available potential); the corresponding utilisation paths will remain until 2020.

The additional available potential in 2020 will be used to process cereal plants or perennial lignocellulose plants for BTL production; here there will be generated heat and power. Electricity production for small output ranges will also be extended to a certain degree (30% of the additional available potential).

- In addition, in 2020 some of the residual straw from food production (20%, see above), as well as any forest wood (logging residues) not purely used for heat generation, will be used to produce BTL.

Table 53: Utilisation of resources in technology scenarios

	Electricity scenario			Fuel scenario		
	2000	**2010**	**2020**	**2000**	**2010**	**2020**
Straw	CHP electricity			CHP electricity		BTL + CHP electricity
Other residues	CHP electricity			CHP electricity		
Forest wood (logging residues)	CHP electricity			CHP electricity		BTL
Rapeseed, sunflower, sugar beet	Biodiesel, bioethanol (residues: CHP electricity)			Biodiesel, bioethanol (residues: CHP electricity)		
Silage maize, alfalfa, plant cuttings	CHP electricity			CHP electricity	Biogas as fuel	
Cereals	CHP electricity			Bioethanol	Bioethanol	BTL + CHP electricity
Cereal straw				CHP electricity	Bioethanol + CHP electricity	

Taking into account the resource situation (CP and E+) gives rise to the following effects for the technology scenarios (see Figure 46 and Figure 47

- Even if the expansion of fuel production is actively supported (Fuel scenario), the most significant growth in this area will be in the medium term.
- In this case, the potential situation (CP or E+) is decisive in determining how quickly the fuel becomes established.
- The total amount of supplied final energy is more or less the same for both technology scenarios (Electricity scenario and Fuel scenario) and comprises approx. 60% of fuel input in 2020.

When considering utilisation, there will not be any significant difference in terms of the contribution made by bioenergy to the energy system regardless of how much biofuels are promoted. The high fuel targets considered in the energy scenarios (section 4.2.1) means that a high fuel contribution has been assumed (Fuel scenario).

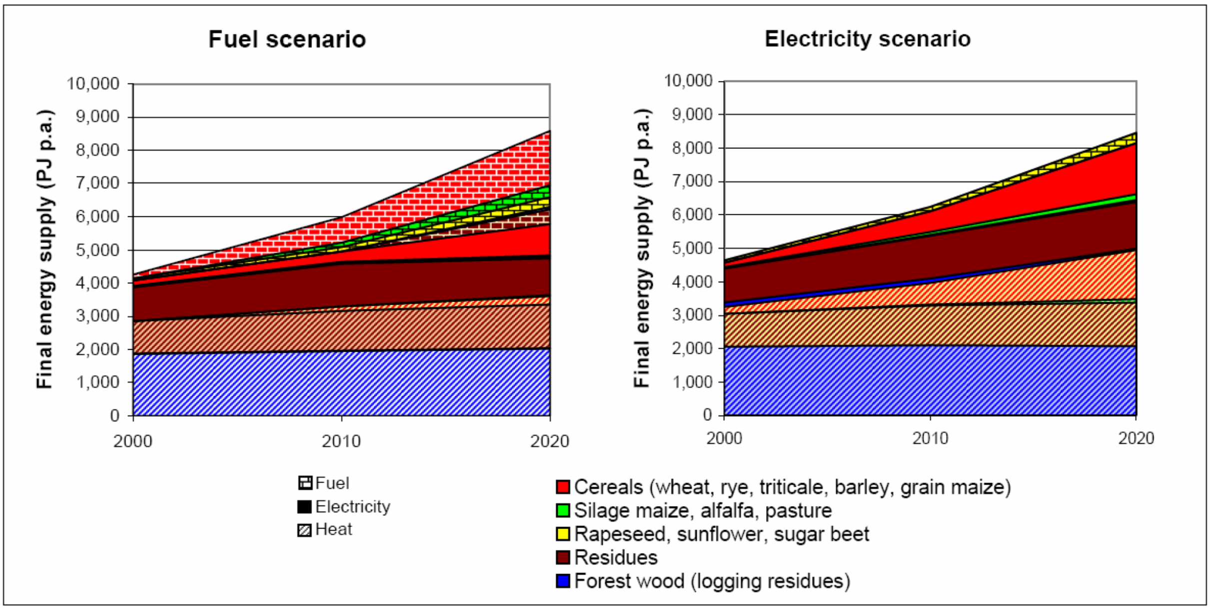

Figure 45: **Technology scenarios for potential situation “CP scenario” for the EU-28**

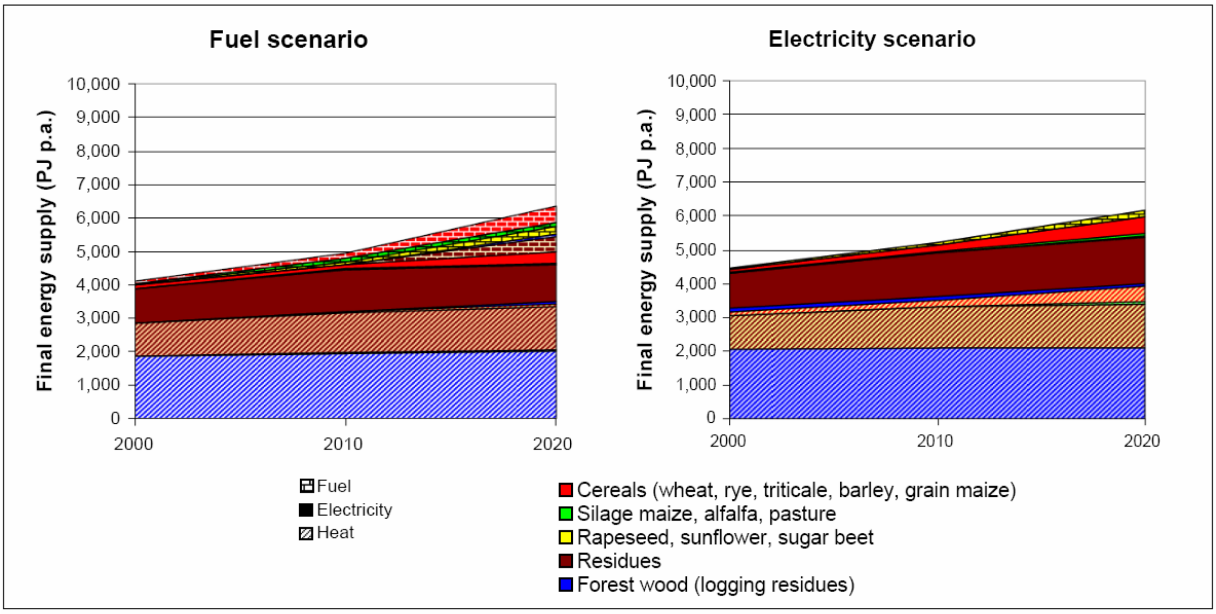

Figure 46: **Technology scenarios for potential situation “E+“ for the EU-28**

5.3 Use scenarios, supply balance sheets and trade flows

The following section will summarise how biomass use will affect each of the EU-28 states in the various scenarios and which future biomass trade flows may occur as a result. The “Bio-Flow” model was developed for this purpose. The model structure, scope of application and results are described below.

5.3.1 Model description

The PC-based software tool “BioFlow” was developed to analyse the expected biomass trade flows. The structure of the model is shown in Figure 48.

It considers the following parameters:

- each of the EU-28 countries
- dates 2000, 2010, 2020
- potential area from the Current Policy (CP) and Environmental+ (E+) scenarios
- cultivation structures und energy crop yields
- fuel potential for each biomass type according to the potential analysis (with switch between the Current Policy und Environmental+ potential scenarios for energy crop cultivation)
- classification of the merchantability of each biomass type according to the potential analysis
- utilisation paths and efficiency in supplying final energy for each biomass type
- final energy demand for electricity, heat and fuel (including switch between the Current Policy und Environmental+ demand scenarios)
- balancing supply and demand at fuel level
- balancing supply and demand at final energy level

The main functions of the software tool are, on the one hand, to determine the final energy potentials for the available biomasses, as well as comparing this with the demand for biomass final energy sources in various scenarios. This comparison of estimates will result in a balance per member state for a given analysis date. This may be used to determine possible developments in the biomass markets and may also indicate future biomass trade flows.

The biomass supply is composed of the forest potential, energy crop potential and residue potential described in chapter 3. The final energy potentials are determined by assigning these potential values to the specified supply paths. This includes the allocation of resources to typical technologies or technology groups used in energy generation (heat, electricity, fuel) for each of the years under consideration (2000, 2010 and 2020) as described in section 5.1 (Table 50, Table 51, Table 52).

Biomass demand is based on the scenarios in section 4.2.1, which describe the development of future biomass use in the EU-28. The projections are modelled for the years 2010 and 2020 using year 2000 as a basis. Biomass demand is differentiated according to the final energy sources (e.g. heat, electricity, fuel) under consideration of both scenarios (CP and E+).

Furthermore the biomass/energy sources are classified according to their tradeability. They are divided into the categories “non-tradeable”, “limited tradeability” and “fully tradeable“.

- “Non-tradeable residues and energy crops” are completely used to meet the domestic demand for bioenergy.
- Specific quotas of “residues and energy crops with limited tradeability” are used to meet the domestic demand for bioenergy. Any excess volume flows can primarily be traded with neighbouring countries.
- “Tradeable residues and energy crops” are primarily used for the global market.

The division of biomasses according to their tradeability results in supply/demand balances for meeting the regional supply.

The function of the “BioFlow” software tool is schematically illustrated in Figure 47.

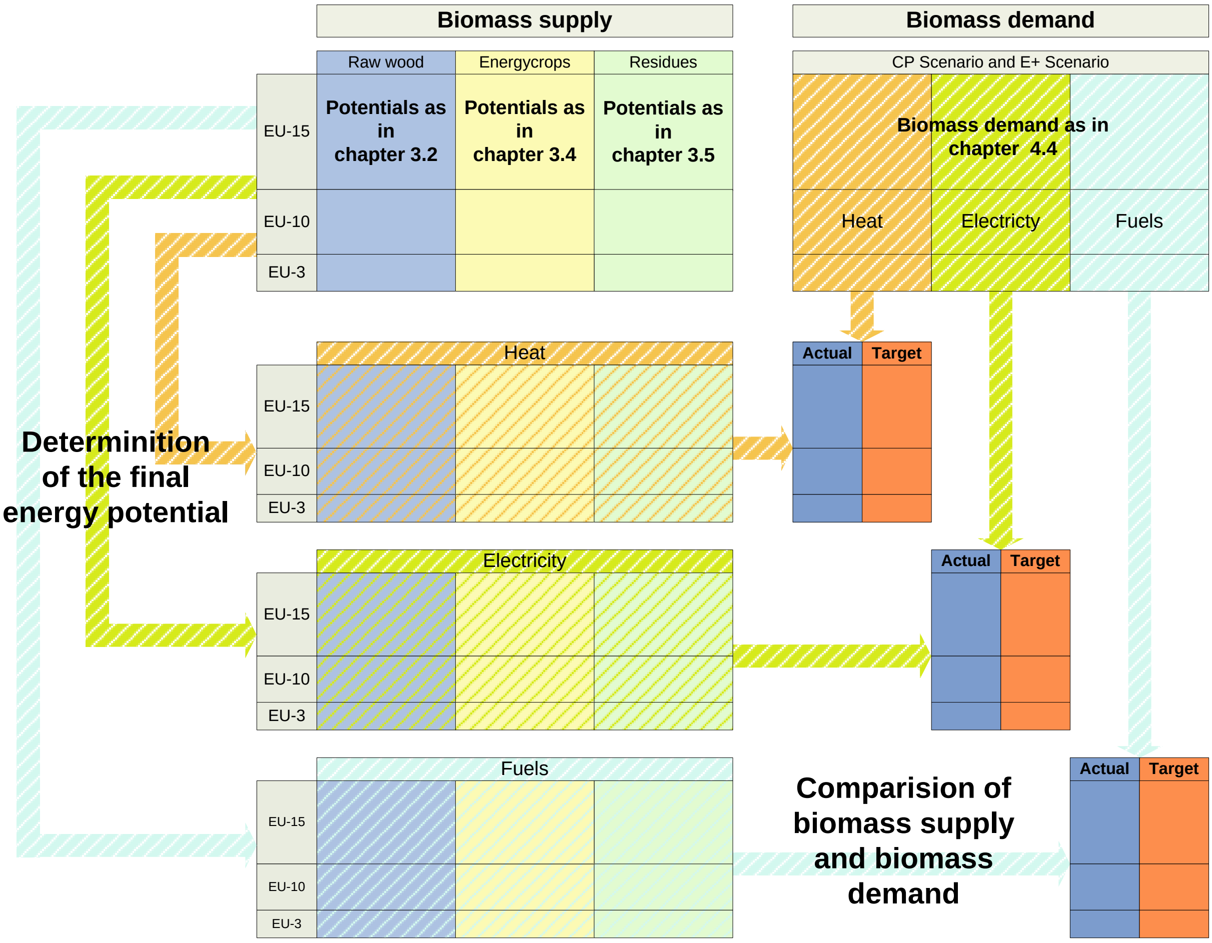

Figure 47: **Function of the "BioFlow" software tool**

5.3.2 Biomass use scenarios

Various supply and use scenarios are considered in order to adequately assess the different framework conditions and their effect on the developing biomass markets. The scenarios described below are not a forecast, instead they provide an if-then statement, particularly regarding the (timing of) changes in energy and material flows.

One of the main parameters affecting biomass supply is the development of potential agricultural area. The main parameter that influences potential agricultural area is the general agricultural policy and hence the amount of land released from the agricultural industry. In order to illustrate the major extremes affecting the development of land for energy crop cultivation, the following scenarios as described in section 3.3.3 will be modelled to simulate the development of the EU biomass market.

- The **Current Policy scenario (CP)** is used to determine the available area for energy crop production by extrapolating current development trends and assuming the utilisation of all agricultural land which is becoming available.

- The **Environmental+ scenario (E+)** considers the area available for energy crop production by assuming reduced yield increases and the partial retention of set-asides. This represents a more sustainable agricultural and environmental policy.

The most significant factor influencing demand is the development of biomass use. This is dependent on political developments regarding the promotion of renewable energy sources. As described in section 5.2, the following scenarios will be considered when modelling the biomass market.

- The **Current Policy scenario (CP)** considers the further development in each of the EU countries based on current political strategies.

- The **Environmental+ scenario (E+)** considers a future evolution based on the European-wide establishment of best-practice strategies in individual countries.

Apart from the possible developments in biomass supply and use – which is primarily determined by political guidelines – the available supply technologies also have an influence on the developing biomass market. As described in section 5.2, biomass use can provide a number of different supply chains. Their differing efficiencies will therefore have an impact on the final energy supply. These effects can also be considered using the described model, however due to their relatively low impact they are not described here in any further detail.

5.3.3 Supply balance sheets

The various use balance sheets for bioenergy in the years 2000, 2010 and 2020 are shown below. The following figures will state the expected final energy demand (“Target“), expected final energy supply (“Potential“) and resulting supply balance (“Balance“). The indicated values are cumulative for heat, electricity and fuel, and initially consider two borderline cases:

- retention of current policy (basis – CP)

- development of more extensive measures concerning the fields of energy and the environment (E+ scenario)

If current policies are maintained (Figure 53), biomass demand in most countries will stay well below the potential supply until 2020. Import demand is only expected in Italy, Great Britain and to a limited extent in Greece and the Benelux countries. EU-15 countries with a larger agricultural industry (France, Germany, Spain) could offer significant volumes to the European market.

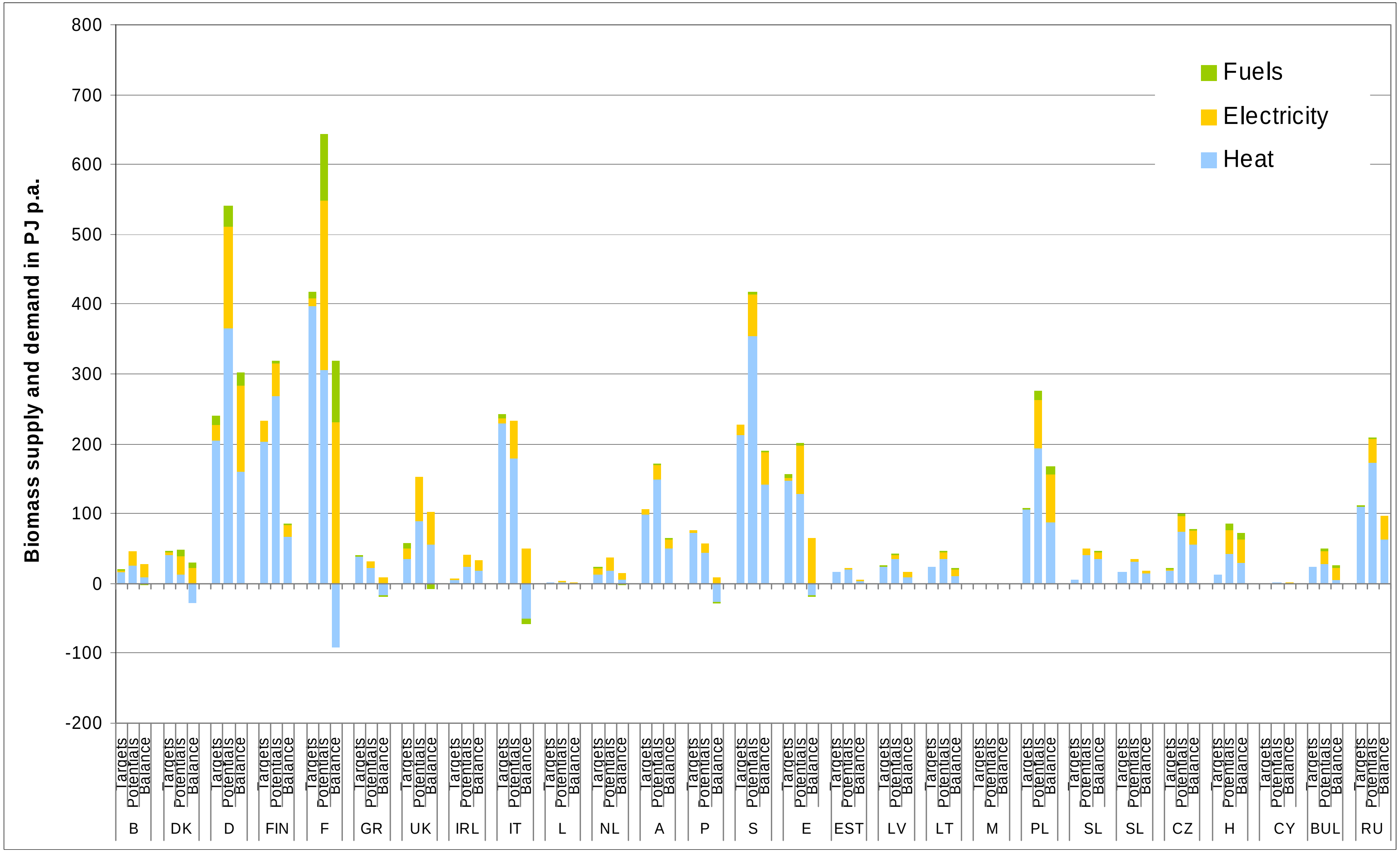

Figure 48: **Supply balance sheet for final energy sources in CP scenario for fuels in the year 2000**

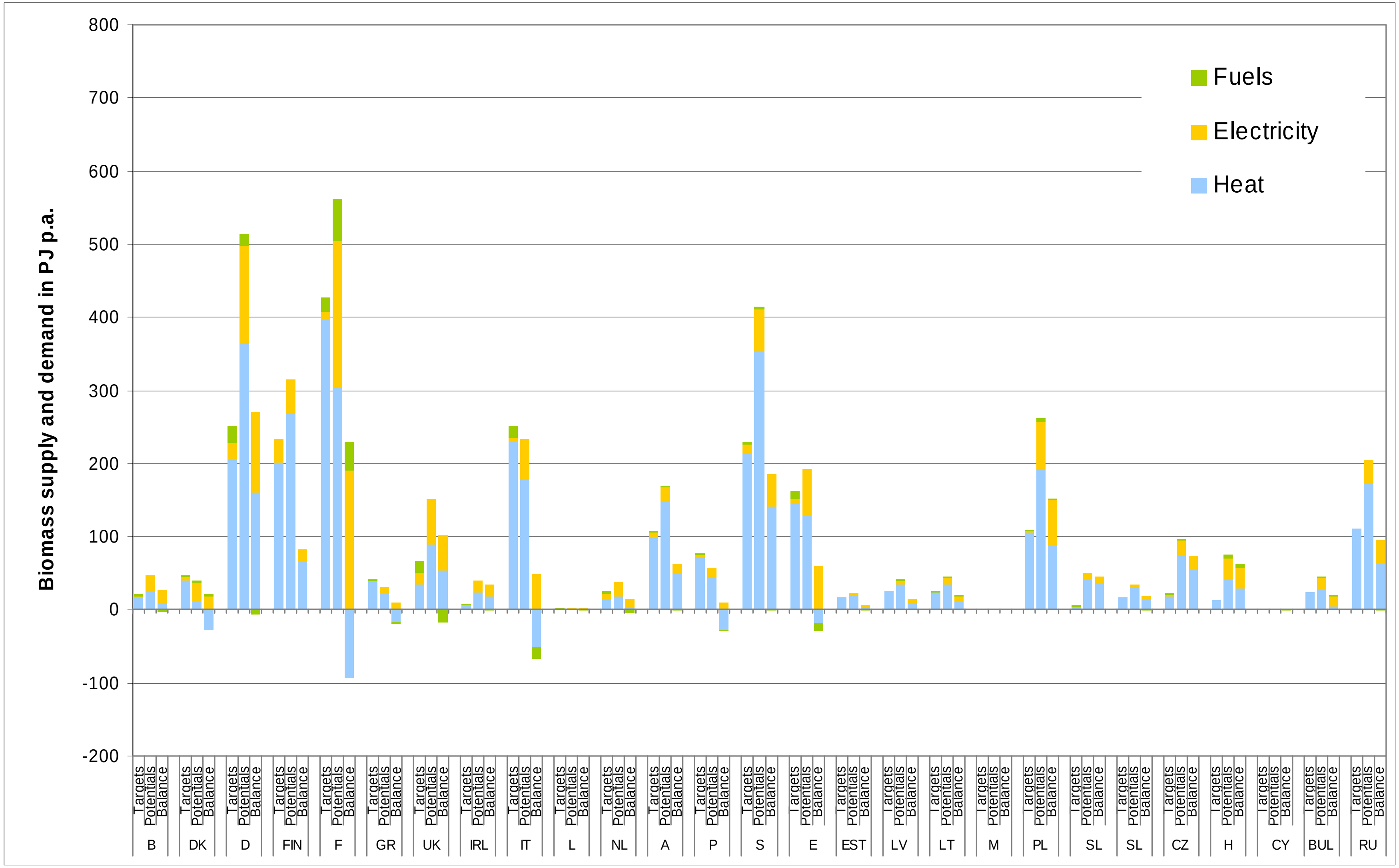

Figure 49: **Supply balance sheet for final energy sources in E+ scenario for fuels in the year 2000**

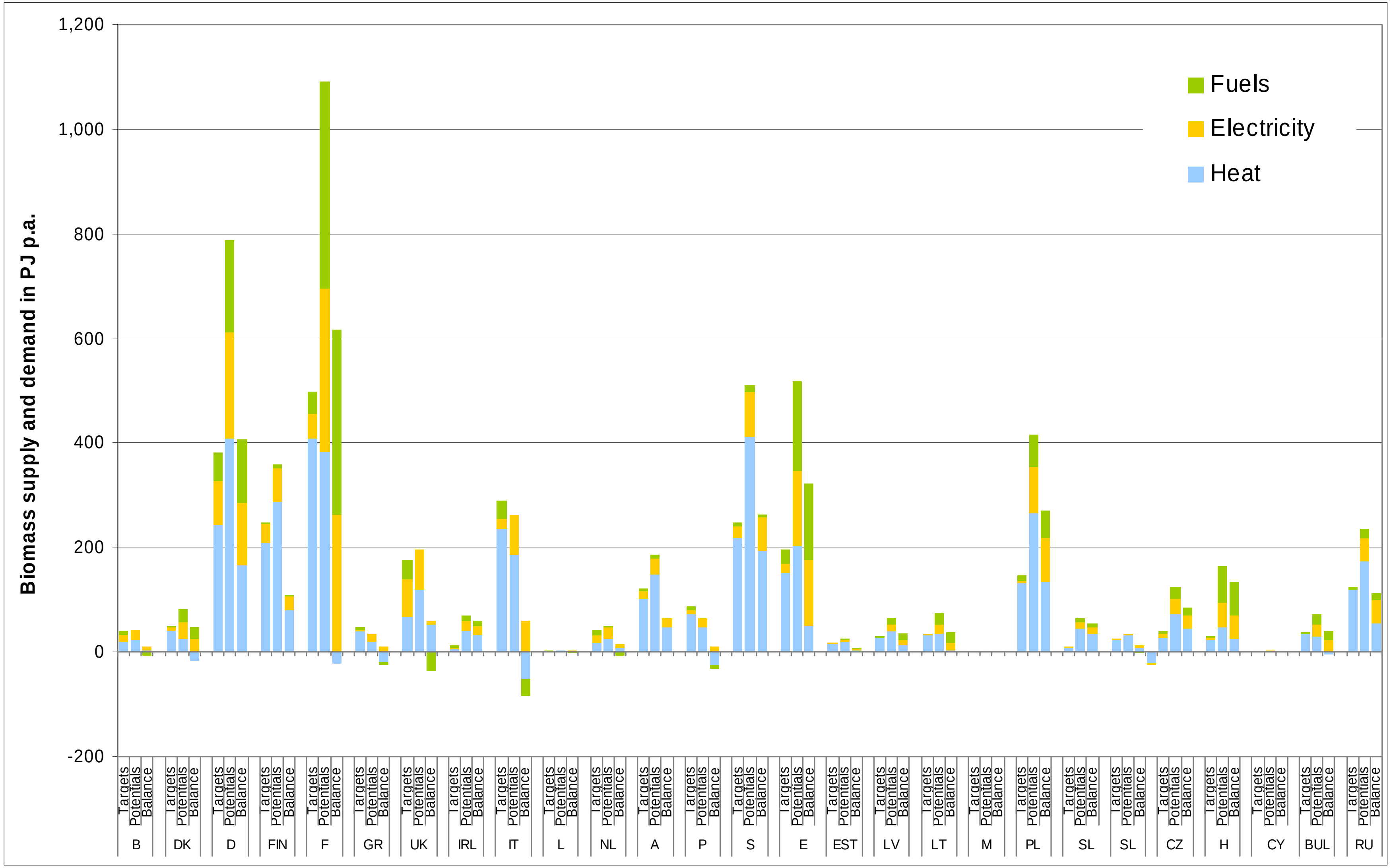

Figure 50: **Supply balance sheet for final energy sources in CP scenario for fuels in the year 2010**

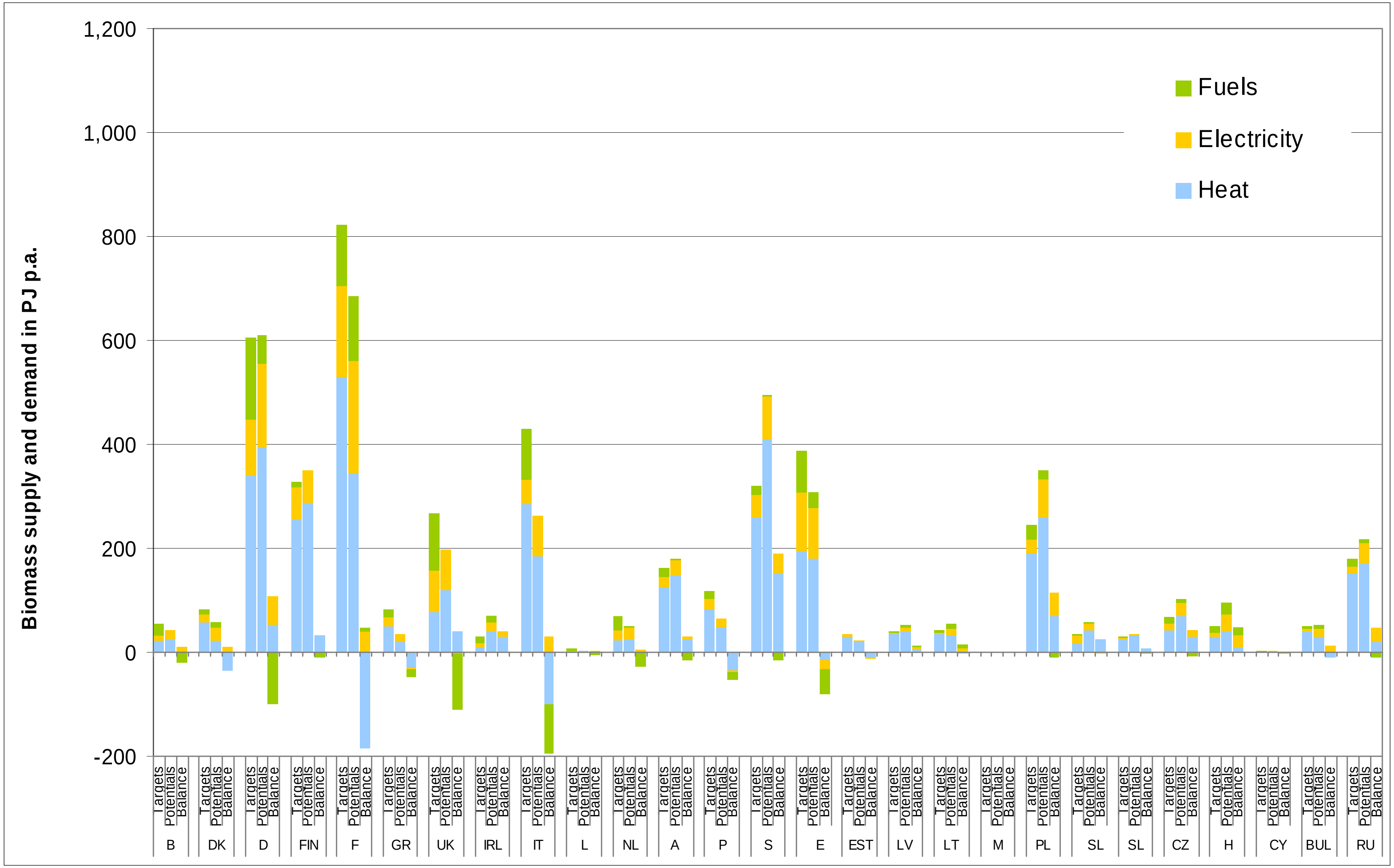

Figure 51: **Supply balance sheet for final energy sources in E+ scenario for fuels in the year 2010**

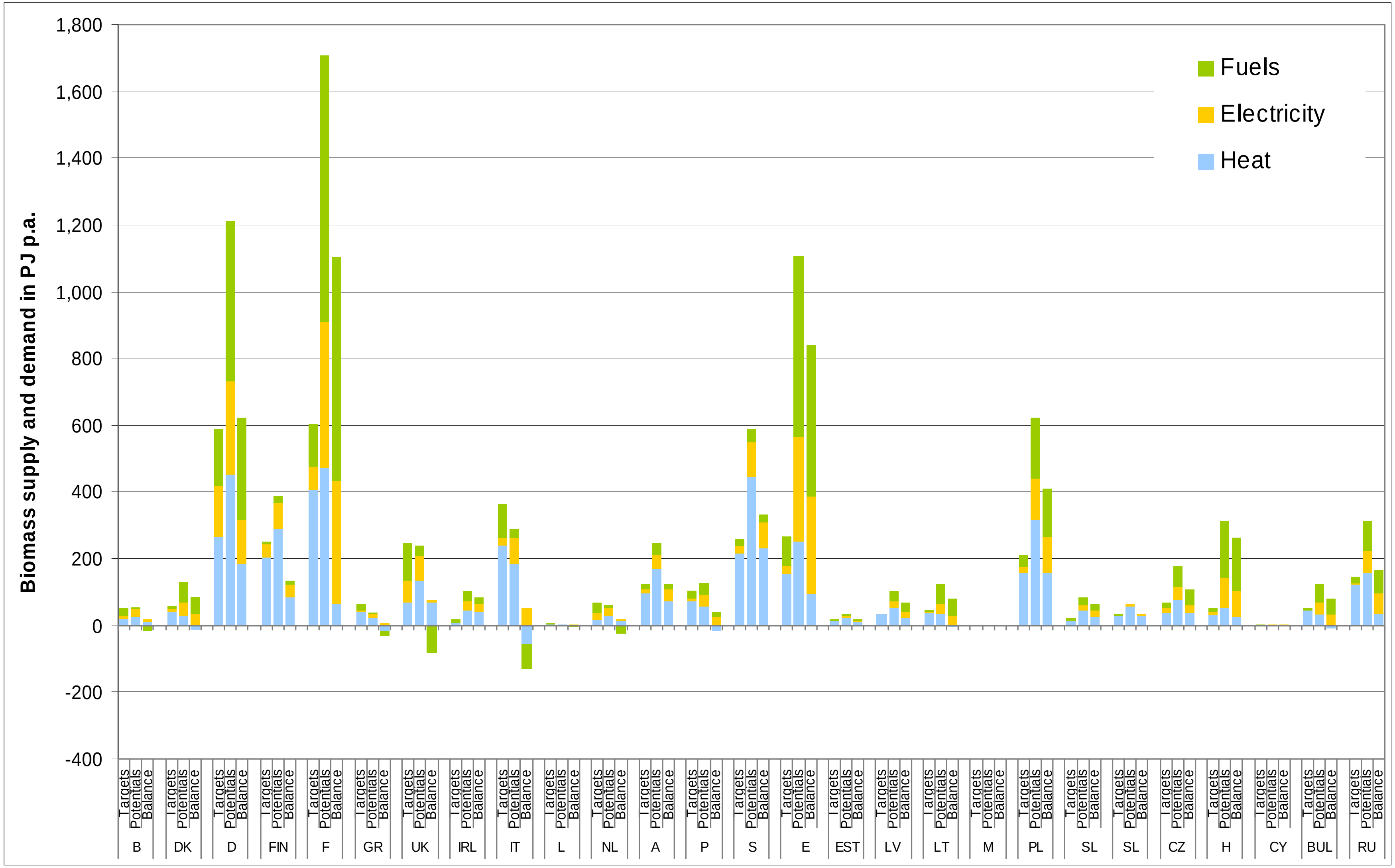

Figure 52: **Supply balance sheet for final energy sources in CP scenario for fuels in the year 2020**

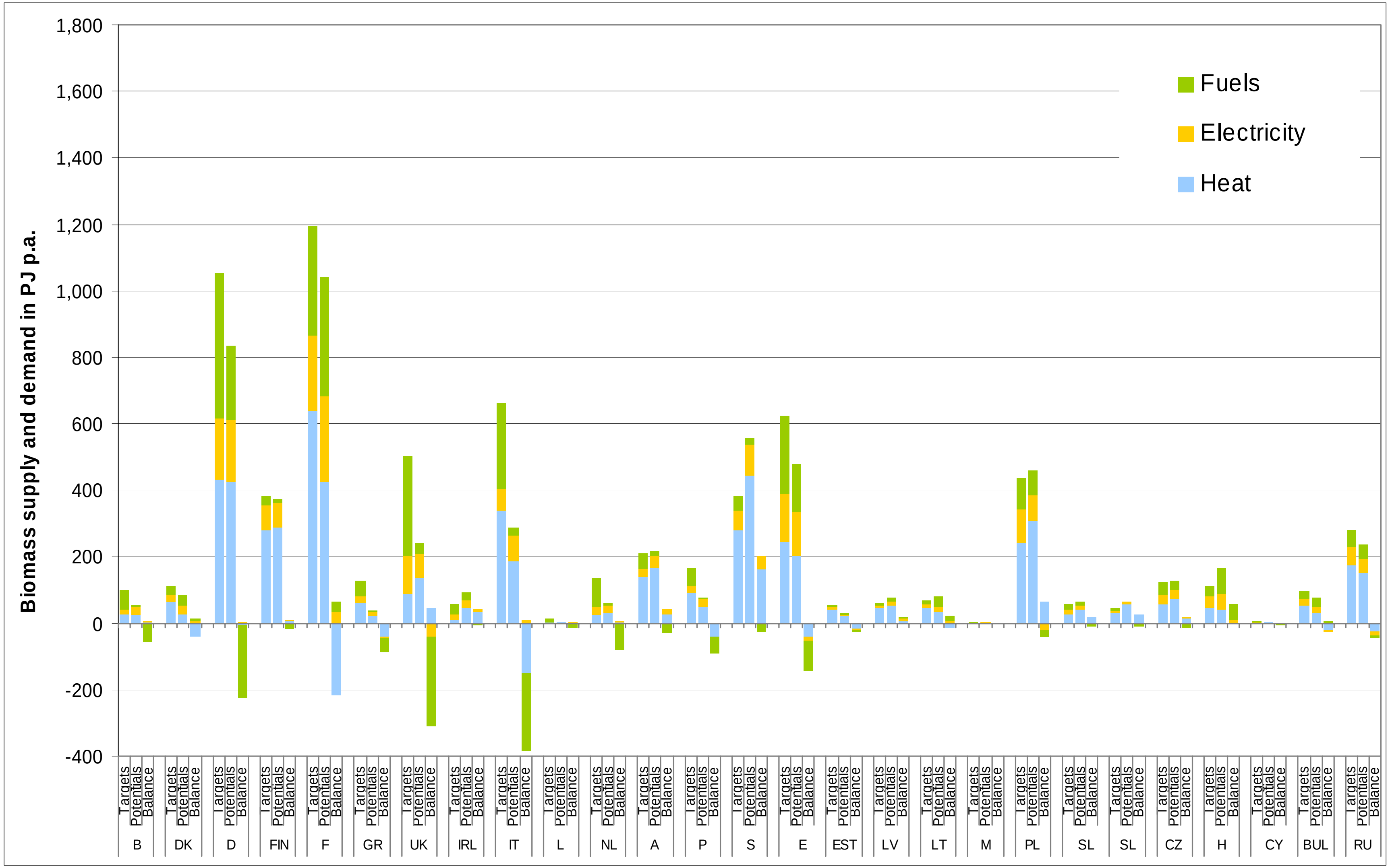

Figure 53: **Supply balance sheet for final energy sources in E+ scenario for fuels in the year 2020**

If the framework for the energy and environmental sector is developed further (Figure 53), biomass demand will develop faster than the supply of additional potential. It is therefore expected that biomass demand will exceed supply in many EU states by 2020, particularly in the EU-15. This particularly applies to Italy and Great Britain, but also to a great extent to France, Germany and Spain. Sweden, whose potential is largely determined by the forestry industry, is the only country with significant excess supply. The acceding countries are able to meet their national demand, however beyond that they are only able to offer limited quantities to the European market. This means that Europe will have a significant import requirement for biomass and bioenergy sources.

A cumulative analysis of the EU-28 over the timeline (Figure 54) further indicates that a shortage in biomass supply will only occur when the framework concerning the energy and environmental sectors is developed further: If further developments are restricted to the energy sector OR the existing environmental protection targets are fully implemented, there will at least be sufficient levels of biomass and bioenergy sources available to meet demand. Furthermore it becomes clear that a shortfall will only occur in 2020 when both the energy and environmental goals are implemented, whereby the fuel target of 15% biofuel is decisive.

The following figures depict the classification of biomass potentials for the EU-28 according to their tradeability in the year 2020. This is then compared to the supply balance (given here as fuel equivalent). In each country, approx. 25-35% of the biomass volume could be made available to the European market. These tradeable products are mainly composed of energy crops in the Current Policy scenario, or residues and forest wood in the Environmental+ scenario.

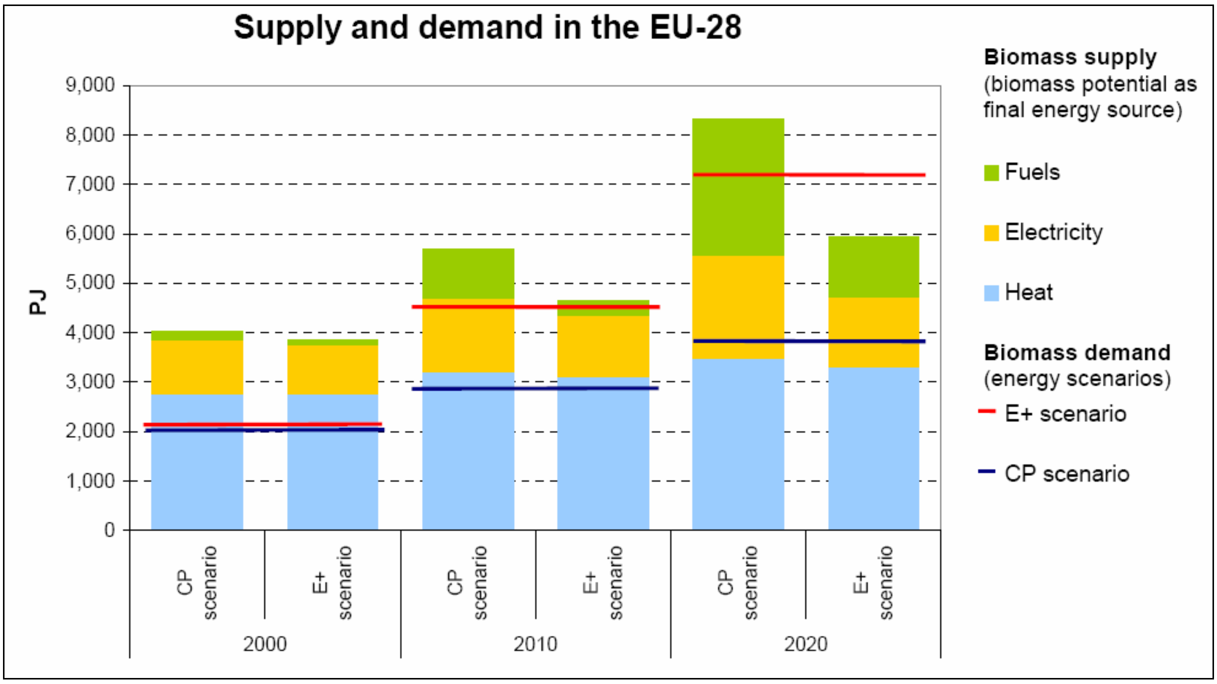

Figure 54: **Supply and demand in the EU-28**

Given the calculated balance figures and extrapolation of the framework (CP scenario), many countries will have a significantly higher supply than the tradeable biomasses which are available (Figure 55). However, this is put into perspective when one also considers the additional available fuel options, i.e. the conversion of non-tradeable biomasses to fuel, which is then also made available to the European market.

Only a few countries would be able to supply the European market if more environmental policies were introduced (E+ scenario). In general, the potential tradeable biomass volume would clearly exceed the biomass available to the European market.

The potential importing/exporting countries in 2020 are summarised in Figure 55 and Figure 56. The various conceivable development paths for the energy and agricultural industries are also illustrated.

In the CP scenario one expects virtually all countries to have significant surpluses. Italy is the only country not in a position to meet its own biomass requirement. This is due to the framework conditions in the agricultural sector. The export surplus will only reduce slightly even if more environmental policies were introduced in the agricultural sector (see sensitivity 1). On the other hand, the biomass surplus will reduce if an increasing amount of environmental policies are introduced in the energy sector. Significant import demands are expected from Great Britain, Portugal, the Benelux countries and Greece.

In the E+ scenario, only a few countries, in particular the EU-10 will be able to use national resources to cover their own needs, whereas the EU-15 countries will have a significant import requirement.

The European trade flows are therefore heavily dependent on the further development of framework conditions in the energy and environmental sectors of the individual countries. These will determine the biomass volumes or bioenergy sources supplied to the European market. Developments in the heavily populated and agricultural countries (France, Germany, Spain, Poland) are decisive for the flow of materials. The policies followed in each of the EU-28 countries, including the extent to which harmonisation and synchronisation are promoted by the EU, are decisive in determining where the trade flows will form.

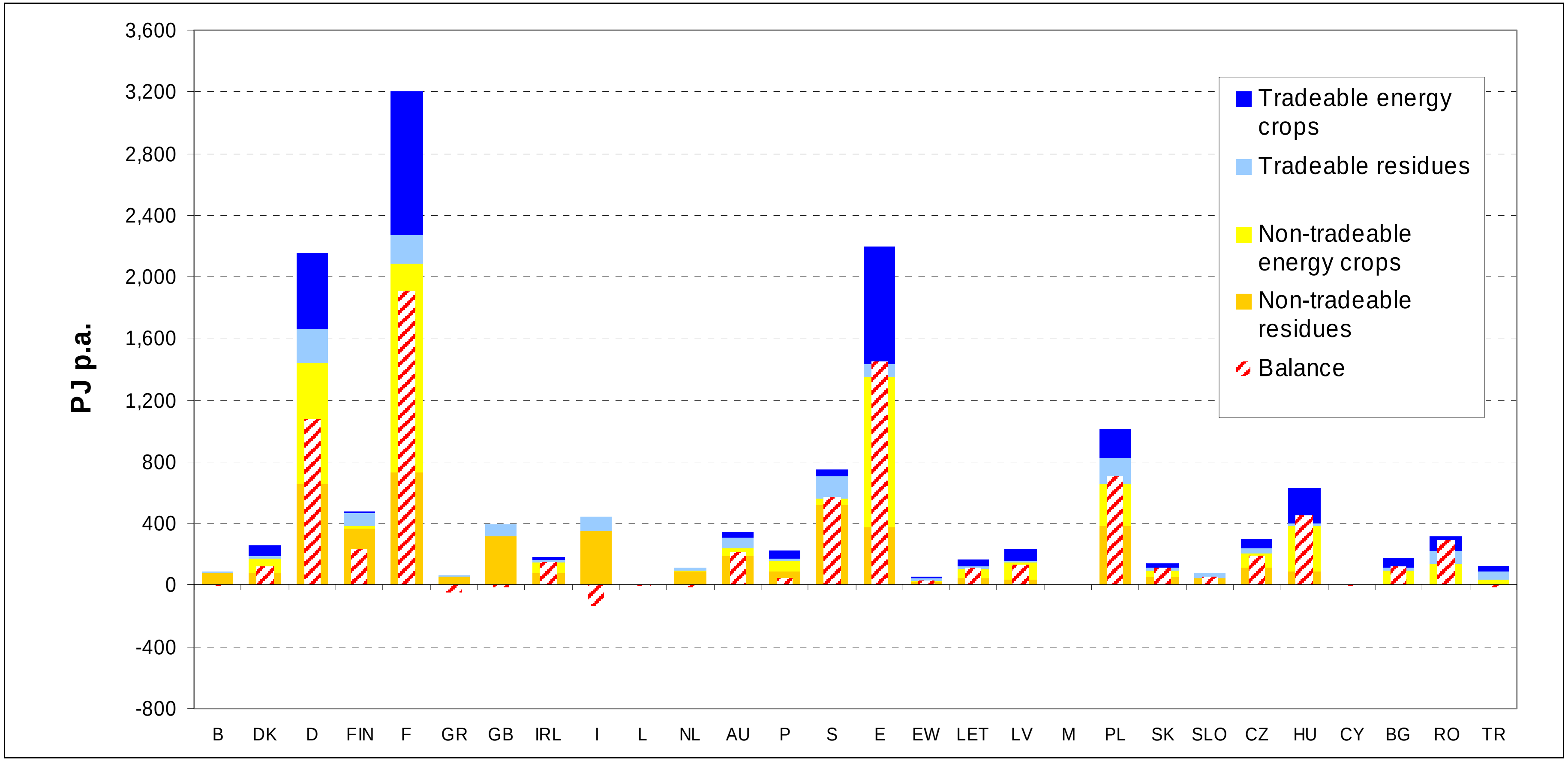

Figure 55: **Tradeable and non-tradeable biomasses in the basis-CP scenario 2020**

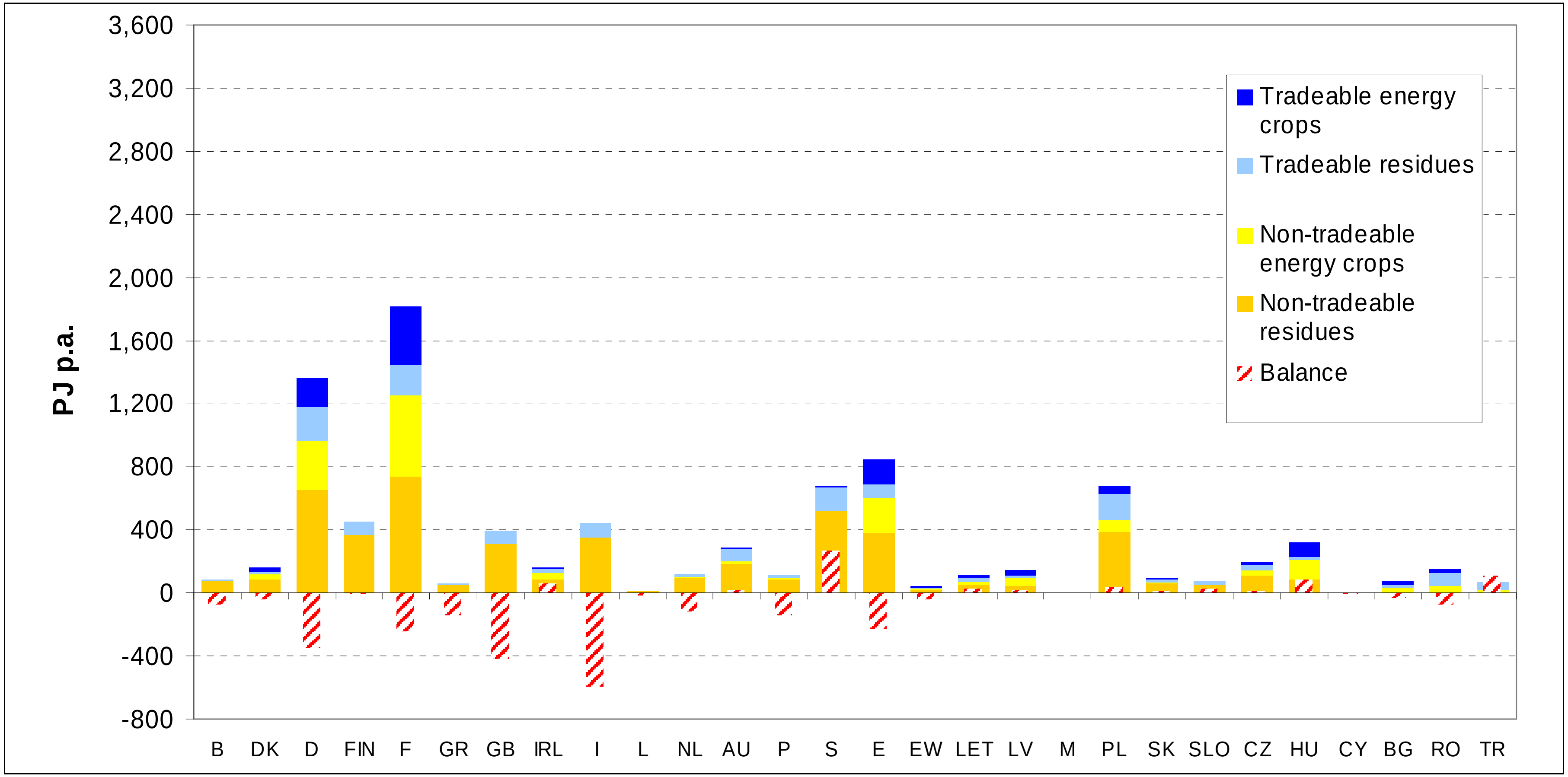

Figure 56: **Tradeable and non-tradeable biomasses in the E+ scenario 2020**

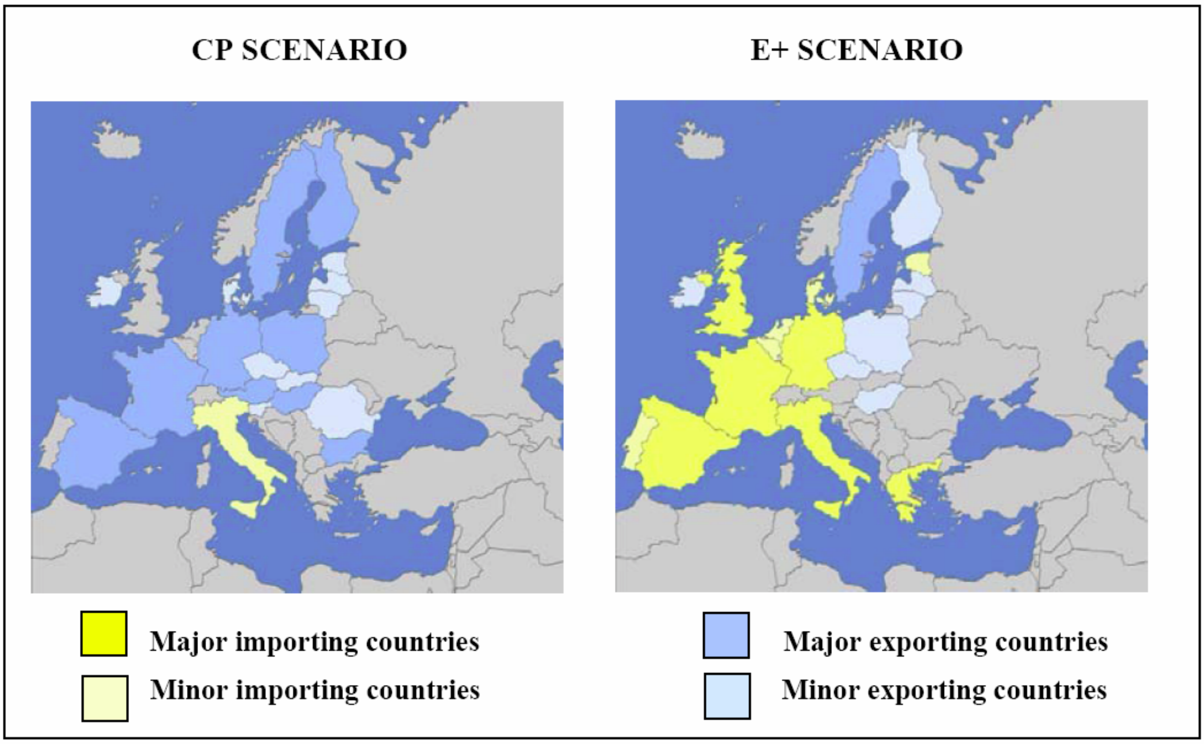

Figure 57: Supply balances in the scenarios for the EU-28 in 2020

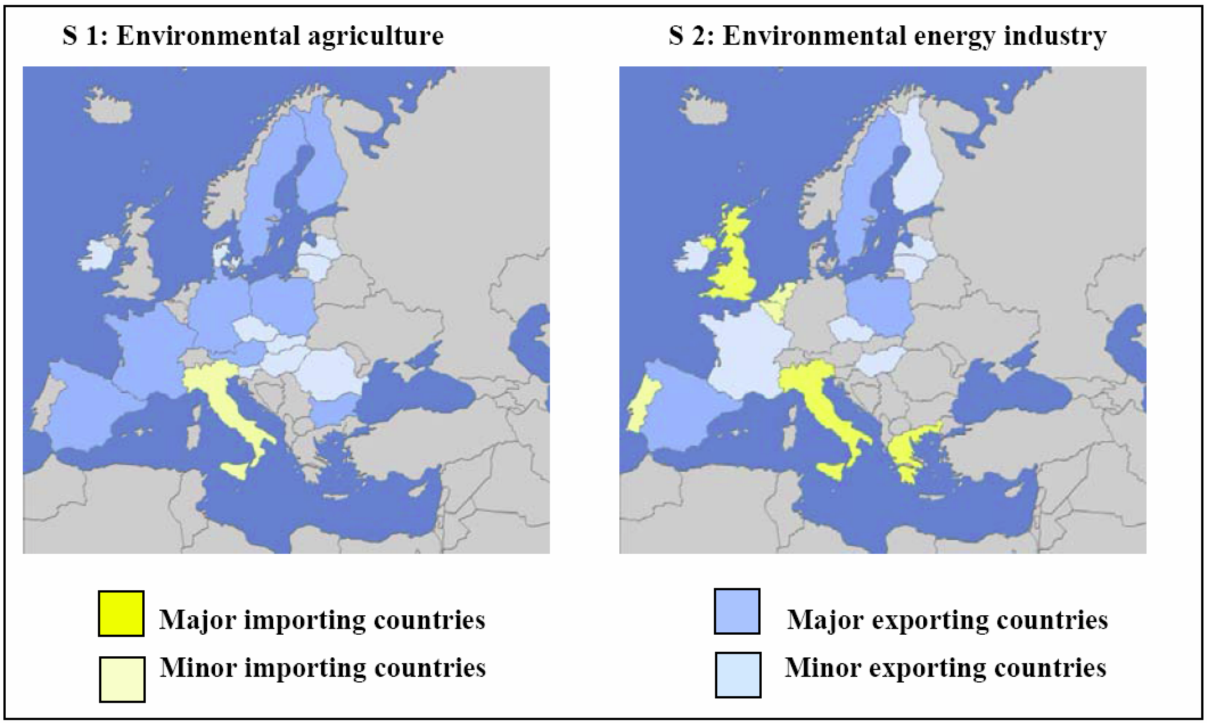

Figure 58: Sensitivity of the supply balances for a partial environmental orientation within the CP scenario for the EU-28 in 2020.

5.4 Ecological aspects concerning the supply and usage of bioenergy

The following section discusses the environmental aspects of trading bioenergy between the EU-15, and the new Member States (EU-10), as well as the candidate countries (CC) of the next planned EU expansion to EU-28 (BG, RO, TR). The central issue concerns the emission of greenhouse gases (GHG), expressed as CO_2 equivalents, as well as acidifying air pollutants (in SO_2 equivalents)[27]. In addition, the question of costs associated with bioenergy imports is addressed as well [28].

The goal of analysis is to clarify whether, and to what extent, there are any emission and cost advantages to be gained when utilised as an import option for Germany and compared to domestic usage in the exporting country.

In a first step, the methodology and database are described and explained using exemplary calculations. The results are then discussed with respect to their possible desirability in terms of European domestic biomass trade, as well as potential imports from non-member states.

5.4.1 Methodology

The environmental analysis is based on results from the German “Material flow analysis of sustainable biomass” project, which dealt with potentials of and selected technologies for bioenergy to provide electricity, heat and, transport fuels /201/. This study offered the core data and the methodical approach for analysing bioenergy use, and to compare relevant technologies.

Therefore, the so-called *material flow analysis* was selected as the methodical basis to determine the balance for all considered products and services (e.g. space heating, electricity, passenger traffic) for all processes up to the supply of primary energy. It also takes into account the manufacture of the required plants as well as the use of auxiliary power, materials

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[27] The methodology and database also permit to calculate other emissions (CO, NMVOC, particulates), as well as the disaggregated representation of individual emissions (CO_2, CH_4, N_2O, SO_2, NO_X etc.), and the determination of residues and resource use (e.g. metals ores, land use).

[28] This is not the main focus of the analysis; however it serves to round off any statements made in relation to the environment. Furthermore, it should be noted that the logistical and transport costs have only been considered in a simplified manner to derive guidance values. A more precise analysis would exceed the scope of this study.

and transports (Figure 59). The material flow analysis was also used in this study to determine the environmental and exploratory cost figures. A more detailed explanation of the methodology may be found in the reference literature /201/.

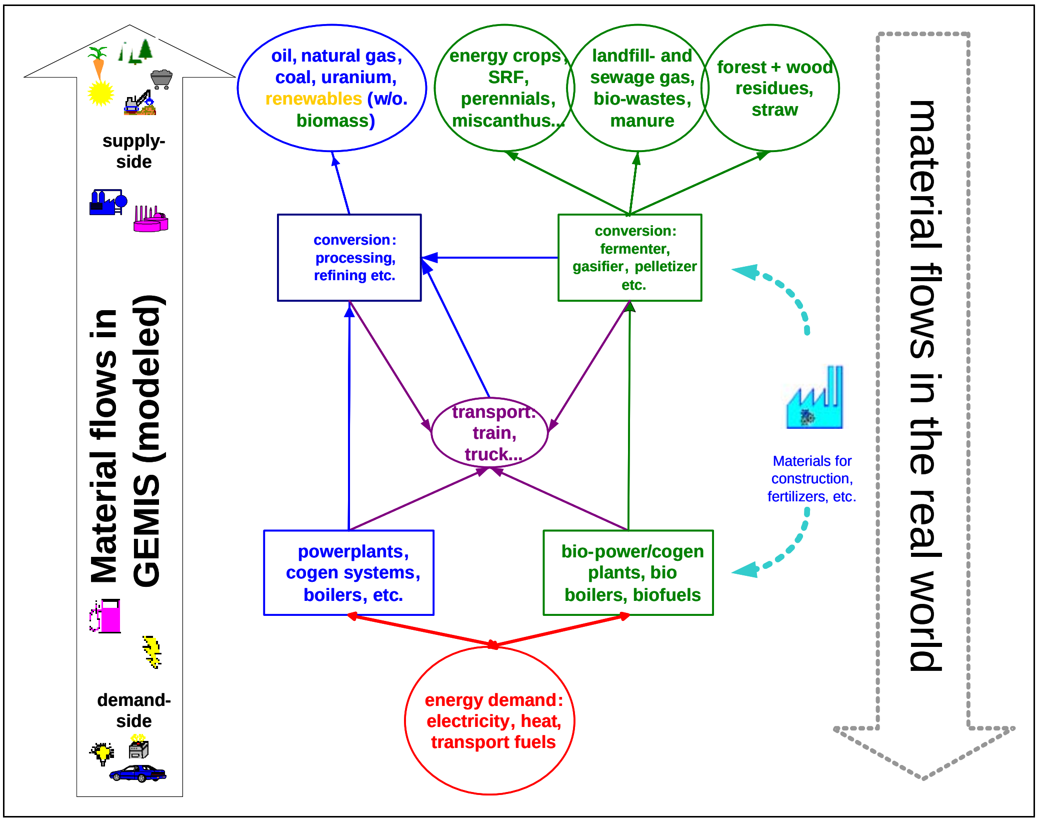

Figure 59: **The principle of material flow analysis when applied to the biomass sector Source: /201/**

The material flow analysis models – opposite to the direction of the real flows – from the "bottom" (demand-side) to the "top" (resource extraction) to provide a comprehensive explanation of all effects. Furthermore, this allows to determine consequences of any change within the process chains, e.g. due to technological improvements,. The acquisition and balancing of data is based on the GEMIS model [29], which offers a broad data background for life-cycle considerations, and material flow analysis. All the required calculations are already integrated in this model. GEMIS also takes into consideration any by-products, e.g. in the initial supply chains for RME or BTL, by adding relevant crediting processes to the balance[30].

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[29] Global Emission Model Integrated Systems – see www.gemis.de

[30] GEMIS can also output "gross" figures, i.e. without allocating any credits for by-products. This allows to analyse the sensitivity of the results with respect to by-product use.

The basic structure of the GEMIS database is shown in Figure 60.

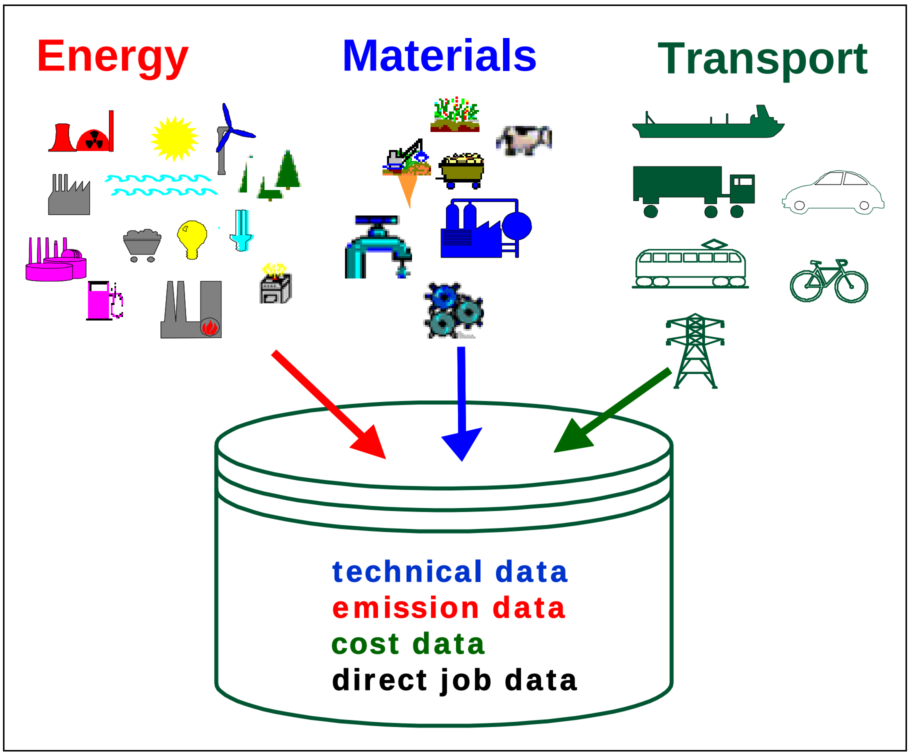

Figure 60: **GEMIS database for material flow analysis**
Source: /201/

GEMIS contains a detailed description for every individual process. Complete process chains are automatically generated by linking individual processes using input, auxiliary energy, auxiliary material and transport links. The results of calculating environmental effects can therefore be broken down to the level of individual process contributions, as well as being aggregated on a regional or sectored basis.

Apart from its database and computational functions, GEMIS also includes result analysis options, importing/exporting routines, and interfaces to the ProBas Internet database operated by the German Federal Environment Agency.

With respect to biomass as an energy source (which is of interest here), GEMIS can also automatically calculate the material flows for carbon, ash and halogens through the *explicit modelling* of fuels using their ultimate analysis.

Furthermore GEMIS can also automatically calculate the balance of environmental effects associated with the transportation of fuels once transportation distances and modes are given.

5.4.2 Data bases for environmental analysis

5.4.2.1 Data for bioenergy processes

The data base to analyse environmental issues draws upon the data core developed for the bioenergy processes in Germany in the “material flow“ project; however, it also uses the updated data for BTL and bioethanol supplied by IE and verified by the Öko-Institut (Institute for Applied Ecology) /204/.

5.4.2.2 Data for electricity and transportation processes

The GEMIS database was also updated and extended within the scope of an EEA project for the EU-28 countries. This project dealt with the electricity sector (Fritsche et al. 2006) and used the database to model the import options. In addition, the initial mineral oil supply chains for diesel fuel in the countries CZ, HU, PL and RO for the period 2000 to 2020 were also modelled based on IEA data and country reports from the United Nations Framework Convention on Climate Change.

5.4.2.3 Biomass supply data

Furthermore, the present project also utilised data from VIEWLS (2005) as well as the data used by IE, in order to represent biomass supply in the selected exporting countries[31].

Finally, the process chains were extended to include the transportation costs for importing bioenergy from CZ, HU, PL and RO, both for domestic transportation (using trucks) and onward transportation to storage facilities/harbours in Germany (by ship or railway). The estimated transportation modes and distances were based on logistical information received from IE Leipzig /205/. This information was then used to estimate the costs.

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[31] The IE data was provided in Excel format, reviewed and subsequently imported into GEMIS. This data is now available in GEMIS 4.3 (see www.gemis.de).

This data was then extended by work of Öko-Institut regarding the bioethanol supply chain from Brazil /206/, and incorporated in GEMIS Version 4.3 which is now available for the public (see /207/).

5.4.2.4 Fuel characteristics data

The fuel characteristics data used in this project was taken from the "material flow" project and supplemented with personal estimates for the elementary analysis of biogenic fuels in the exporting countries based on BIOBIB (2005) /200/.

5.4.3 Environmental effects resulting from the supply of electricity and heat

5.4.3.1 Environmental effects of conventional electricity and heat supply

Figure 61 shows that the generation of electricity in the EU countries differs significantly when compared to the generation mix in the Federal Republic of Germany.

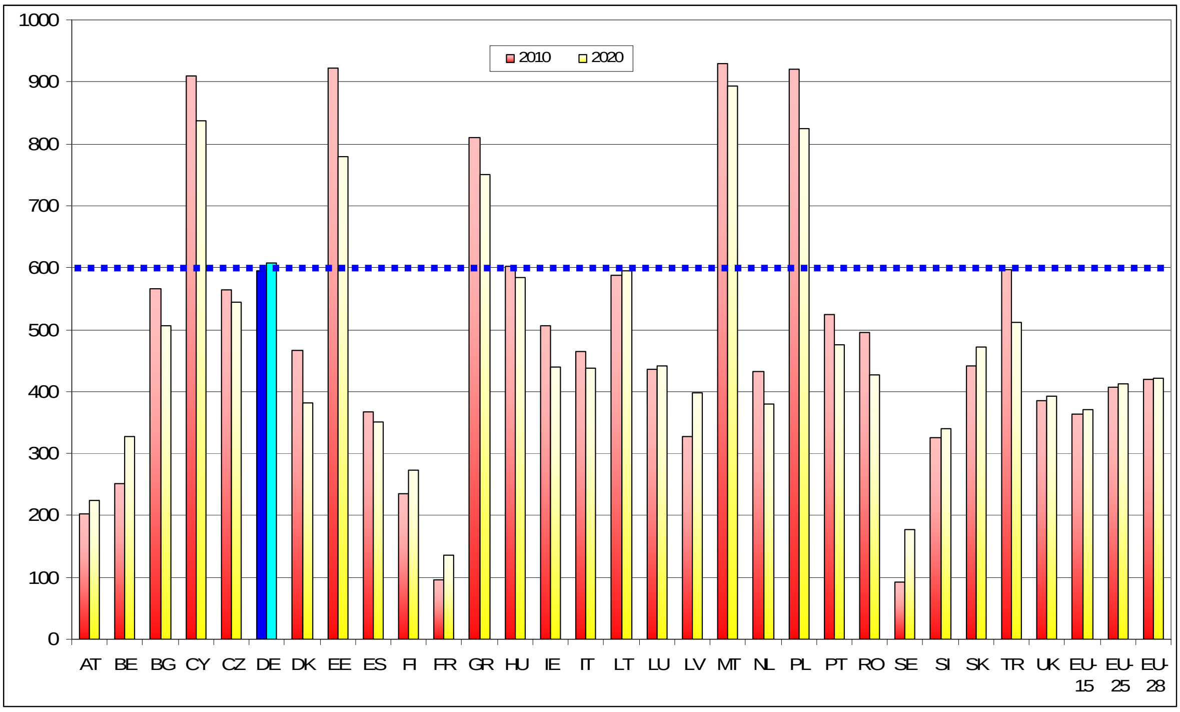

Figure 61: **Greenhouse gas balance for electricity supply using any type of power station in DE and the other EU-28 countries in 2010 and 2020**
Source: /211/

In many EU countries, GHG emissions per kWh of generated electricity in 2010 und 2020 are below the values for DE, whereas they are higher in CY, EE, GR, MT and PL. On the whole, GHG emissions will be reduced in most countries by 2020, whereas they are expected to rise slightly in DE (Reference scenario EWI/Prognos) due to restructuring of the electricity generation system caused by the nuclear phaseout. This also applies to most of the EU-15 countries, whose electricity generation mix will produce higher GHG emission levels by 2020 due to the increased use of natural gas and, to a certain extent, coal; however, those will not reach the levels of Germany.

This comparison shows that, from the point of view of GHG emissions, the utilisation of “domestic” biomass for electricity production in e.g. PL provides a higher reduction potential than when exporting biomass to e.g. Germany for conversion to electricity.

On the other hand, biomass exports from e.g. CZ or RO and the use of this biomass for electricity generation in DE is potentially more “productive” than when used in the domestic market.

Biomass exports from the EU-15 countries to DE would in most cases reduce emissions in DE. However, the EU-15 countries are obliged to reduce GHG in accordance with the Kyoto Protocol, for which biomass plays an important role. Form this perspective, exports are less attractive. Admittedly, the EU-15 countries can export biomass to DE and use the project-related mechanisms stated in the Kyoto Protocol to take into account the emission reductions achieved in Germany. This could result in lower avoidance costs when compared to domestic biomass usage. However, from a German perspective, this does not offer any environmental benefits.

The differences in the GHG balances for heat generated from oil-fired heating systems are predominantly based on the foreign share in the initial oil supply chains, as well as differences in the refinery-related content (approx. 10%). These foreign shares are determined by the crude oil import structures and are the result of differences in oil production, processing and downstream transports. The GHG emissions from the “upstream” part of the oil supply chain are approximately 30 g/kWh useful heat for Germany, whereas for CZ, PL and RO they are around 50 g/kWh, since these countries import a much higher proportion of crude oil from (relatively emission-intensive) Russian crude oil production. However, since the Kyoto Protocol only considers territorial (i.e. domestic) emissions, the calculated “upstream” GHG savings from replacing oil-fired heat with bioheat would will remain insignificant when viewed from a domestic perspective and within the scope of the Kyoto Protocol.

Since biomass resources are primarily used for combined heat and power supply (CHP plants), it is also important to consider heat supply.

Table 54 **Environmental figures for heat supply from oil-fired heating systems in DE and other selected countries in 2010 and 2020**
Source: /211/

Oil heating in		**CO_2-equivalent**	**SO_2-equivalent**
		[g/kWh$_{Useful\ Heat}$]	
2010	CZ	439,2	1,3
	DE	390,0	0,7
	HU	433,6	1,5
	PL	459,5	1,2
2020	RO	444,4	1,5
	CZ	422,8	1,1
	DE	388,1	0,5
	HU	420,4	1,2
	PL	442,6	1,1
	RO	424,3	0,9

The figures show that oil heating systems in DE are more favourable in respect of air pollution and GHG emissions when compared to other countries. The use of biomass resources to replace oil-fired system (e.g. using pellets or CHP heat) is therefore more “fruitful” in these countries than in Germany.

It should be noted that when considering these “heat-related” figures, the most significant difference between these countries lies in their varying crude oil import policies (proportion of North Sea, OPEC and RUS oil), which, according to the Kyoto Protocol, should *not* be assigned to domestic emissions but instead to the exporting countries.

For example, the replacement of oil-fired heating systems in PL would not achieve any reduced emissions when compared to the replacement of oil-fired heating systems with biomass in DE.

5.4.3.2 Environmental effect of supplying biomass to the consumer

Based on the above data, environmental figures were determined in GEMIS when supplying selected bioenergy sources from the sample countries CZ, HU, PL and RO to the German consumer (gas stations, pellet retailers, oil heating tanks etc.).

Table 55 shows an example of emission data for the supply of wood pellets in the Czech Republic (CZ) and their export to Germany (DE) in comparison with the supply in DE.

The decisive point for supplying wood pellets from sawmill residues is the energy required to produce the pellets, which is covered by the national electricity mix in CZ und DE. When importing pellets from CZ one must also consider the transportation costs (in this case by ship).

Table 55 **Environmental figures for supplying wood pellets in CZ and DE**
Source: /211/

Wood-pellets from		CO_2-equivalent	SO_2-equivalent
		$g/kWh_{Final\ Energy}$ (without combustion)	
2010	CZ domestic	14,4	0,04
	CZ to DE	24,8	0,15
	DE	13,0	0,03
2020	CZ domestic	12,6	0,04
	CZ to DE	23,0	0,15
	DE	13,2	0,03

The impact of transporting the wood pellets is clearly visible in the “import” case from CZ when compared to domestic supply.

The same effect as for transporting/importing solid biomasses into Germany is also apparent for wood chips (Table 56).

In contrast to wood pellet production from sawmill residues, the manufacture of wood chips requires a diesel engine as well as a domestic “upstream” supply chain. The cultivation of wood from short rotation forestry (SRF) also provides differing yields and emission loads per country (fertilizer and harvesting costs). The emissions caused by the production of SRF wood chips in the exporting countries CZ and RO used in the above example are significantly higher than those in DE.

Table 56 **Environmental figures for the production of wood chips from short rotation forestry in CZ, DE and RO in 2010 and 2020**
Source: /211/

Wood-pellets from		**CO_2-equivalent**	**SO_2-equivalent**
		g/kWh$_{\text{Final Energy}}$ (without combustion)	
2010	CZ-	28,6	0,2
	CZ-export to DE	38,6	0,3
	DE	20,6	0,1
	RO	46,4	0,3
	RO-Export to D	77,4	0,7
2020	CZ	31,3	0,2
	CZ-Export nach DE	41,3	0,3
	DE	20,6	0,1
	RO	50,2	0,3
	RO-Export nach DE	81,1	0,7

Emissions will significantly increase when transporting bioenergy from the exporting countries, which particularly applies to air pollutants. The increase in emissions depends on of transport mode and distance travelled, though.

If these “upstream” emissions are compared with those, for example, from an oil-fired heating system (see Table 54), it becomes clear that a relatively large saving can be achieved by importing bioenergy sources despite their “upstream” emissions.

5.4.3.3 Environmental effects when utilising biomasses for electricity and heat

Biomass should primarily be used in CHP plants to achieve maximum efficiency. For this reason, an additional comparison was made between using biomass from the case study countries PL and RO in local (domestic) CHP plants, and exporting and utilising the fuel in CHP plants in DE. The examplary country cases represent a broad spectrum in terms of emissions due to electricity production, biogenic potentials, and distance from Germany. This way they form a kind of “corridor” within which a large number of other EU countries lie. The results are therefore representative for the whole of the EU-28.

In the *reference case (REF)*, electricity and heat demand is always covered by the domestic electricity generation mix, and by domestic oil-fired heating systems, respectively.

In order to compare this reference case with biomass use in CHP, a basis of 1 kWh electricity plus 4 kWh heat was applied to each country, as this is a typical ratio of electricity to heat in decentralised CHP plants using biogenic solid fuels (steam engines, ORC processes)[32]. In the reference case, a demand of 1 kWh of electricity generated both in Poland and Germany, and 4 kWh of heat in Polish and German oil-fired heating systems was therefore assumed.

Similar to before, a distinction was made for the years 2010, and 2020. Table 57 shows the results using the example of *Polish* wood chips derived from logging residues that are used in decentralised CHP plants in PL or DE.

Table 57 Environmental figures for supplying electricity and heat from a power station mix + oil-fired heating versus wood chips with CHP in PL and DE
Source: /211/

Combination of		**CO_2-equivalent**	**SO_2-equivalent**
		g pro 4 kWh_{th} + 1 kWh_{el} per country	
2010	Oil heating&elec. PL + Oil heating&elec. DE	4912	13,6
	Woodchips CHP PL + Oil heating&elec. DE	2466	7,1
	Oil heating&elec. PL + Woodchips imp. CHP DE	3080	14,0
2020	Oil heating&elec. PL + Oil heating&elec. DE	4750	12,4
	Woodchips CHP PL + Oil heating&elec. DE	2401	6,8
	Oil heating&elec. PL + Woodchips imp. CHP DE	2848	13,9

Approximately 5 kg of GHG and almost 14 g of acid emissions are released in the reference case. The emissions could almost be halved when using Polish wood chips from short rotation forestry in a CHP plant in PL, whilst at the same time generating electricity in a German generation mix + German oil-fired heating in DE.

On the other hand, the emissions would be *higher* if the Polish wood chips were exported to DE and used in an identical (!) German CHP plant and the Polish demand for electricity were covered by the Polish generation mix and heat from Polish oil-fired heating systems.

This result is also valid for the year 2020, although the values are slightly lower.

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[32] Here one has assumed a steam engine CHP utilising SRF wood chips versus a 10 kW oil heating system and electricity generated from domestic power stations. The CHP heat distribution and electricity distribution have not been considered in order to simplify the comparison.

Figure 62 provides an overview of this situation.

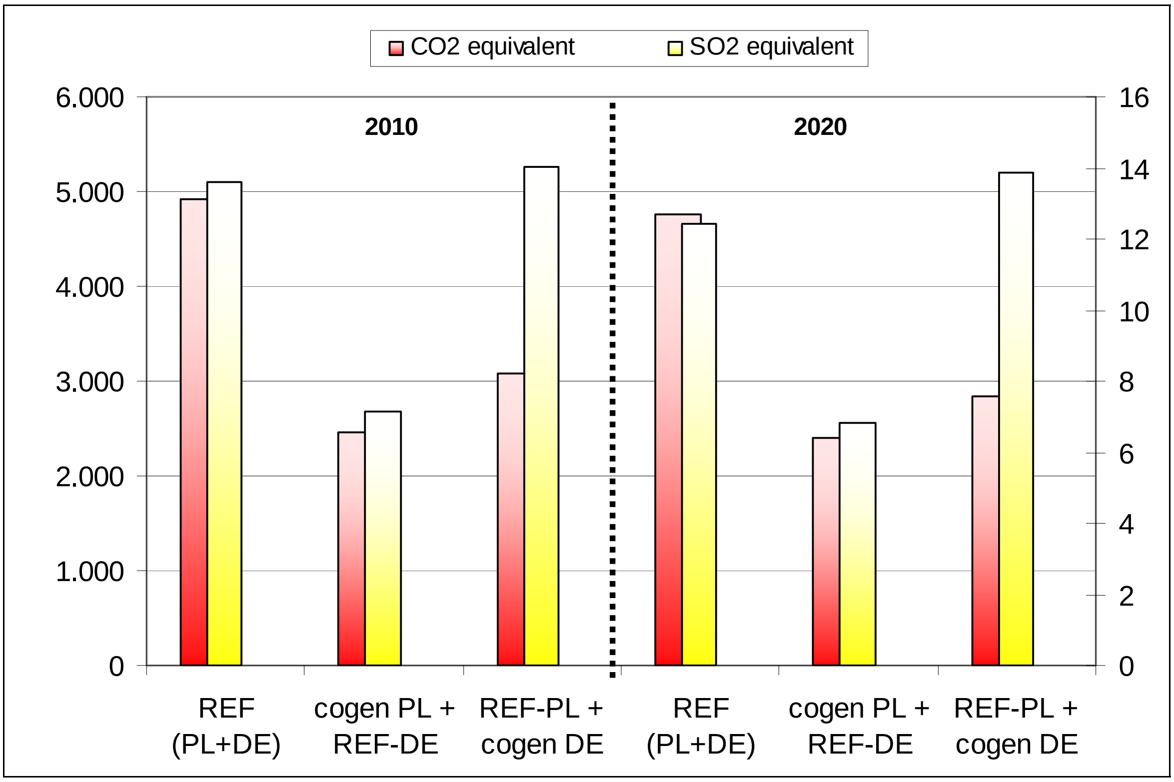

Figure 62: **Comparison when using wood chips from Polish SRF for electricity and heat supply using CHP in Poland and Germany**
Source: /211/

This brief analysis shows that the "domestic" use of Polish wood chips is clearly preferable from the point of view of environmental protection and reduced air pollution when compared to the export of wood chips to Germany.

The reason for this lies in the Polish generation mix – CHP electricity generation using Polish wood chips in Poland replaces more emissions as compared to supplying the same amount of electricity from (imported) biomass in Germany.

On the other hand, the transport-related emissions of Polish wood chips for use in Germany do not play a significant role in the emissions balance.

What is the situation in the other countries? A similar comparison was carried out for wood chips from SRF in Romania (RO) (Table 58)

Table 58 **Environmental figures for supplying electricity and heat from a power station mix + oil-fired heating versus wood chips with CHP in RO and DE**
Source: /211/

Combination of		**CO_2-equivalent**	**SO_2-equivalent**
		g pro 4 kWh_{th} + 1 kWh_{el} per country	
2010	Oil heating&elec. RO + Oil heating&elec. DE	4426	11,5
	Woodchips CHP RO + Oil heating&elec. DE	2501	7,6
	Oil heating&elec. RO + Woodchips imp. CHP DE	2850	15,0
2020	Oil heating&elec. RO + Oil heating&elec. DE	4279	8,0
	Woodchips CHP RO + Oil heating&elec. DE	2502	7,8
	Oil heating&elec. RO + Woodchips imp. CHP DE	2671	12,7

It can be clearly seen that also the use of Romanian wood chips in “domestic” CHP plants is preferable in terms of emissions when compared to an export to DE for use in German CHP plants. This is also illustrated in Figure 63.

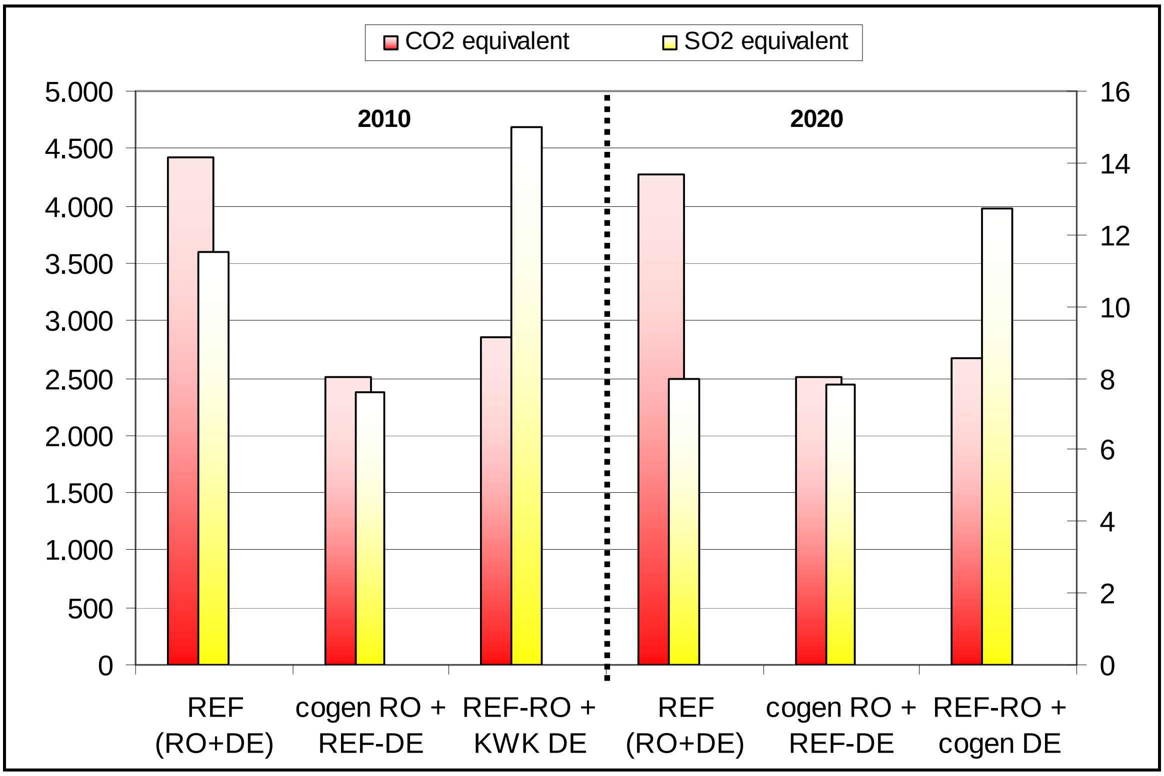

Figure 63: **Comparison when using wood chips from Polish residue wood for electricity and heat supply using CHP in Poland and German**
Source: /211/

5.4.3.4 Cost effects when utilising biomasses for electricity and heat

Apart from the emission figures, the costs for the various wood usage options were also determined. Hereby it is assumed that the investment and operational costs of the wood chip

CHP and oil-fired heating systems were identical in DE and PL, whereas the costs of the actual wood chips and electricity generation were determined per country[33].

The supplementary cost figures for the above variants are shown in the followingTable 59:

Table 59 **Costs for supplying electricity and heat from a power station mix + oil-fired heating versus wood chips with CHP in PL or RO and DE**
Source: /211/

Combination of		PL vs. DE	RO vs. DE
		€ pro 4 kWh_{th} + 1 kWh_{el} per country	
2010	Oil heating&elec. + Oil heating&elec. DE	0,93	0,97
	Woodchips CHP + Oil heating&elec. DE	0,66	0,67
	Oil heating&elec. + Woodchips imp. CHP DE	0,64	0,69
2020	Oil heating&elec. + Oil heating&elec. DE	1,01	1,07
	Woodchips CHP + Oil heating&elec. DE	0,7	0,71
	Oil heating&elec. + Woodchips imp. CHP DE	0,67	0,74

In the year 2010, the use of *Polish* wood chips in a *German* CHP plant would be approximately 2 Euro-cents *cheaper* than in a Polish CHP plant; by 2020 this will rise to 3 Euro-cents. This is mainly the result of the higher German electricity generation costs.

In contrast, the utilisation of *Romanian* wood chips in a *German* CHP plant in 2010 will be roughly 2 Euro-cents more *expensive* than its “domestic” use in Romania; this will rise to approximately 3 Euro-cents by 2020. This is due to higher transportation costs involved in the export of Romanian wood chips.

From a Romanian perspective, the cost figures for the *non-export* would also be better, whereas Poland would gain a slight cost advantage through the export business, as the transportation distances are relatively short, thereby having little effect on the costs.

However, if one considers the *trade with avoided CO_2 emissions* through the use of “local” CHP plants instead of trading Polish wood chips, Poland could roughly save an additional 0.5

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[33] The costs for a wood chip CHP and oil-fired heating system are based on Fritsche et al. (2004) /207/ whereas the wood chip supply costs in PL and RO are based on VIELWS (2005) /210/. The transportation costs for export to DE have been estimated by the Öko-Institut within the scope of this project; the national electricity generation costs are the result of a calculation using GEMIS 4.3 (see /208/).

kg by using local CHP plants as opposed to the export option. Given a certificate price of €20 per t of CO_2, this would correspond to roughly 1 Euro-cent "income" per kWh CHP electricity from *emission trading*, at €40 per t CO_2 one would achieve monetary balance.

In the case of Romania, a German investor could launch a *joint implementation* project in Romania and "transfer" the higher levels of CO_2 reduction in Romania as compared to the export option. This would result in a monetary value of approx. 0.5 Euro-cents at prices of €20 per t CO_2 and approx. 0.3 kg *additional* GHG savings compared to the reference case.

It should be noted that the above cost analysis only considered the economic figures and that investments were calculated using a uniform capital interest of 7% (real). However, in reality capital interest from investors in DE, PL and RO will differ according to the institutional basis and risk assessment, i.e. the "value" perceived by the investors may vary significantly. Furthermore, there will be transaction fees for emissions trading as well as in joint implementation projects. These costs have not been considered here.

5.4.4 Environmental effect of supplying biofuels to the consumer

Apart from the potential trade in solid fuels for stationary energy supply, it is interesting to consider the avoidable imports of fossil oil-based fuels, and how the environmental and cost figures will be affected by the possible import of *biogenic fuels*.

In order to address this question, the life-cycles for supplying biofuels from various raw materials in different countries were investigated and discussed using the following examples:

- ➢ The first option is bioethanol, which can be used as an additive or in its pure form as a fuel for Otto engines.
- ➢ Bioethanol can only be added to a limited extent in diesel engines. The alternative is to use either RME (derived from rapeseed oil) or a synthetic biodiesel obtained through the gasification of biomasses and subsequent Fischer-Tropsch synthesis (BTL).

5.4.4.1 Bioethanol

Table 60 shows the life cycle emissions from the extraction of raw materials to the tank in the vehicle ("well-to-tank"), but does not include the actual usage in the engine.

Table 60 **Environmental figures for the supply of bioethanol in various countries (well-to-tank figures without usage of the fuel)**
Source: /211/

Bio-Ethanol from		CO_2-equivalent	SO_2-equivalent
		g/kWh_{Fuel} (well-to-tank)	
2010	Wheat CZ	215,6	0,8
	Wheat DE	194,3	0,6
	Wheat PL	217,7	0,7
2020	Wheat CZ	205,7	0,7
	Wheat DE	198,3	0,6
	Wheat PL	207,1	0,5
2010	Sugar cane BR with transport	104,9	0,9

The production of bioethanol from German wheat (in Germany) will produce less emissions in 2010 and 2020 than imported bioethanol – in contrast, Czech and Polish exports will have almost the same emission levels. Imports from these countries therefore do not provide any benefit from an emissions perspective.

The situation with Brazilian bioethanol is different as there are favourable cultivation conditions for sugar cane which is assumed as a feedstock to bioethanol. Its low GHG figures are not even compensated by the need for ocean shipment to Germany. However air pollutant emissions are higher than for all other options Without considering overseas shipments, Brazilian bioethanol contains SO_2 equivalents of approx. 0.7 g/kWh, which corresponds to the values for wheat-based bioethanol from CZ and PL. Overseas shipments are responsible for almost 10 % of the GHG emissions in Brazilian bioethanol..

When considering the cost figures, Brazil (approx. 3.6 euro cents/kWh bioethanol incl. transport) is more or less comparable with Polish wheat-based bioethanol (3.3 euro cents/kWh), but significantly below the cost of German wheat-based bioethanol (7.2 euro cents/kWh) or Czech wheat-based bioethanol (4.2 euro cents/kWh).

Imports of Brazilian bioethanol could therefore lower GHG emissions as well as costs when compared to German bioethanol, whereas bioethanol imports from CZ and PL (both wheat-based) would slightly lower the costs but not emission levels.

These cost reductions arise from the lower initial wheat costs in CZ and PL, as stated in VIEWLS (2005), which are not fully compensated by the additional transportation costs to Germany for bioethanol produced abroad /210/. The emission figures (in terms of greenhouse gases) are approximately 10% higher for bioethanol imports into DE, and therefore relatively low when compared to the use of petrol extracted from imported crude oil; hence it is still possible to achieve significant reductions in emissions.

In contrast, the cost differences for imported bioethanol are relevant as they are up to 50% lower when compared to actual costs in Germany. It is interesting to note that the cost of importing bioethanol from Poland could still lie below that for Brazilian bioethanol.

5.4.4.2 Biodiesel

In a similar way to bioethanol, figures were also determined for RME with respect to production in Germany and abroad (including the onward transport to the German border). This is summarised in Table 61.

Table 61 **Environmental figures for the supply of RME in various countries (well-to-tank figures without usage of the fuel)**
Source: /211/

RME from		**CO_2-equivalent**	**SO_2-equivalent**
		g/kWh_{Fuel} (well-to-tank)	
2010	CZ	176,7	1,4
	DE	63,4	0,8
	PL	76,3	0,8
2020	CZ	159,9	1,2
	DE	60,8	0,8
	PL	63,7	0,6

One can see a similar effect as for bioethanol; imported RME does not provide any savings in terms of greenhouse gases and air pollutants when compared to “German goods”. In terms of cost, Polish imports could provide slightly more favourable figures (approx. 10% lower).

Even more interesting are non-European biodiesel import variants derived from e.g. jatropha, castor oil or palm oil. These could offer monetary as well as environmental benefits (alternative uses in e.g. detergents). Furthermore, recent studies on these vegetable oils have shown that their regional usage in manufacturing countries (e.g. Brazil, Tanzania, India) is also more attractive from an economic perspective (see /203/ and for India /209/), and that there is still a need for practical assessment criteria to ensure the sustainable supply of biofuels in developing countries /208/.

5.4.4.3 Synthetic diesel fuels

The last fuel option to be considered is synthetic diesel fuel derived from biomass, which converts wood chips from short rotation plantations (SRF) to fuel using gasification and subsequent Fischer-Tropsch synthesis (so-called biomass-to-liquid = BTL or FT diesel). Here, German BTL from SRF wood is compared with equivalent imported BTL fuels from SRF wood chips in CZ, HU, PL and RO. The imported fuel was assumed to be produced from SRF wood chips in the exporting countries, and subsequently transported to the German border.

The BTL plants generate excess electricity which is fed into the national grid, thereby replacing the corresponding amount of domestically generated electricity. This credit in terms of costs and emissions was deducted from the total emissions for the supply of the fuel, i.e. the emissions figures are “net” values (Table 62).

Table 62 **Environmental figures for the supply of BTL from short-rotation wood in various countries (well-to-tank figures without usage of the fuel)**
Source: /211/

BTL Wood SRF (net) from		CO_2-equivalent	SO_2-equivalent
		g/kWh_{Fuel} (well-to-tank)	
2010	CZ	-81,5	0,7
	DE	-102,2	0,6
	HU	-67,9	0,6
	PL	-67,9	0,6
	RO	-14,8	0,7
2020	CZ	-75,6	0,7
	DE	-105,3	0,6
	HU	-63,2	0,7
	PL	-121,4	-0,2
	RO	13,9	1,0

The effect of this credit on the GHG figures is clearly visible: a significant proportion of the biomass is not converted to fuel in the BTL plant, but to electricity using the residual gas in a combined-cycle powerplant. This credit is deducted from the balance for the total emissions of FT diesel. This usually results in negative GHG balances.

The most favourable is BTL from Polish SRF wood, which has lower emission levels in 2010 and 2020 when compared to BTL from German SRF wood. This is due to the fact that the electricity credit in PL is particularly high.

The opposite effect can be observed for BTL from Romania: the generation mix has relatively low GHG emissions, the specific emissions will even decrease by 2020 (see table 54); BTL production will only receive a moderate credit until 2010, and by 2020 one would expect a positive balance to occur. In this case, the export of Romanian SRF wood chips to Germany and their conversion in a German BTL plant would be significantly more favourable at only slightly higher costs, which are the result of transporting low calorific value wood chips.

In terms of costs, German BTL from SRF is at 9 Euro-cents/kWh, whereas imported BTL from other countries could achieve values in the range 4.5 (PL) to 6.5 (HU) Euro-cents/kWh (in 2010) or 5.8 (PL) to 7.8 (HU) Euro-cents/kWh in 2020, respectively.

5.4.4.4 Comparison of the fuel options

Table 63 compares all the partial results for the fuel import variants, in each case for the years 2010 and 2020.

Table 63 Overview of environmental and cost figures for the biofuel variants investigated Source: /211/

		CO_2-equivalent	SO_2-equivalent	Tax
		[g/kWh$_{Fuel}$]		[€cent/kWh$_{Fuel}$]
2010	Bio-EtOH wheat CZ	215,6	0,8	4,2
	Bio-EtOH wheat DE	194,3	0,6	7,2
	Bio-EtOH wheat PL	217,7	0,7	3,3
	Bio-EtOH sugar cane from BR	104,9	0,9	3,6
	RME CZ	176,7	1,4	7,5
	RME DE	63,4	0,8	7,7
	RME PL	76,3	0,8	7,3
	BTL Wood SRF CZ	-81,6	0,7	5,9
	BTL Wood SRF DE	-102,2	0,6	8,8
	BTL Wood SRF HU	-67,9	0,6	6,5
	BTL Wood SRF PL	-146,6	-0,2	4,5
	BTL Wood SRF RO	-14,8	0,7	6,3
2020	Bio-EtOH wheat CZ	205,7	0,7	4,5
	Bio-EtOH wheat DE	198,3	0,6	7,8
	Bio-EtOH wheat PL	207,1	0,5	3,5
	RME CZ	159,9	1,2	7,8
	RME DE	60,8	0,8	8,2
	RME PL	63,7	0,6	7,9
	BTL Wood SRF CZ	-75,7	0,7	7,2
	BTL Wood SRF DE	-105,3	0,7	9
	BTL Wood SRF HU	-78,4	0,6	7,8
	BTL Wood SRF PL	-138	-0,4	5,8
	BTL Wood SRF RO	13,9	1	7,6

Figure 64 and Figure 65 compare the GHG figures and costs for 2010 and 2020.

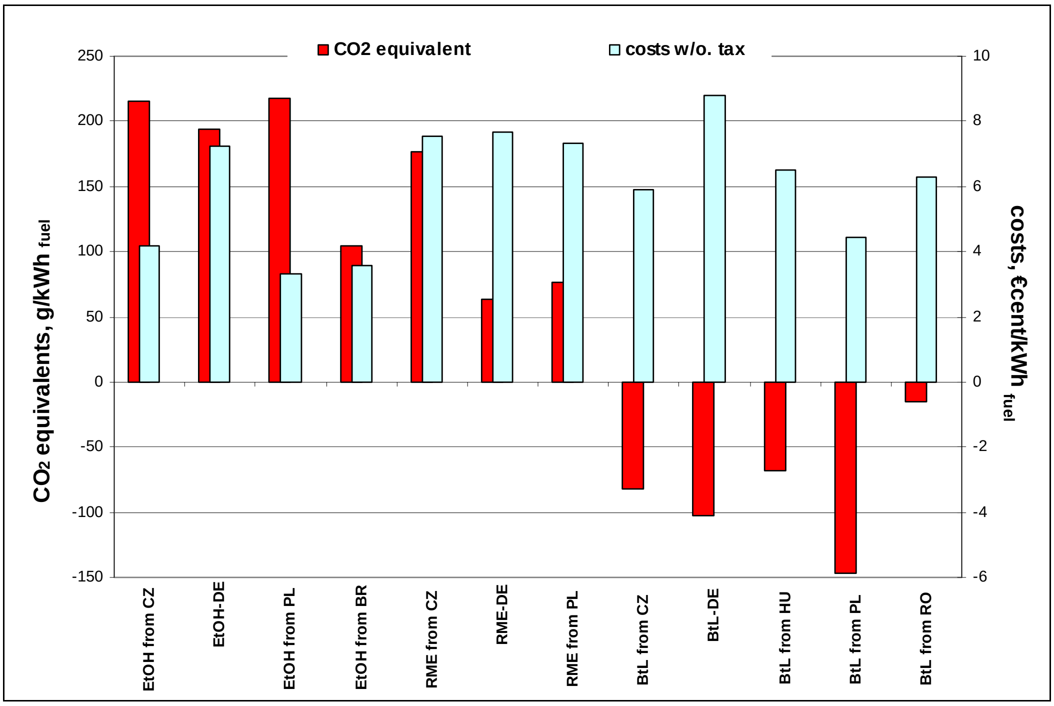

Figure 64: **GHG and cost figures for biofuel variants in 2010**
Source: /211/

It should be noted that the projected cost development until 2020 only considers the effect of price increases for biogenic inputs (wheat, rapeseed, SRF wood), and *not* the potential learning effects gained through the ongoing development of conversion technologies [34].

The BTL options are quite clearly the most favourable in terms of emissions and also low from a cost perspective (particularly for PL). This means they could compete with *untaxed* fossil fuels.

When considering transport fuels, it is important to note that the “attractive” EU countries CZ and PL are also interested in using biogenic fuels *in their own country*, as they are also obliged to reduce greenhouse gases and can improve their balance of payments by avoiding oil imports.

The conversion of potential CO_2 reductions into monetary terms (as for solid fuels) is not possible for biofuels as the transportation sector is not (yet) subject to emissions trading. It

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[34] The possible learning curves for biogenic fuels are given in /201/

remains to be seen how far the *joint implementation* approach can be applied to the “trade” of CO_2 certificates instead of biofuels in the transportation sector, as the monitoring and verification costs are unclear at present.

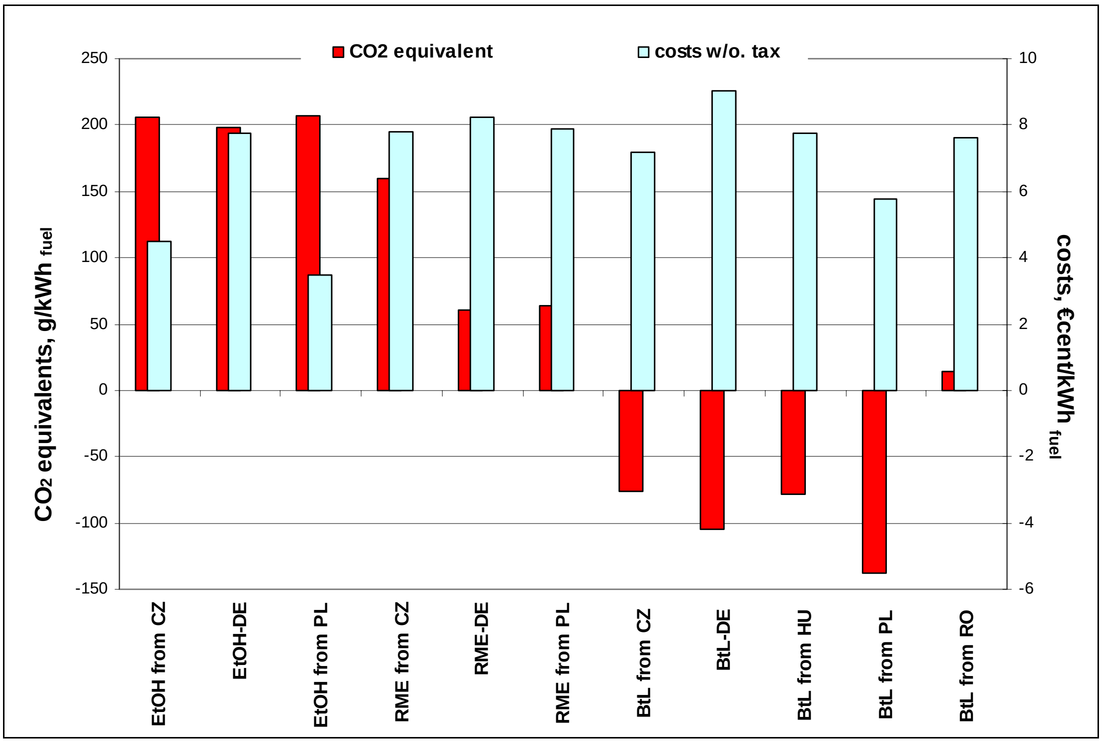

Figure 65: **GHG and cost figures for biofuel variants in 2020**
Source: /211/

5.4.5 Summary of the environmental analysis

The examples show that the environmental balances of potential biomass trade will differ depending on the country and framework conditions – CHP electricity generation is always less costly in those countries where relatively high emissions occur in electricity generation (e.g. PL), whereas exports are a viable alternative for countries with “low-emission” electricity generation (e.g. RO).

The results also show that the “domestic” use of biomass resources in the country of origin may be less costly for CHP when compared to exports; the GHG and air pollutant figures are usually more attractive than for the export option.

The examples for heat production (wood pellets) provide similar results, as “domestic” bioheat supply in the country of origin provides more favourable emissions figures when compared to exports to Germany.

When considering German imports, the extreme cases of PL and RO prove that the export of biomasses does not provide any GHG benefits and will result in slightly increased levels of air pollution. The cost advantages tend to be minimal (if any at all), and can at least be partially compensated with emissions trading.

Despite a few exceptions, the results show that the import of solid fuels (pellets, wood chips) and biofuels (bioethanol, RME, BTL) offer few environmental advantages compared to production using “domestic” resources. The cost effects also tend to be minimal. Exceptions are bioethanol from PL and Brazil and BTL from PL.

When considering the situation in the EU and the medium-term development, there is no significant motivation to trade large quantities of biomass between EU Member States, or candidate countries. Some of the differences observed in greenhouse gas emissions could also be realised to a great extent using the flexible instruments provided by the Kyoto Protocol (joint implementation, emissions trading) *without the need for physically importing* biomass sources.

The significant cost advantages offered by potential bioethanol and FT diesel imports from Poland and BTL from CZ must also be considered from the point of view that these fuels are also attractive for the “domestic” markets in CZ and PL, as the export trade balance and balance of payments can be improved by avoiding the import of fossil energy sources.

The options realistically chosen by these countries are dependent on the development of CO_2 certificate prices[35] as well as crude oil prices.

The forecast CO_2 prices below €30 per t and oil prices around $50/barrel by 2020 will make exports less attractive when compared to domestic usage – this also applies to bioethanol and BTL from Poland and the Czech Republic.

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[35] With biofuels one must also consider the transaction costs for “joint implementation” projects, as long as the transportation sector is not incorporated into the European emissions trading regime.

6 Biomass markets

6.1 Wood markets

Wood and wood products are traded on a global basis similar to other goods. It is not uncommon for producers and consumers to be on different continents. A wide range of different products can also be summarised under the term wood products. This includes raw woods such as (sawn) roundwood, industrial wood and firewood, so-called raw- and semi-manufactured goods such as timber, veneers and derived timber products, but also paper, cardboard and pulp, as well as manufactured items such as furniture and packaging. Processed raw wood has some special characteristics when compared to semi-manufactured or manufactured goods. It is relatively inhomogeneous in terms of its characteristics. Raw wood is not always raw wood; instead, one differentiates between the type of wood, its size, quality and intended application. These inhomogeneous characteristics are the reason that processed raw wood is only traded in limited quantities on commodity forward exchanges. In contrast to other agricultural products, it is therefore not possible to determine a daily global market price for raw wood. Pricing is determined by “regional markets” for certain types of wood or wood groups (e.g. hardwood or softwood) in a certain size and quality. It is therefore common to have price differences between “regional markets”. Price adjustments are always delayed. The situation is different for a large number of semi-manufactured and manufactured goods, particularly paper, cardboard and pulp. Here prices are determined in a similar way to other goods by the global market.

In the case of firewood and energy wood (wood chips), which is considered to be raw wood, and regardless of whether a global trade establishes itself, it is conceivable that pricing on the global market can be based on homogenous product characteristics, since wood type, size and quality would not be decisive pricing factors; only the net calorific value is of importance.

The global trading centres for wood products will be discussed below. This representation is based on statistical analysis from the FAO (FAOSTAT). The goal is to show the magnitude and direction of trade flows and reveal how well the trading of wood products is established.

6.1.1 Global wood trading flows

The average global annual export of wood products over the last three years amounted to 150 billion US$. In terms of value, the largest contribution of 82 billion US$ was made by paper, cardboard and pulp. Derived timber products constituted 20 billion US$ of the worldwide exported goods. The global export of roundwood amounted to approximately 8 billion US$ per year in the same time period.

International wood product trading is mainly concentrated in North America, Europe and by some distance in Southeast Asia, particularly in Japan. Intra-trade in Europe and North America constituted almost 50% of the global trading volume. If one considers the trade flows of the various product groups, one obtains the following picture /130/.

The largest raw wood exporters are the Russian Federation, Canada and the USA. The main importers of this raw wood are the EU and Japan. The largest global consumer of wood chips is Japan. This large demand in Japan is mainly covered by imports from North and South America as well as the Oceanic region. The global export of derived timber products is relatively small in comparison. Intra-trade in North America, the EU and Southeast Asia is even more intensive in comparison. The same applies to paper, cardboard and pulp.

The worldwide trade of energy wood is effectively not yet established. The unfavourable ratio of goods value to transport costs does not make global trading a viable proposition. The fact that energy wood is exported to the EU from the large raw wood exporters Russia and Canada cannot be confirmed using the available statistics.

6.1.2 Trade flows of selected wood products in the EU

The trading relationships developed between the EU member states are relatively stable and tightly knit. It is not uncommon for there to be both imports and exports of e.g. roundwood between two member states. Large variations in trading volume or the establishment of new bilateral trading relationships may occur due to changing market conditions. There can be numerous reasons for this. Changes in the political framework conditions, both at national and international level, or the installation of promotional or market regulation instruments, or even more fundamentally, the collapse of a state or confederation of states can lead to drastic changes in trading flows and relationships. At European level, the creation of an internal

European market, national promotional instruments such as the EEG in Germany or the collapse of the Soviet Union and the CMEA are good examples. Aside from these changes, some of which have long-term effects, natural events such as storms or pest outbreaks can suddenly affect the trading volume and flow of wood products. Once the storm or pest wood phase is over, the old market situation will usually return in the following year.

The most significant trading flows for wood chips and firewood in 2001 will be shown below in the form of a flow diagram; this helps gain an impression of the extent and volume of internal European trade with these partially or fully utilised wood products. In order to assess these trade flows, the trade flows for roundwood have been included as a reference. The data used in these graphics is based on the World Trade Analyzer (WTA). FAOSTAT could not be used as a source for reasons of availability.

6.1.2.1 Trade flows in roundwood

Raw wood is mainly traded as roundwood in the EU-28 countries. The total trading volume in 2001 was approximately 1.3 billion US$. This is the most intensively traded raw wood product in terms of quantity and value. When considering the trade flows between the EU-28 countries, the trading volume between Germany and Austria, as well as between the Czech Republic and Austria, are the most pronounced (Figure 66). The large processing capacities of the Austrian sawmill and derived timber product industries generate a pull in demand, which is compensated by the export of roundwood from neighbouring countries. At the same time, there are significant Austrian roundwood exports to Italy.

Since the mid-1990s, the Baltic States of Lithuania and Estonia also belong to the most prominent raw wood exporters. After the collapse of the Soviet Union, Swedish and Finnish companies have tapped into these natural resources. The significant raw wood exports to Sweden are a major reason why wood felling in Lithuania (see 3.2.2.3) currently outstrips the growth of new woodland. The most significant roundwood importer in Europe is Finland. However, the large demand of the Finnish paper and pulp industries is mainly satisfied by Russia and not the other EU member states. In 2001 the import volume from Russia was in excess of 330 million US$.

Figure 66 also shows that there is a significant trade in roundwood between neighbouring countries. This is due to the increased transportation costs over longer distances. Overland transport using lorries over long distances is only viable for high quality roundwood. The long-distance transportation of low quality roundwood is generally only economic by rail or ship.

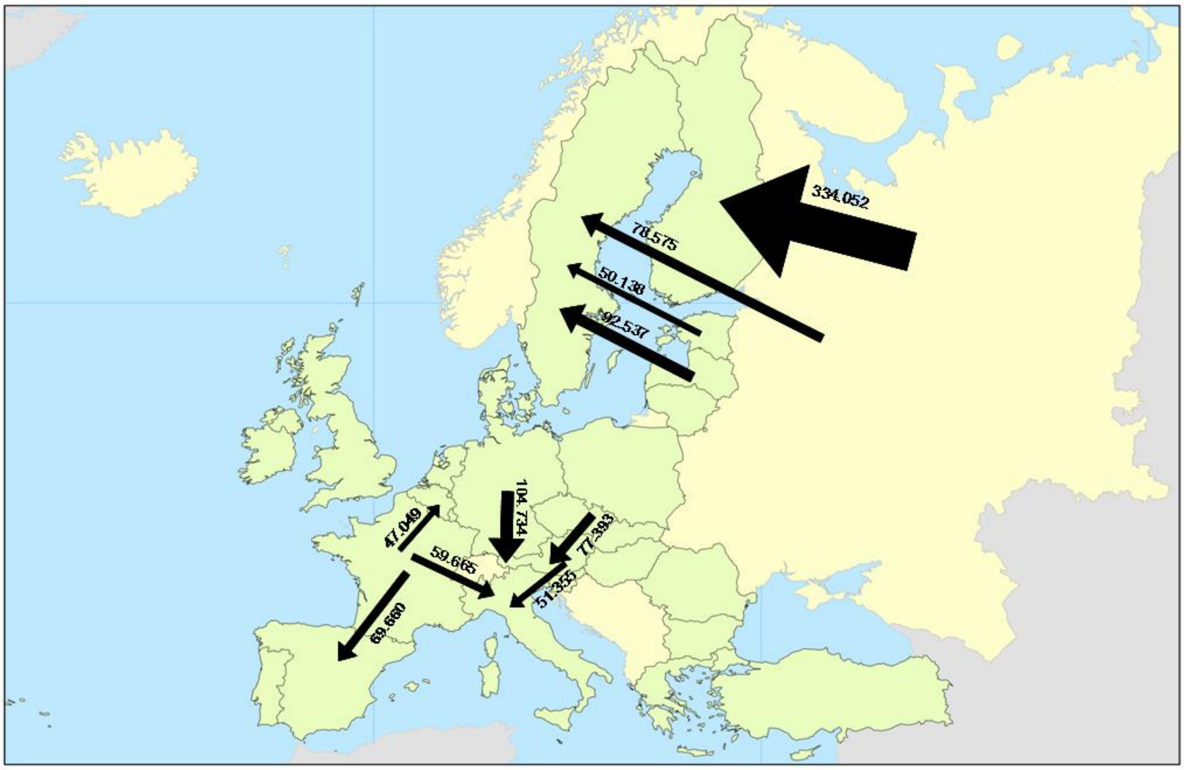


Figure 66: **The most significant roundwood trade flows in 2001 stated in 1000 US$**

6.1.2.2 Wood chip trade flows

The characteristics of wood chips and wood shavings are such that they can be used in either their material form or converted to energy. It is not known in which proportions this occurs for wood chips and shavings. However one can assume that the majority is used in its material form in the derived timber product, paper and pulp industries.

In 2001 the trading volume of wood chips and shavings between the EU-28 countries was approximately 258 million US$. This is therefore significantly lower than the volume in traded roundwood. The highest trade flows in 2001 occurred between Lithuania and Sweden, as well as between Germany and Austria (Figure 67). The largest wood chip exporter in 2001 was Germany. Wood chip exports from Germany to the EU-28 countries amounted to a total of 58 million US$. Sweden is the largest importer of wood chips. The value of wood chips imported into Sweden in 2001 was 37 million US$. France and Finland were almost equal importers and exporters of wood chips. Other significant trade flows could be observed between Estonia and Finland, as well as between the Netherlands and France.

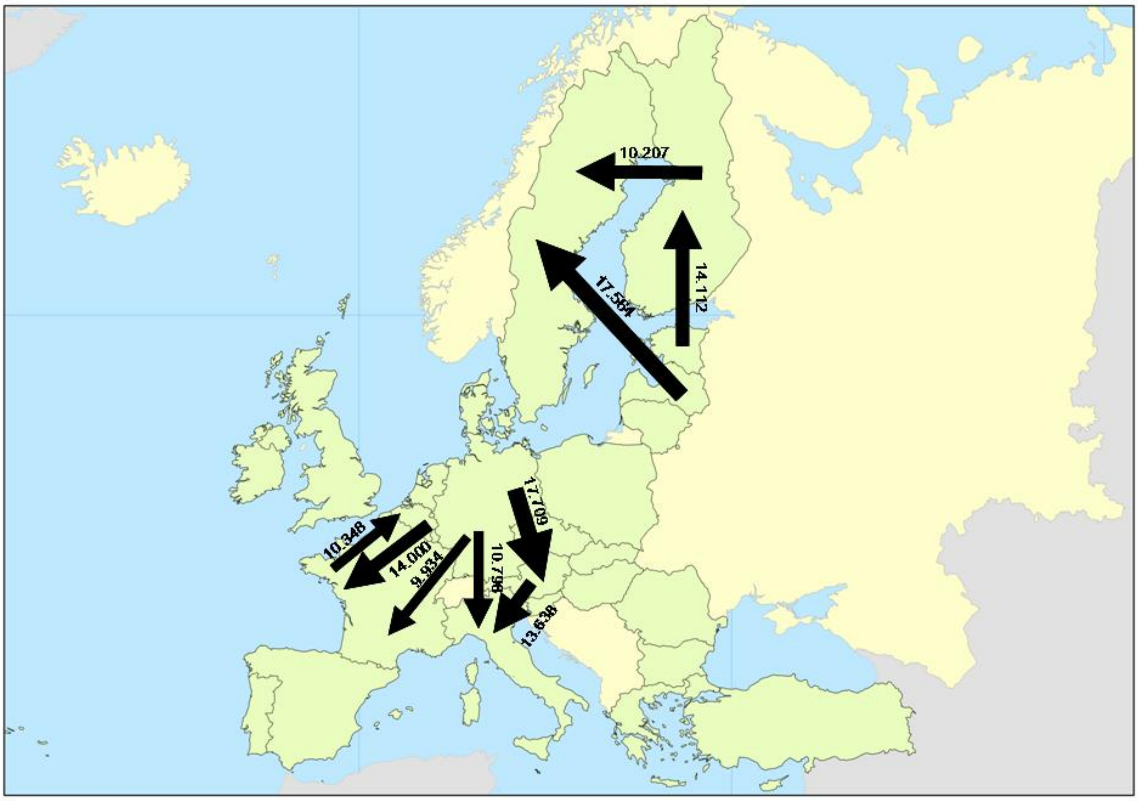


Figure 67: **The most significant wood chip trade flows in Europe in 2001 stated in 1000 US$**

As for roundwood, the import and export of wood chips mainly took place between neighbouring countries. The average transportation distances in relation to the value of the goods are nevertheless relatively high. This is mainly dependent on the structure of the consumers. These are usually larger enterprises from the derived timber product, paper and pulp industries with a large demand in raw materials. These enterprises attempt to secure the supply of raw materials by agreeing high-volume delivery contracts. This reduces the transaction costs and provides a certain level of price security. Distances to suppliers of large quantities of wood chips can therefore be relatively high. Transportation distances in the region of several hundred kilometres are not uncommon.

6.1.2.3 Energy wood trade flows

Energy wood comprises traditional log wood for open fires, chimney or tiled ovens, as well as wood chips which have been processed for energy. It is not possible to determine their relative proportion in the trading volume. In 2001, the total volume of energy wood traded in the EU-28 countries amounted to 102 million US$. The most prominent energy wood exporter is Poland. The export volume was 16 million US$. Germany was the main consumer of this energy wood (Figure 68). Other significant energy wood trade flows occurred between Bulgaria and Greece, as well as from Hungary to Austria and Italy. The main importer of energy wood is Germany. The total import value amounted to 22 million US$.

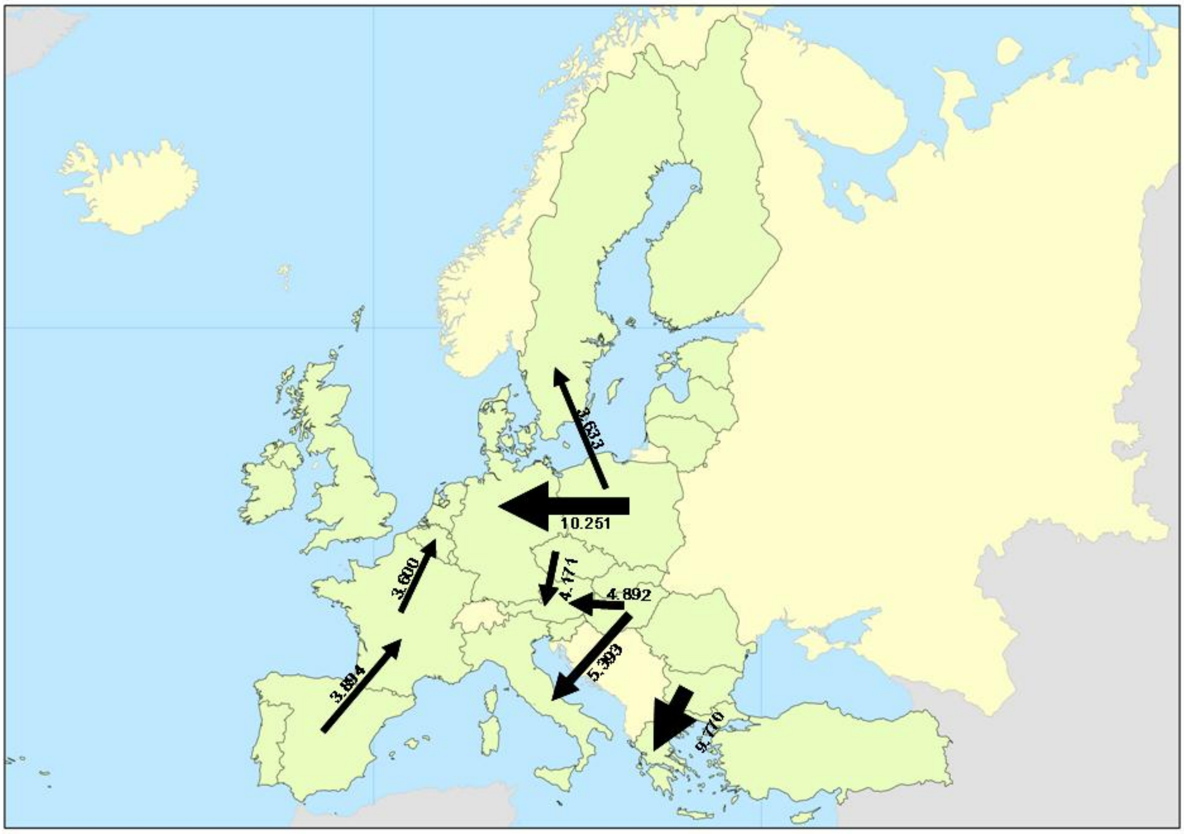


Figure 68: **The most significant energy wood trade flows in Europe in 2001 stated in 1000 US$**

Most prominent are the trading relationships between neighbouring countries. One exception is the export of firewood from Hungary to Italy. Due the low value of the goods, one can assume that the suppliers and consumers of energy wood are situated near the border. For instance, the main consumers of Polish energy wood are in Brandenburg.

On the whole, the trade of energy wood is still relatively low in comparison. The rising prices of fossil energy sources and national/international instruments to promote the use of renewable energy sources make it probable that the future trade in energy wood will increase. Trade will be restricted to border regions as long as the value of energy wood remains comparatively low. Longer distance trading will only become possible in case of large price differences between neighbouring countries or if one country has a very high energy wood demand.

6.2 Pellet markets

The European pellet market is a rapidly growing market, whereby pellets are used as fuel in a wide range of plants; from several 100 MW down to small-scale plants with ratings of a few kW. The pellets are easy to transport and store due to their high energy density and bulk density. These are essential criteria for the expansion of European or even global trade. The rapid expansion of the pellet market is also a consequence of rising mineral oil prices whereas pellet prices have remained more or less stable.

The technology for producing pellets from organic or inorganic substances was introduced more than 15 years ago in the heavily forested countries of Scandinavia. At first the pellets were used in heating and heat and power plants or co-combustion plants to replace fossil fuels. In the last 10 years, pellets have also been used for private use in small combustion plants. Combustion technology in Scandinavia often comprises a converted oil tank, in which the burner and control/regulation elements are replaced. This is made possible by the relatively low legal emission limit values and the low comfort demands of plant operators with respect to fuel supply and ash disposal.

In central Europe the pellet market originated in Austria and developed further via Germany, Switzerland and Italy. In contrast to the Scandinavian countries, pellets in central Europe are mainly used in small and medium-sized central heating systems (< 100 kW) and solely for heat production. The plant technology differs from Scandinavia in that the complete tank including exhaust system is optimised for use with pellets.

By the end of 2004, there were approximately 284,000 wood pellet plants installed in Europe for small and medium-sized applications (< 100 kW) (Table 64)

Table 64: **Installed number of pellet boilers and individual stoves in each of the EU countries Source: /185/**

	Plant rating	No. of pellet boilers and individual ovens < 100kW			
		2001	**2002**	**2003**	**2004**
Sweden	< 25 kW	36,000	44,700	54,700	67,200
Denmark	< 100 kW	31,000	32,000	32,500	33,000
Finland	< 100 kW	730	1,370	2,120	3,000
Austria	< 100 kW	12,300	16,800	22,000	28,000
Germany	< 35 kW	7,200	11,800	18,150	27,250
Italy	< 35 kW	.	70,000	100,000	25,500
Total					**approx. 284,000**

6.2.1 Supply and demand

The European pellet market has experienced significant growth over the last 4-5 years. The consumption of pellets has therefore risen by approx. 15% to approx. 3.0 million t between 2001 and 2004. In 2005 one expects the pellet market to grow by a further 20% to 3.5 million t /187/. Pellet production and usage is currently restricted to a few countries within the European Union due to the availability of raw materials. These are the Scandinavian countries of Sweden, Denmark and Finland, the Baltic States of Latvia, Estonia and Lithuania, as well as Germany and Austria. At present there are approximately 200 pellet production plants in operation with numerous others in the planning stage. Most of these plants are relatively small with an annual production capacity not exceeding 50,000 t, whereby there are various plants with a production capacity of more than 100,000 t being planned (Wismar 60,000-120,000 t and Schwedt with 135,000 t) /184/.

Sweden

At present Sweden represents the largest pellet market apart from Canada. Pellet consumption has risen by almost 40% since 2001 to 1,250,000 t p.a. in 2004 (Figure 69).

Three major factors have determined this rapid market development – large areas of woodland, a tax system that specifically rewards the use of renewable fuels and a high degree of district heating systems in highly populated areas. Whereas pellets were previously only used in larger plants, the use of pellets in small combustion plants has grown strongly over the last 5 years. This is mainly due to investment grants in excess of 30% when converting to a pellet oven, as well as rising electricity and heating oil prices. In 2004 a third of the total consumption in Sweden was used in small-scale plants. A further quarter was burnt in district heating plants. The rest was used in co-combustion plants and for industrial purposes /184/.

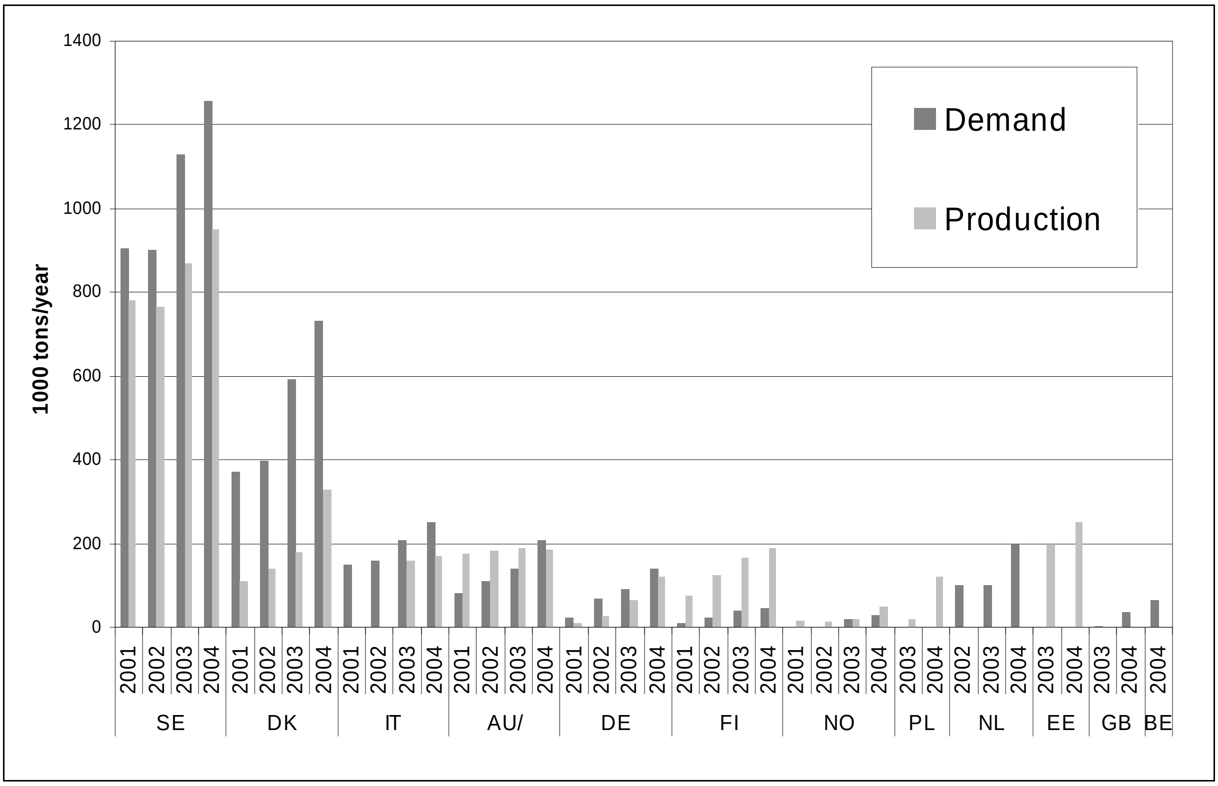


Figure 69: **Pellet production volume and consumption**
Source: data from /184//185/

Denmark

The Danish pellet market has developed in a similar way to Sweden and is now the second-largest wood pellet market in Europe. Pellet consumption almost doubled between 2001 and 2004 and amounted to approx. 732,000 t p.a. in 2004.

In 2004 the company Energi E2 put into operation the second largest pellet production plant worldwide in Køge. This plant produces more than 180,000 t of pellets per year, the majority of which are used in the 2nd block of the Avedøre II CHP plant /188/. By the end of 2004, a total of 2 co-combustion plants, 34 district heating plants (> 0.5 MW), roughly 300 CHP plants (100-350 kW) and approximately 33,000 private pellet boilers with a rating < 100 kW were installed for pellet usage. Approximately 300,000 t p.a. are burnt in pellet central heating systems in Denmark /184/.

Finland

Heavily wooded and scarcely populated Finland has a relatively low demand for pellets by Scandinavian standards. However, one expects that there will be an increased demand for the domestic market /186/.

Austria

The “wood pellet boom” began in Austria in 1997 when the state granted financial subsidies for the usage of biogenic fuels. Approximately 330,000 t of wood pellets were produced in Austria in 2004, whereby the ever-increasing number of plant operators used roughly 220,000 t. This corresponds to a growth of roughly 250% since 2001.

This is mainly due to the promotion of plant operators, manufacturers, as well as research and demonstration projects to increase the efficiency of wood pellet plants. Roughly 28,000 pellet boilers with ratings of up to 100 kW were successfully installed by the end of 2004. The Austrian wood pellet market, which was intentionally launched to reduce CO_2 emissions, is able to completely meet the demands of the domestic market for high-quality wood pellets.

Germany

In Germany, the first fully-automatic wood pellet central heating systems were installed around 3 years after their market introduction in Austria. The subsequent years saw the successful establishment of the pellet market. (Situation by end 2004: 25-30 pellet manufacturers, almost 300 dealers, approx. 27,000 plant operators < 35 kW). A significant contribution has been made by the financial support of plant operators through the federal government’s market stimulation programme and the additional investment subsidies of individual federal states. Despite nationwide supply potential, the pellet plants are still predominantly installed (almost 70%) in South Germany and often combined with solar thermal plants /185//189//190/.

Great Britain

In Great Britain, the pellet market has begun to develop its first consumers and pellet producers over the last 3 years. Great Britain produced a total of only 5,000 t wood pellets in 2004, whereas 55,000 t are already forecast for 2005; the required plant capacity was already completed by the end of 2004. Although there is currently not much interest in the usage of pellets in small-scale plants, there is relatively high interest in the joint combustion of pellets in large CHP plants /184/.

Netherlands

The development of pellet usage in the Netherlands is similar to that in Great Britain. There is a large interest in using pellets in joint combustion systems. The main driver is the electricity feed-in tariff for renewable energy sources which has been in place since 2002 /184/.

Italy

In 2004, 250,000 t of pellets were consumed in Italy. Strong growth levels have also been observed in Italy over the last few years. Pellet consumption has increased by two thirds over the last 4 years.

Pellet usage in Italy is concentrated in the north of the country which has more woodland. There are already more than 125,000 plant operators mostly using small-scale units with a rating of 8-12 kW.

For example, in south Italy wood pellets are hardly produced or used as there are not sufficient natural resources (natural residue wood from sawmills and the derived timber product and forestry industries). However, here there are several R&D projects attempting to manufacture fuel pellets from agricultural residues (e.g. olive press cake). The first pilot systems are already in operation in Italy /185/.

Estonia and Poland

Poland has also become a prominent pellet producer within the last 2 years. Last year, it produced the same quantity of wood pellets as Germany (120,000 t). At present, Estonia and Poland are purely wood pellet producers without any domestic market, whereby production can be adjusted to meet the qualitative requirements of a given market. At present this is mainly aimed at high-power pellet combustion plants or co-combustion plants /191//192//185/.

Czech Republic

The Czech Republic also plans to extend its wood pellet production capacity which is currently at a level of 35,000 t (2004 figures). Currently there is insufficient demand and inadequate infrastructure (e.g. installation firms, dealers) in the Czech Republic and other Eastern European countries which slows down market development and represents a major obstacle /185/.

6.2.2 Pellet trade flows

The present cross-border trade of wood pellets between countries in the European Union is mainly concentrated in the Eastern European countries (e.g. Poland, Estonia) and Scandinavia, as well as between the Scandinavian countries (e.g. from Finland to Sweden and Denmark). The main importers in the European pellet market are Denmark, Sweden, Italy, the Netherlands and Belgium.

In 2004, Sweden imported approx. 350,000 t, which corresponds to a quarter of the annual Swedish consumption. During the last few years these imports have been increasingly covered by the Baltic States, as well as Finland, Norway and Canada. Sweden has set itself the goal of reducing the high levels of pellet imports over the coming years and thereby increasing the value of its own market (Table 65)

In the case of Denmark, Belgium, Great Britain, Italy and Denmark, the dependence on imports is mainly due to the lack of natural resources and the low levels of domestic pellet production at a time when demand is increasing.

Until now Denmark has not been able to cover its comparatively high pellet consumption levels with domestic producers. Denmark therefore imports roughly a half of its demand from the Baltic States.

In Italy the supply gap is actually getting wider. Whereas domestic demand continues to climb, the installation of additional wood pellet production capacity is lagging behind, which in turn increases the dependence on imports.

Despite the increased production capacity in Germany, it is still not able to meet the growing domestic wood pellet demand which now lies at a level of 140,000 t. During the last 1-2 years, domestic production has increased so rapidly that one expects production to meet domestic demand providing production growth remains at the same rate.

Table 65: **Pellet import countries**
Source: /184/

	2001	**2002**	**2003**	**2004**
	1000 tons / year			
Sweden	174	172	266	350
Denmark	200	215	323	470
Italy	n/a	n/a	52	60
Germany	20	24	25	20

The major exporters in the European pellet market in 2004 were Finland, the Baltic States and Poland (Figure 70).

The production surplus in Finland in 2004 amounted to approx. 160 000 t, of which only roughly 20% were sold on the domestic market. A large proportion of Finnish pellets are exported to Sweden. The other major markets for Finnish pellets are Denmark and the Netherlands.

The overall volume of approx. 450 000 t contributed by the Baltic States is by far the largest contribution to the pellet market. Due to the relatively new production sites in Eastern Europe and the longer transportation distances, wood pellet shipments of several 10 000 t are offered on the market, however these are relatively low-grade products. High-power pellet combustion plants or co-combustion plants, of which many have been established in Scandinavia and to a limited extent in the Netherlands, are able to process these low-grade wood pellets without any problem. However, they are limited in their suitability for the small combustion plants in Germany and Austria. Some plant manufacturers are now specifying industry standards to deal with this issue. Consequently the East European pellet producers are now also trying to find sales channels or direct consumers for high-grade wood pellets in Germany and Austria /185/.

In addition, a significant amount of pellets is imported into the European market from North America. In 2004 approximately 317 000 tons from Canada were sold in Europe. Most of the Austrian overcapacities are sold in South Germany, Italy or Switzerland.

Although there is hardly a pellet market in Southern Europe, the first assessments and small pilot projects have been made with a view to future pellet production. In particular, the export of pellets from Spain, Greece and, to a certain extent Italy, to countries with a high demand for pellets (e.g. Austria, Germany and also Northern Europe) becomes of interest when transportation and logistics are used effectively; this is because raw materials and labour can be provided at a lower price level as compared to Central Europe. Pellets may be manufactured from natural residue wood (logging residues and small-dimensioned wood), agricultural residues (e.g. straw, olives and grape press cakes), and in the medium term using energy crops (e.g. miscanthus, reeds, hemp). It is expected that only the Eastern European countries will remain competitive in this field.

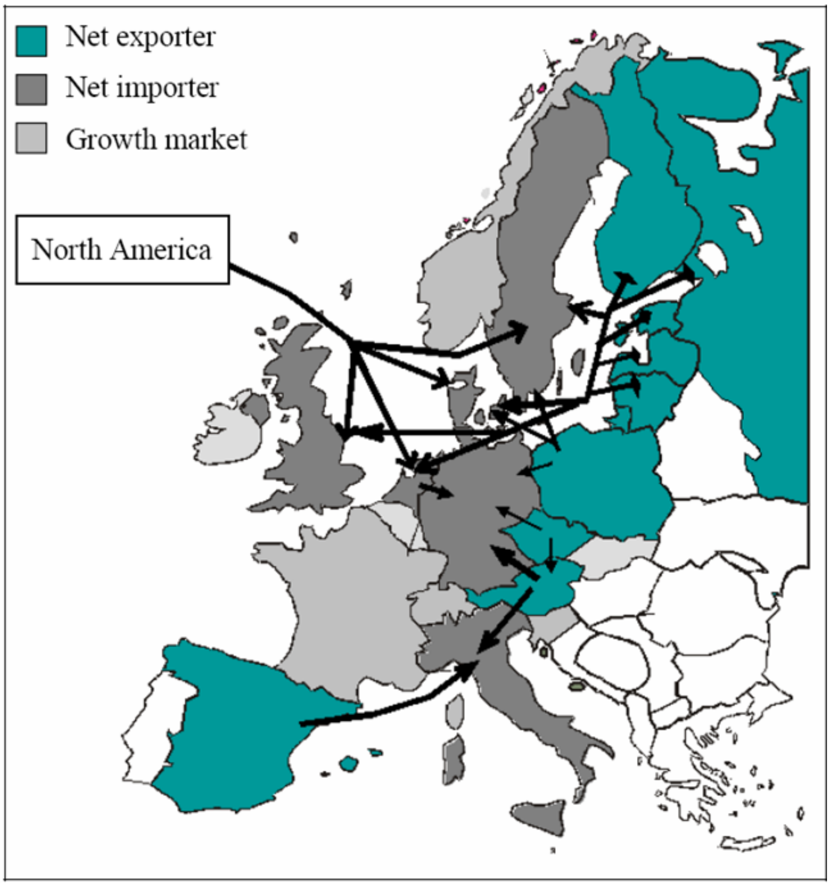


Figure 70: **Pellet trade flows within the European Union**
Source: /184/

6.2.3 Pellet prices

Wood pellet prices generally differ due to the different means of transportation, quantities and terms of delivery. Larger pellet deliveries are usually transported as loose goods using lorries or by railway or ship. Wood pellets are generally also supplied to small and medium-sized plant operators in big bags (500-1000 kg loose goods) or sacks (10-20 kg). European wood pellet prices have developed in a stable fashion over the last two years and have not been influenced by rising crude oil prices on the global market. On the contrary, in almost all countries (except Sweden and Great Britain) it was possible to slightly lower wood pellet prices for the same transportation conditions and services. In spring 2005, the average price for loose pellet deliveries to large plant operators (delivery quantity > 3-5 t) lay between 90 and 180 €/t (including VAT) within the European Union. Small consumers (delivery quantity < 3-5 t) pay a slightly higher price of 120-200 €/t due to the higher transportation and delivery costs.

The average price for wood pellets in sacks – available in DIY stores or from fuel dealers at a collect price – was between 225 and 300 €/t at the end of 2004, whereby sack products were the cheapest in Austria (225 €/t) and the most expensive in Great Britain (300 €/t). It is more common for sack goods to be delivered to customers on 990 kg pallets. Here Poland is able to offer the lowest price at 135 €/t. In most other countries the average price at the end of 2004 was 210-250 €/t; whereas sack goods pallets in Great Britain still had the highest offer price of roughly 300 €/t /185/.

6.3 Waste wood markets

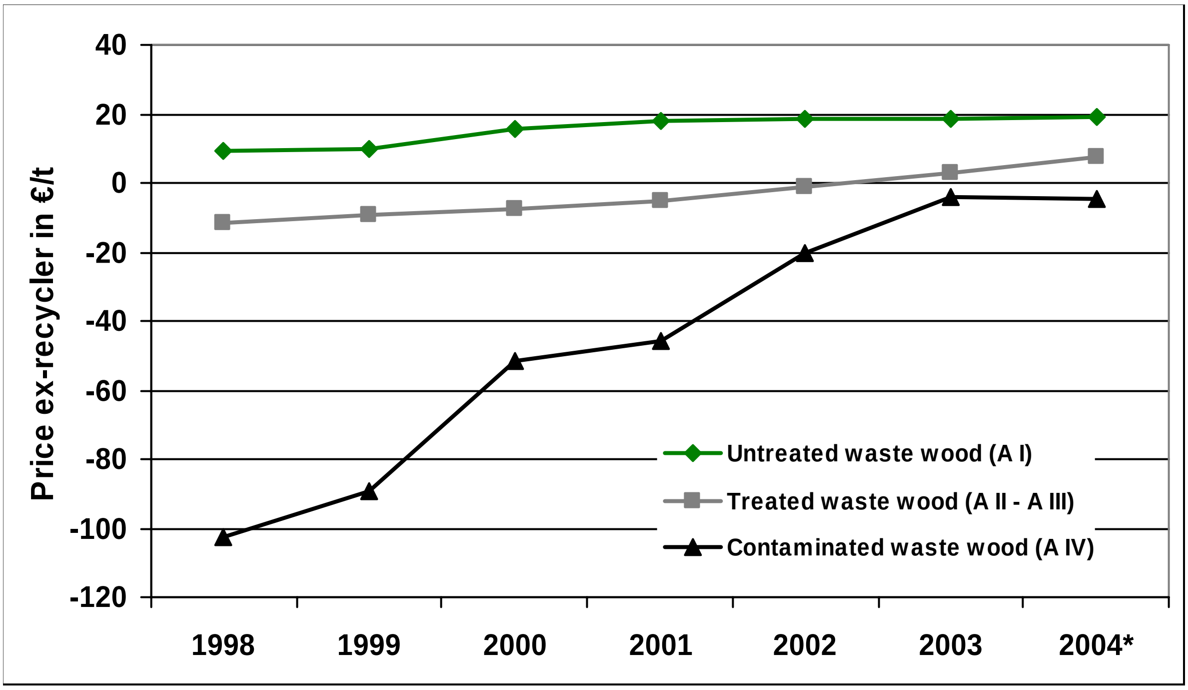
Waste wood is available in different areas of the economy in various forms. One differentiates according to the origin of the wood; this is mainly timber and demolition wood, packaging wood as well as furniture and other wood goods (handles, shafts, toys, sports equipment etc.). The annual quantity of timber and demolition wood is approximately 2.5-4 million t p.a., for packaging wood approx. 1 million t p.a., and for furniture wood and other products approx. 2-3 million t. The amount of available building and demolition wood can vary significantly from year to year depending on the situation in the construction market. The other two areas are less susceptible to such large variations. There are also regional variations in waste wood quantities depending on building projects and population density. The highest quantities by far occur in the German federal state of North-Rhine Westphalia where the volume is almost 2 million t /101/. A detailed breakdown of the total wood quantities into waste wood classes A1-A4 is not (yet) possible or was not carried out to date. The majority of these are A3 and A4 woods with a total volume of roughly 6 million t p.a. A1 and A2 woods have a volume of 2 million t p.a. The quantities traded on the market are however significantly less. In 2001, a value of approx. 4 million t was determined within the scope of a detailed analysis /103/. In the meantime, this quantity will have increased and will continue to rise /97//106/.

In contrast to wood processing industry by-products and residues, the external trade with waste wood is of more importance; it is here that significant changes took place over the last few years. In 1999 a total of approximately 82 000 t of waste wood was imported and roughly 520 000 t were exported; this compares with approx. 570 000 t of imports and 350 000 t of exports in 2002 /100/. The bulk of imports in 2002 came from the Netherlands (almost 83%) with exports mainly going to Italy for use in the chipboard industry (approx. 65% of all exports). The shift in import and export quantities is due to the higher domestic demand for energy applications and decreasing exports to the Scandinavian derived timber product industry /97/ /96/. It is also worth considering the waste wood transit trade, which totalled around 300 000 t in 2002 and slightly less in 1999. The main target country was Italy /100/.

If one considers the demand market in waste wood, there have been major changes over the last few years. The reasons for this are the improved economic efficiency of converting waste wood into electricity based on the German Renewable Energy Sources Act (EEG) in conjunction with the Biomass Ordinance and the related commissioning of new waste wood electricity conversion plants with a corresponding fuel requirement. It is also worth mentioning that the German Waste Wood Ordinance (AltholzV) which came into force in March 2003, and which specifies the requirements concerning the use and removal of waste wood, specifically describes the use of virtually all waste wood products /107/, incl. that landfilling waste wood is no longer permitted. In 1998/99 approx 2.8 million t p.a. of waste wood was landfilled /101/. It has been assumed that the current implementation of the landfill ban will cause the amount of landfilled waste wood in 2003 to lie below this value and to reduce further in future. These quantities will then also become available on the market once they have been processed accordingly.

In 2003, approx. 3.8 million t of waste wood was utilised in power generation plants /101/ with a smaller quantity being solely used for heat generation, resulting in a total quantity of approx. 4 to 4.5 million t. The use of waste wood in energy applications has significantly increased when compared to around 2 million t in the year 2000. The use of waste wood as a material in the derived timber product industry in 2003 was approx. 1.3 million t /64/; there were only slight changes when compared to the year 2000. It is estimated that 2 to 3 million t were landfilled per year /101//108/. There are large regional variations in waste wood demand for use in electricity generation; the Berlin-Brandenburg region is one of those with a large demand. The highest demand for waste wood (A1 and A2) for use in the derived timber product industry exists in North-Rhine Westphalia /104/.

The average waste wood prices in Germany are (depending on the class) between 10 and 20 €/t, i.e. when accepting class A IV waste wood (even though this is becoming much rarer) it is still possible to generate a disposal profit. Figure 71 shows that the waste wood prices, particularly those for contaminated waste wood have continued to rise since 1998. However, it should be noted that the indicated waste wood prices are average values; there may be significant regional variations depending on the market situation. These prices apply to large quantities ex-recycler (power stations) /96/.



* provisional prices for 2004
- negative prices signify additional payments to the recycler

Figure 71: **Development of waste wood prices (for large quantities ex-recycler)**
Source: /97/

Further changes in the waste wood market are expected over the next few years. The demand for waste wood in energy applications will continue to rise due to the commissioning of additional power plants; however, some smaller power stations may change their fuel supply from waste wood to natural wood as a result of the new German EEG regulation, which may result in a certain reduction in demand. It is also unclear how much waste wood will be replaced by substitute fuels /98/. The landfilling of waste wood will reduce significantly and in the medium term will tend to stop altogether; the scope of its use in the derived timber product industry will probably remain at the same level. On the whole, waste wood prices are only expected to change slightly in the next few years when compared to current levels. When viewed from a regional perspective, there may be some significant changes.

6.4 Agricultural products

Figure 72 and Figure 73 illustrate the share in terms of value for the most important importers and exporters in the global trade of agricultural products in 2003.

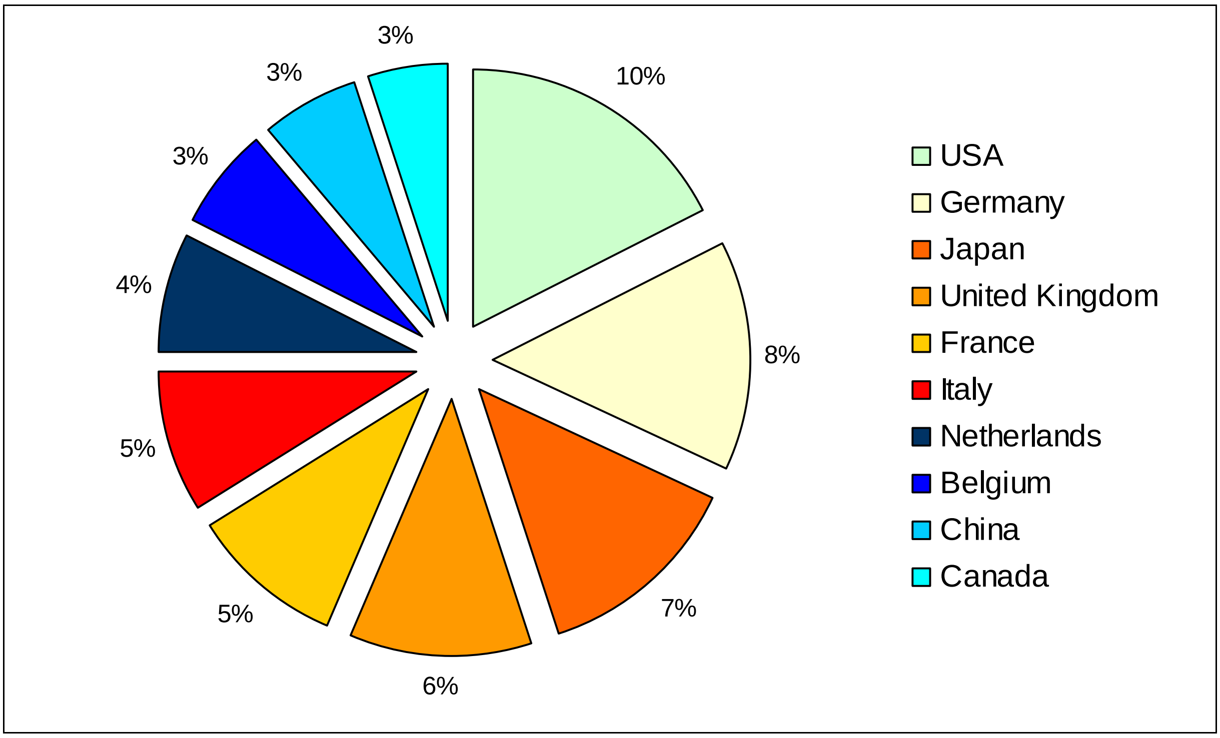


Figure 72: **Import share in terms of value for global trade of agricultural products in 2003 in US$**
Source: /118/

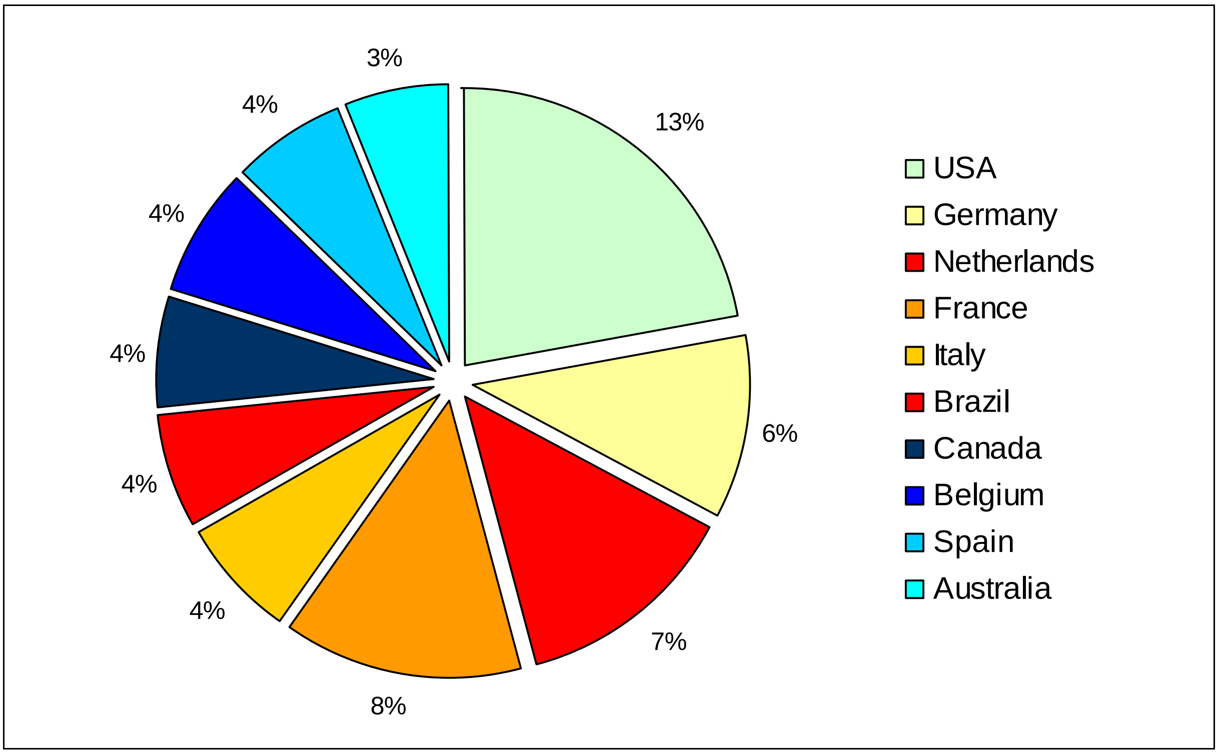


Figure 73: **Export share in terms of value for the global trade of agricultural products in 2003 in US$**
Source: /118/

The main agricultural products traded are the cereals wheat, maize, rice and barley, the oilseeds soya, rapeseed and sunflowers as well as sugar (see FAPRI Agricultural Outlook 2005) (Table 66, Table 67)

For **wheat** there was a global net export in 2004/05 of 89.9 million t (14.5% of global production of 619 million t, 217.9 million ha), for 2014/15 a rise of 21% to 108.4 million t is expected (16.4% of global production of 658.6 million t, 219.1 million ha). The 4 most important export countries in 2004/05 were the USA with a market share of 28.3%, followed by Australia with 18.8%, Canada with 17% and Argentina with 11.1%. These 4 countries accounted for 75% of all wheat exports. They were followed by the EU-15 with 9.4%, Russia with 5% and the Ukraine with 3.3% export share. By 2014/15 the most important export countries will also be the USA with 23.8%, Australia with 20.4%, Canada with 16.1% and Argentina with 13.9%, making a total market share of 74.2%. In 2014/15 the following countries will also be regarded as important exporters: EU-15 with 8.7%, Russia with 5.2% and the Ukraine with 4%. The importers are distributed among a large number of countries, particularly in Africa, the Middle East and Asia. In 2004/05 the largest importers with the following market share were: Egypt 8.3%, China 7.8%, Japan 5.8%, Brazil 5.3% and Algeria 4.8%. By 2014/05 the largest importers will remain the same: Egypt 8.1%, Brazil 3%, China 6.1%, Japan 5%, and Algeria 4.9%. Whereas price increases of almost 10% in US dollars are forecast for the global trading centres in the USA (Table 66) and Canada from 2004/05 to 2014/15, price increases of almost 20% in US dollars are expected on the European market.

There was a worldwide net export of 76.5 million t of **maize** in 2004/05 (10.9% of global production of 700.8 million t, 143.3 million ha). The export share of the USA (64%) was as large as the export share of the three largest wheat exporters. The second largest exporter was Argentina with a market share of 16.3%. Both these countries accounted for 80% of all exports.

The third most important exporter was China with an export share of 5%. By 2014/15 it is expected that the export market will grow by approx. 25% to 95.2 million t (12.4% of global production of 767.1 million t, 144.9 million ha) and that the market share of the USA (73%) and Argentina (16.4%) will climb to approx. 90%. In contrast, China will change from being an exporter to becoming an importer. The most important importers in 2004/05 were Japan 22%, South Korea 11.1%, Mexico 7.6% and Taiwan 6.1%. The most important importers in 2014/05 will be Japan 16.4%, South Korea 11.1%, Mexico 10.1% and Taiwan 5.8%. The price of maize in US dollars is expected to rise by 20% between 2004/05 and 2014/15.

Table 66: **Global production and trade of cereals**
Source: according to FAPRI, other sources stated in brackets

		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)

Table 67: **Global production and trade of oilseeds and sugar**
Source: according to FAPRI, other sources stated in brackets

		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

Barley is the second most important variety of traded feed grain next to maize. There was a considerably lower worldwide trading volume of 13.8 million t in 2004/05 (9.1% of global production of 151.3 million t, 58.2 million ha). In 2014/15 one expects a worldwide trading volume of 17.5 million t (11.7% of global production of 149 million t, 56.3 million ha). The most important exporters in 2004/05 were the Ukraine 25.1%, Australia with 24.1% and the EU-15 with 20%. By 2014/15 Australia is expected to have the largest export share (26.9%), followed by the EU-15 with 24.7% and the Ukraine with 21.4%. The largest importer by far is Saudi Arabia 2004/05 47%, 2014/15 37%, followed by China with 13% and 21.4%.

In 2004/05 only 5.8% of the global **rice** production of 400 million t was traded. By 2014/15 the share is expected to be 7.4% of a global production of 447.5 million t. The largest exporters are Thailand and India with approximate market shares of 35% and 14% respectively. Roughly 10% of world exports are accounted for by the USA. Production and net trade in the EU and most OECD countries are relatively insignificant.

Soya beans are by far the most important **oilseeds** to be traded. In 2004/05 there was a net soya seed trading volume of 57.2 million t (24.8% of global production of 230.8 million t, 93.1 million ha). In addition, 45 million t of meal were traded in 2004/05, of which 45.1% were exported from Argentina and 37.5% from Brazil, and 45.6% imported from the EU-15. In addition, 9 million t of oil was traded, of which 51.8% was exported from Argentina and 32.5% from Brazil; China and India were the major importers (26.8% and 11.6% respectively). In 2004/05 the largest soya seed exporters by far were the USA with 47.9% and Brazil with 37.4%, followed by Argentina with 12.5%. These 3 countries accounted for almost 99%. By 2014/15 it is expected that exports will increase by 48.5% to 84.9 million t (31.1% of production of 272.9 million t, 103.6 ha due to increased land area in Brazil and Argentina), and that the market share of Brazil will rise to 53.9%, the market share of the USA will drop to 29.3% and the market share of Argentina will rise to 16.1%. China was by far the largest importer in 2004/05 with a market share of 38%, followed by the EU-15 27.7% and Japan 8.7%. By 2014/15 it is expected that China will increase its dominant market share from 48.5% to 50% and that the shares of the EU-15 and Japan will sink to 19.3% and 6.3% respectively. The price of soya beans is expected to rise by 5% in US dollars between 2004/05 and 2014/15.

The net trading volume of **rape seeds** is relatively low in comparison. This was 5.7 million t in 2004/05, 13.3% of a global production level of 43 million t, 26.5 million ha (an additional 2.2 million t were traded as meal – 53% of which was exported by Canada and 52% imported by the USA- and 1.3 million t rapeseed oil - 70% of which was exported by Canada and 36% imported by the USA). The largest exporter of rape seeds in 2004/05 was Canada with a market share of 63.8%, followed by Australia with a market share of 17%. By 2014/15 it is expected that the export market will grow by approx. 20% to 6.9 million t (15% of global production of 46.1 million t, 26.5 million ha) of which Canada and Australia will have a market share of 64.1% and 19% respectively. The most important importers in 2004/05 were Japan with a market share of 38.6% followed by China (23.6%). Japan and China are forecast to have an import share of 32% and 26% by 2014/15 respectively. Global rape seed prices in US dollars are expected to remain largely stable between 2004/05 and 2014/15.

The net trading volume of **sunflower seeds** in 2004/05 was only 1.3 million t, which was approx. 5% of global production of 25.3 million t, 21.8 million ha. An additional 2.3 million t of sunflower meal was traded, which was exported from the former USSR, Ukraine and Belarus (52.5%) and Argentina (46.3%), and mainly imported by the EU-15 (71.1%). In addition, approximately 1.6 million t of sunflower oil was traded, 50% of which was exported from Argentina and 45% from the so-called CIS countries of the former USSR; 30% was imported by the EU-15.

The largest exporters of sunflower seed in 2004/05 were the so-called CIS countries of the former USSR with a market share of 37%, followed by the new EU member states with 12.4% and Argentina (12%). In 2014/15 a global trading volume of 2.1 million t is expected (7% of total production of 30.2 million t, 22.3 million ha) with export shares of 22% for the CIS countries of the former USSR, 17.2% for the new EU member states and 11.4% for Argentina. The most important import region for sunflower seed in 2004/05 was the EU-15 with an import share of 76.1%. An import share of 84.5% is expected by 2014/15. Global prices in US dollars are expected to remain largely stable between 2004/05 and 2014/15.

The **global sugar trade** in 2004/05 amounted to 33.2 million t (23.4% of global production of 141.7 million t, 20.4 million ha sugar cane including ethanol production, 5.8 million ha sugar beet including ethanol production). The most important exporters were Brazil with a market share of 54.5%, Thailand 14.5%, Australia 12.5%, and the EU-15 5.4%. By 2014/15 it is expected that the export market will grow by approx. 16.6% to 38.7 million t (22.6% of global production of 170.9 million t, 22.2 million ha sugar cane, 6.1 million ha sugar beet) and that the market share of Brazil will be 56.5%, of Thailand 14.6%, of Australia 13.7% and of Cuba 5.4%. The importing countries are less concentrated. The 2 most important importers in 2004/05 were Russia/Ukraine 13.5% and Japan 4.4%. In 2014/15 it is expected that Russia/Ukraine will have a share of 9% and Indonesia 4.4%. Whereas FAPRI forecasts a 30% global price increase between 2004/05 and 2014/15, OECD-FAO estimates a drop in prices (table 66). On the whole, the following predictions can be made regarding 2014/15:

The USA will continue to dominate global exports in cereals (wheat 25.8 million t, approx. 8.2 million ha and maize 70 million t, approx. 6.7 million ha). Aside from the USA, the other important exporting countries will be Australia (wheat 22 million t, 10.3 million ha), Canada (wheat 17.5 million t, 6.2 million ha) and Argentina (wheat 15 million t, 5 million ha and maize 15.9 million t, 2.2 million ha). They will lead by some distance from the EU, Russia and the Ukraine.

Global oilseed exports in 2014/15 will be shaped by Brazil (soya seed 45.8 million t, 15.2 million ha), the USA (soya seed 24.9 million t, 8.7 million ha) and Argentina (soya seed 13.7 million t, 4.7 million ha). Argentina and Brazil will also be the largest exporters of soya meal (Argentina 28.5 million t, Brazil 23 million t) and soya oil (Argentina 6.9 million t, Brazil 5 million t). In 2014/15 Canada will also be the largest exporter of rape seeds (4.4 million t, 2.7 million ha), rapeseed meal (1.3 million t) and rapeseed oil (0.9 million t). The most important exporters of lower quantities or similarly low quantities of sunflower seed, meal and oil will be the CIS countries of the former USSR, Argentina and the new EU member states.

Brazil will also be the largest sugar exporter in 2014/15 with 21.9 million t, 3.9 million ha sugar cane, followed by Thailand 5.7 million t, Australia 5.3 million t, Cuba 2.1 million t.

The EU-25 will be the largest importer of soya meal by some distance in 2014/15 with 27.3 million t, the largest importer of sunflower seed, meal and oil, and the second largest importer of soya seed with 16 million t after China. China will be the largest importer of soya seed (42.2 million t) and soya oil (4 million t) and the second largest importer of rape seeds after Japan. It will also be a significant importer of all varieties of cereals. On the import side, the global trade in agricultural products will be heavily influenced by China, Japan and the developing countries.

Whereas global price increases of 8% to 20% in US dollars of wheat, maize and barley are expected between 2004/05 and 2014/15 (they may even rise further if EU exports are reduced in favour of bioenergy production), FAPRI only forecasts a price increase of 5% for oilseeds. This appears to be very optimistic when compared to the figure of approx 12% provided by OECD-FAO (Table 66). In the case of sugar, there are diverging price forecasts made by FAPRI and OECD-FAO (Table 67).

6.5 Bioethanol

6.5.1 Demand

The number of EU countries currently producing bioethanol is still limited. The total annual production in 2003 was only approx. 5.3 million hl. One differentiates between three groups of member states:

- The main producers are Spain, France, Poland and Sweden
- Member states which promote biofuel programmes and have a huge potential are Germany, Italy, Great Britain, Austria and Finland
- Member states without any significant bioethanol production or plans for setting up production: For example Belgium, Denmark, Greece, Ireland, Portugal and Luxembourg

The current economic situation in the member states and the statutory and legal underlying conditions will be briefly discussed below for the first two groups above (refer to: Vierhout, European Public Affairs Adive. The European fuel alcohol programme, Miami, 18 - 29 April 2003), whereby the focus is on Germany (Table 68)

Table 68: Mineral oil tax reductions for bioethanol in selected countries
Source: /193/

Country	Mineral oil tax reduction		Annual bioethanol production
	[%]	[€/hl]	[million hl]
Germany (until 2009)	100	65.45	5.85[1]
Spain (until 2012)	100	39.6	5.2[1]
France (until 2010)	62.7 (direct) / 64.5 (ETBE)	37.0 / 38.0	1.2
Sweden (until 2008)	100[2]	52.5	0.65
United Kingdom[4]	42	33.0	-
Poland (unlimited)	5	1.72	
Lithuania (until 2010)	100	28.8	0.1
Hungary (until 2010)	100	42.6	-
Brazil	43	11	144
USA	280[3]	[3]	127

1) by the end of 2005
2) for 2.2 million hl
3) only for 10% additives (E-10) are 28% of the whole additive tax-exempt (tax burden 0.132 US cents/gal instead of 0.184 US cents/gal)
4) 5 years per producer or importer

Germany

Until now bioethanol was not used as a fuel in Germany. One of the reasons is that it requires a special engine when used as a pure fuel. One of the other reasons was that bioethanol additives in conventional fuel were not exempt from mineral oil taxes until the end of 2003. The future sales potential of biofuels in Germany is very high due to the above guideline on promoting biofuels. In 2004 approx. 25.0 million t of petrol were consumed. If 5.75% of the energy were to be replaced by bioethanol (this corresponds to the EU directive mentioned), it would correspond to a required quantity of almost 30 million hl.

According to the Federal Monopoly Administration, there are approx. 800 small and medium-sized bonded distilleries, approx. 30 000 distilleries with standardised tax regimes and approx. 200 000 raw material owners who manufacture agricultural alcohol. The total volume of alcohol produced in 2003/2004 in the bonded distilleries was 1.983 million hl plus the additional amount of 84 092 hl alcohol produced in distilleries with standardised tax regimes and by raw material owners, as well as the alcohol production in bonded distilleries outside the German spirits monopoly which amounted to 212 000 hl. In the operating year 2002/2003 only 644 000 hl of the produced alcohol (approx. 2.3 million hl) was delivered to the Federal Monopoly Administration. This raw alcohol is then taken and processed in their plants to produce 96 to 99% neutral alcohol. Sales to cosmetics, drug and vinegar producers etc. are handled by eight sales offices.

The distilleries are obliged to supply a certain proportion of the produced alcohol at a takeover price of 3 - 4 €/l of raw alcohol as stipulated by the Federal Monopoly Administration. Bioethanol intended for fuel applications is exempt from this supply obligation within the German spirits monopoly since 2004.

One can therefore deduce that the established alcohol production level of 2.3 million hl per year only corresponds to one large bioethanol plant. Since the smaller distilleries and raw material owners produce directly for consumers, who demand a certain level of quality and services, and as these distilleries only operate small plants that are able to produce raw alcohol and are able to utilise the by-products with synergy effects within the agricultural sector, they are not considered to be significant market producers in the fuel sector. The amount of market and supply competition to large distilleries (cereals and potatoes) provided by the large-scale bioethanol industry and the danger this poses to the comfortable takeover prices currently protected by market regulations, which are oriented towards the production costs of smaller producers and justified to maintain the viability of these distilleries, is subject to further economic analysis. At the present time one cannot assume that the increased bioethanol demand for the fuel market will enable lucrative production potential for established distilleries. Furthermore, one does not expect the smaller distilleries to utilise their free production capacity for biofuel given the price levels of ethanol.

The agricultural sector is demanding supply opportunities in the fuel market, particularly due to the abolition of the intervention for rye by the European Union in 2004, as well as the possible abolition or amendment of the EU sugar market regime which commenced in 2006. Despite the 100% exemption from mineral oil tax, investors in Germany are very cautious as they fear that they could lose substantial market shares to imported bioethanol from Brazil and North America; new installations will therefore not pay for themselves in the expected time frame. Nevertheless, three bioethanol plants with a total capacity of 5.85 million hl were installed last year.

Spain

In Spain there are two plants for manufacturing ETBE which are operated by a non-agricultural company group (Abengoa) having a total capacity of 3.2 million hl. A third plant with a capacity of 2 million hl should be installed in 2005. The total production in approx. 5 years from now is estimated to be 5.2 million hl bioethanol/year. The raw materials used are cereals, wine alcohol and, in future, other biomass raw materials. Tax exemption is at a level of 100%. Spain will probably fulfil the two percent goal set by the EU (proportion of biogenic fuels as compared to consumption) and could participate in the trade of bioethanol within the EU.

France

France has a long history of biofuel production. For a long time it was the only country producing bioethanol for the fuel market. It has only recently lost its leading role in the EU to Spain. Annual production is more or less constant at 1.3 million hl, which is used as a 15% additive in ETBE fuel. A total of 15 bioethanol plants supply alcohol to 3 ETBE plants. There are also plans to increase capacity. The main driver for French bioethanol production is the sugar industry, however the French government has now reduced the general purchase tax on fuel from 80 to 60% which reduces the motivation for producing bioethanol. France is unlikely to meet the two-percent EU target for biogenic fuels (compared to total consumption) in 2006 with its existing capacity levels.

Sweden

In Sweden, the capacity for biogenic fuels is also expanding rapidly. The Swedish government has declared a production quota of 2.2 million hl/year. Bioethanol production in 2003 amounted to 0.65 million hl. The remaining 1.55 million hl have previously been mainly composed of imports from Brazil. The two largest producers in Sweden are planning to install new plants in EU member states; these plants will have a capacity between 1 and 1.5 million hl. The raw materials used are cereals and wine alcohol. Tax exemption is 100% for a quota of 2.2 million hl. Sweden will probably meet the 2% EU target set for the end of 2005.

Great Britain

Biofuel production in Great Britain is very limited and has until now been restricted to biodiesel. The British government has introduced a tax reduction of almost 33 €/hl ethanol, which has hardly moved investors, particularly those from the sugar industry, to build conversion facilities. At the present time one hardly expects Great Britain to meet the two-percent EU target by 2006.

Italy

Italy already produces biodiesel, similar to Germany. The Italian government has decided to grant a mineral oil tax reduction of 42% for three years (2003 - 2005) with an annual cap of 15 million €. This corresponds to 230 000 hl bioethanol for ETBE. There is one ETBE production plant with a capacity of 90 000 t/year. Other planned investments are not known. Italy will therefore remain well short of the EU minimum target.

Netherlands

There is no significant diesel or bioethanol production in the Netherlands. Nevertheless expansion plans are now being developed.

Finland

The same applies to Finland, although here there is only partial tax exemption. Until now only limited quantities of wine alcohol were processed into fuel in Finland.

Poland

In Poland 1.32 million hl bioethanol were processed into ETBE in 2003. There was 100% tax exemption for bioethanol additives meeting specified additive ratios.

Lithuania

Biofuels are exempt of mineral oil tax in Lithuania. The first bioethanol plant with a capacity of 0.1 million hl was opened in autumn 2003.

Overseas regions

Brazil dominates as the largest overseas producer of bioethanol, where the bioethanol industry was built up 30 years ago by means of a start-up financing programme and thanks to the low production costs for sugar cane; approx. 50% of sugar cane is used as biomass and roughly 50% of the fuel market is supplied with bioethanol. Other notable production quantities of bioethanol are manufactured in the USA for use in the domestic fuel sector. The overseas regions are of great significance to the bioethanol markets in Germany and Europe. This is discussed in further detail in the next chapter.

Only a few percent of the total global production of 380 million hl ethanol stems from the European Union. The 144 million hl of ethanol produced by Brazil represents almost 40% of global production, followed by the USA with an annual production of 127 million hl (30% of global production). Brazil dominates global trade. It is exporting increasing quantities to East Asia, North America and the EU.

6.5.2 Supply

The supply of bioethanol in the EU is provided through imports and domestic production. Domestic supplies are influenced by the development of crude oil prices, long-term trends in changes to agricultural production and demand for food products, as well as short- and medium-term fluctuations in crop production. As already mentioned above, it was decided in 2004 within the scope of the CAP for the EU-25, that fiscal transfers will no longer be linked to production from 2005 onwards. From the economic perspective of producers, premium payments will no longer be considered as part of the cultivation of crops. When viewed from the other side, this means that the direct costs for manufacturing food and energy crops will reduce by the previously granted product-based payments.

The production costs of foreign suppliers compared to those in the EU, as well as the protection mechanisms or promotional instruments implemented by the EU and its member states are of central importance to the EU in terms of supply. The following section will first deal with a quantitative analysis of the dominance of Brazilian bioethanol production and the situation of foreign suppliers. This will be followed by a discussion on the economic efficiency of bioethanol production in the EU. Its competitiveness compared to substitute products (fossil crude oil) will then be separately assessed for the German market.

6.5.3 Production costs of bioethanol in Brazil and other non-EU countries

In the 2003/04 campaign, approximately 347 million t of sugar cane were supplied to the Brazilian alcohol and sugar factories (Figure 74). Roughly half of all Brazilian sugar cane is used in the production of sugar and bioethanol. Of the 23.9 million t of sugar produced, approximately 14.4 million t were exported. This makes Brazil the largest sugar exporter in the world, ahead of the EU, Thailand and Australia. The remaining sugar cane was used to produce 83.4 million hl water-free and 55.6 million hl hydrated bioethanol. Of this only 7.0

million hl was exported. In fact, the export potential is not necessarily higher given the changing legislation in Europe and other countries. The current high mineral oil prices also mean that bioethanol should not just be viewed from an environmental but also an economic perspective.

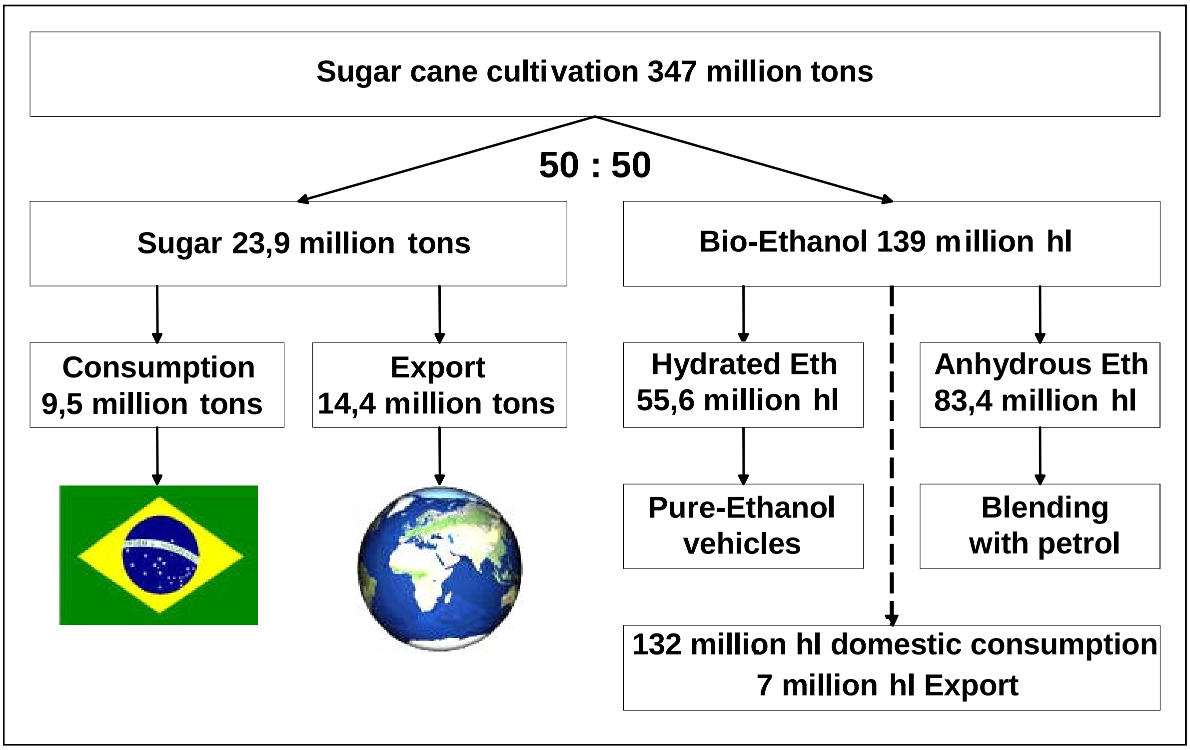


Figure 74: **Sugar cane production in Brazil**

Production costs of sugar cane

In the case of Brazil one can assume that there will be six harvests in the year following cultivation of sugar cane. This results in average variable production costs of 5.90 $/t assuming that one of the less costly production sites is used with an average yield of 95 t/ha and that harvesting is carried out by means of machines. The fixed costs per ha which must be added are dependent on the size of individual companies and their equipment and have therefore been disregarded at this stage to facilitate better comparison. Nevertheless, the value of arable land in São Paulo is the highest in Brazil with an average value of 2500 US$ ha due to the optimum cultivation conditions for sugar cane; when adding an interest rate of 10% for opportunity costs, an additional 250 US$/ha or 2.63 US$/t will be included in the calculation. In theory this raises production costs to 8.53 US$/t.

The sugar cane price in 2003 was on average approx. 10 US$/t. This price has been used in the following calculations. In principle, the value of sugar cane is primarily dependent on the global sugar market price. As this reached a low point during the last few years, it also had a cost-reduction effect on the production of bioethanol. In 2005 the global price for bioethanol rose to three times its long-standing price level due to developments in the global oil market.

Costs of bioethanol production

The following calculations assume an alcohol yield of 85 l/t sugar cane, which corresponds to the average in the São Paulo region. The raw material share of the alcohol production price is therefore 11.76 US$/hl (Table 69). However, since most plants produce both sugar and alcohol, one can assume certain synergy effects. B-treacle from sugar production and thin juice are used in the production of alcohol. Heavy soluble sugar is added to the fermentation process instead of applying an elaborate process to improve the yield.

Table 69: **Production costs of bioethanol in Brazil**
Source: /194/

Plant type	**550,000 hl ethanol** **0.65 million t sugar cane**	
Building	0.25 $/hl	1.4%
Machines/Inventory	1.38 $/hl	7.9%
Sum of investment	**1.63 $/hl**	**9.4%**
Labour	0.62 $/hl	3.6%
Insurance/Repairs	0.58 $/hl	3.3%
Raw material	11.76 $/hl	67.7%
Process materials	2.78 $/hl	16.0%
Gross production costs	**17.37 $/hl**	**100.0%**
Bagasse	for required energy	
Vinasse	1.00 $/hl	5.8%
National and regional aid	0.00 $/hl	0.0%
Net production costs	**16.37 $/hl**	**94.2%**
Export price (FOB São Paulo)	18.37 $/hl	105.8%
$-Import price (CIF Rotterdam)	23.37 $/hl	134.5%
€-Import price (CIF Rotterdam)	**19.48 €/hl**	
+ Duty on non-denatured ethanol	19.20 €/hl	
+ Transport to Germany	1.00 €/hl	
Total costs to refinery	**39.68 €/hl**	

One has assumed that a plant can process 1.3 million t of sugar cane per year. Of this amount 650 000 t are used for bioethanol production. According to expert estimates, an annex plant to an existing sugar factory with an annual production of approx. 550 000 hl water-free bioethanol will cost approx. 6.4 million US$. A best-case split of this figure into 20% building costs and 80% inventory costs for a usage period of 20 or 10 years and a calculated interest rate of 10% results in investment costs of approx. 1.63 $/hl. This cost share would be significantly higher if part of the investment costs were allocated to alcohol production. On the other hand, it must be said that plants are partially used for much longer durations than stated here.

Since the manufacture of alcohol in Brazil does not require any fossil fuels, the energy and CO_2 figures will be significantly lower than those for bioethanol production in Europe. The use of Brazilian bioethanol in Europe is therefore also an attractive option particularly since it represents a cost-effective way of avoiding climate-relevant gases as defined in the Kyoto Protocol.

A further by-product is vinasse, of which roughly 1 300 l per hl are produced. This is used as manure. The calculation of substitute values based on N-, P_2O_5- and K_2O content results in a credit of approx. 1 US$ per hl. However, here one must consider the higher output costs when compared to mineral manure.

According to official sources, Brazil does not provide any direct subsidies for the production of bioethanol at present. In this respect the net production costs are approximately 16.37 US$/hl.

If a further 2 US$ are added for transport to the harbour, it is possible to export bioethanol from Brazil at a cost of approx. 18.37 US$/hl FOB São Paulo. Freight costs across the Atlantic are currently charged at 5 US$/hl alcohol. The prices for overseas transportation have risen sharply due to the sustained economic boom in China; this has resulted in a transportation capacity shortage. This results in a CIF-price in Rotterdam of approx. 23.37 US$/hl or an import price of 19.48 €/hl at an exchange rate of 1.20 US$/€.

Import duty in the EU on denatured bioethanol is 10.2 €/hl, however import duty charges of 19.2 €/hl will be levied since the German Parliament Bundestag decided that only the use of non-denatured bioethanol is permitted. A further 1 €/hl cost can then be added for onward transportation by ship to a refinery in the western part of Germany. This means that Brazilian bioethanol can theoretically be bought in Europe for approx. 40 euro cents/l without considering any profit margins for the producers or VAT. This is well below the production costs in Germany.

In theory Europe is a very lucrative market for Brazil. However it should be noted that there are large variations in tax exemption within Europe. For example, in France the reduction is only 37 euro cents/l. Furthermore, global sugar market prices are currently at a relatively high level and ethanol prices are stimulated as it represents an alternative to petrol, which in turn is also very expensive due to high crude oil prices in excess of 60 US$/bar. The motivation for producing bioethanol is therefore very high when domestic and international demand rises. In addition, the ongoing EU-Mercosur negotiations are discussing the introduction of a duty-reduced import quota of 1 million t (12.7 million hl) bioethanol for Brazil. This is approximately 10% of the EU-15 demand from 2010. The German Agricultural Minister has already asked for a transition period, as these imports represent a risk to previous and future state-promoted bioethanol investments. On the other hand, two years ago Brazil introduced vehicles with so-called Total Flex engines, which can be used with any mixture of hydrated and water-free ethanol as well as petrol. This has increased domestic demand for bioethanol in Brazil over the last year.

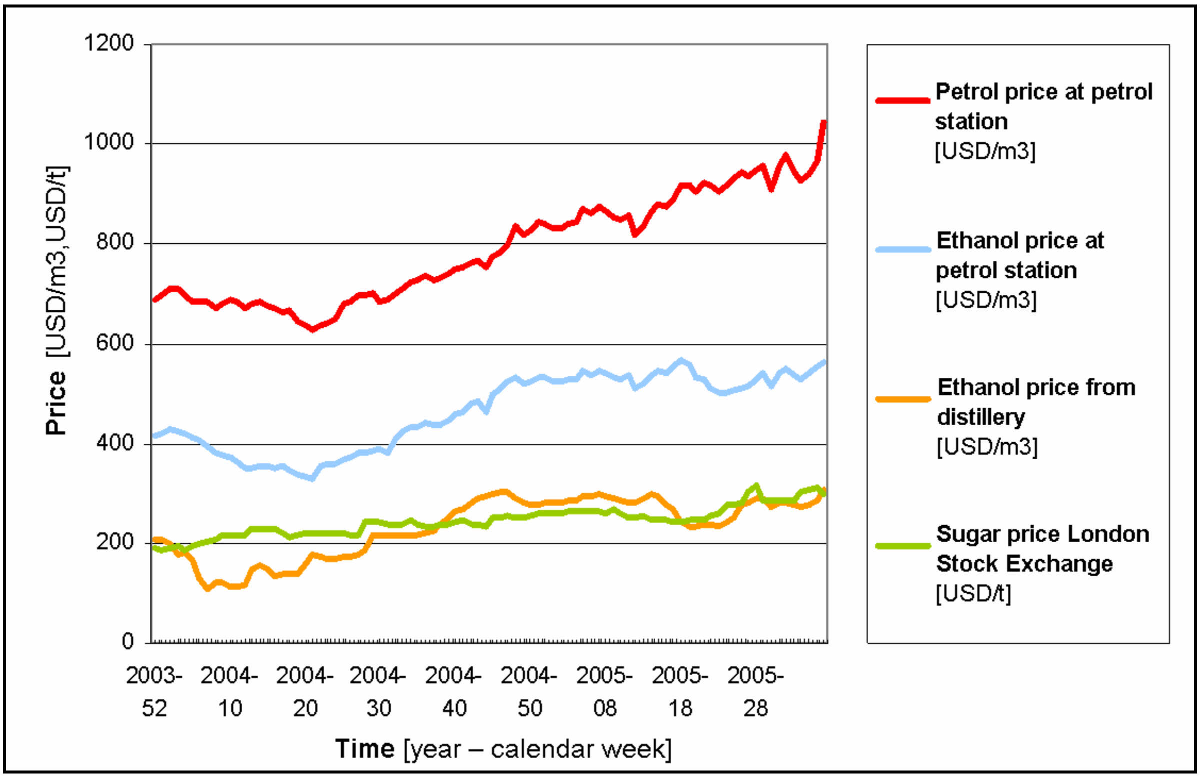


Figure 75: Fuel prices in Brazil
Source: /193/

In the USA, bioethanol production is based on maize as the raw material. Production has been expanded to 127 million hl/year since the 1990s. The US government wants to continue increasing production and more or less double the use of biofuels by 2012. Ethanol capacities of approx. 210 million hl should be ready by 2010. Apart from maize, limited quantities of soya beans will also be used as raw material. The production costs of bioethanol from maize in the USA have been determined by Henniges and Zeddies (2003). Table 70 shows that investment costs make up approx. 10% of the total costs. Raw materials (maize) constitute approx. 53% of the total costs. The gross production costs are almost 40 €/hl. A similar price level is obtained in the USA for the by-product DDGS (Distillers' Dried Grain with Solubles). This reduces the gross total costs by 17%. If one considers the subsidies from the federal government and state (in this case South Dakota), one obtains net production costs of approx. 25 €/hl. When compared to an ethanol sales price of 31.5 €/hl in 2002, one was able to generate a profit even though this was only possible with the help of subsidies.

Table 70: **Absolute and percentage composition of production costs for bioethanol in the USA Source: /193/**

Costs for	€/hl	%
Building	0.4	1.0
Machines/Inventory	3.4	8.6
Sum of investment	3.8	9.6
Labour	2.8	7.2
Insurance/Fees/Repairs	0.6	1.6
Raw material	20.9	53.0
Process materials	11.3	28.6
Gross production costs = 100%	**39.5**	**100.0**
By-products	-6.7	-17.0
National and regional aid	-7.9	-20.1
Net production costs	**24.8**	**63.0**

The probability of large US bioethanol imports into the EU is low, as production grants are not provided for exports and maize prices are currently almost 2 US$ per bushel[36]. The import price including duty is at the same level as production costs in Europe. In addition, current bioethanol demand in the USA is also very high due to changes in the law and driven by extremely high fuel prices.

Apart from the established bioethanol production base in Brazil and the USA, new production capacity has recently been set up in Southeast Asia, in particular in Thailand and China as well as in Australia (see Henniges O. and Zeddies J, 2005, Economics of Bioethanol Production in the Asia Pacific: Australia, Thailand, China: F.O.Licht, World Ethanol &

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[36] 1 bushel of maize ≈ 25,401 kg

Biofuels Report, Vol. 3, No. 11, February 8, 2005). Ethanol production in Australia is at present estimated to be 1.2 million hl. The raw materials used are treacle, a by-product from the sugar industry, and other by-products from the starch industry. Only 0.55 million hl of bioethanol are used as fuel. In Thailand approximately 5 million hl of bioethanol are produced per year. The materials used are treacle from the sugar industry, cassava (fresh), tapioca chips, maize, sorghum and sugar cane juice. Bioethanol is sometimes mixed with petrol for domestic use or exported to Japan and the Philippines. China currently has four ethanol plants with a capacity of 11.6 million hl/year. Other plants are under construction: this should double the capacity. Whereas maize is the important raw material in the north-east of the country, southern China predominantly uses cassava.

A comparison of global production costs (Figure 76) shows that Brazil has by far the lowest bioethanol production costs (in 2004 approx. 20 €/hl). In Thailand the production costs are only slightly higher due to the availability of cheap raw materials. In Australia, production costs are around 30 €/hl, which is similar to the levels in the USA. In China, production costs are slightly higher, whereas in the EU it is virtually impossible to produce bioethanol for less than 50 €/hl. The production costs do not contain any direct or indirect subsidies, however all countries support bioethanol production by means of various instruments, e.g. investment aid, raw material subsidies, equipment subsidies, tax relief and tax exemption, export aid or import duties. The effect this has on the two most important bioethanol producers, Brazil and the USA is that Brazil is not competitive in the US market, although the production costs in Brazil are only two-thirds of those in the USA. This is due to the complex system of subsidies, duties and tax relief at state and federal level in the USA. Although the EU is showing potential future growth in terms of raw materials for bioethanol, it is not competitive on the global ethanol market without the assistance of subsidies and import protection mechanisms.

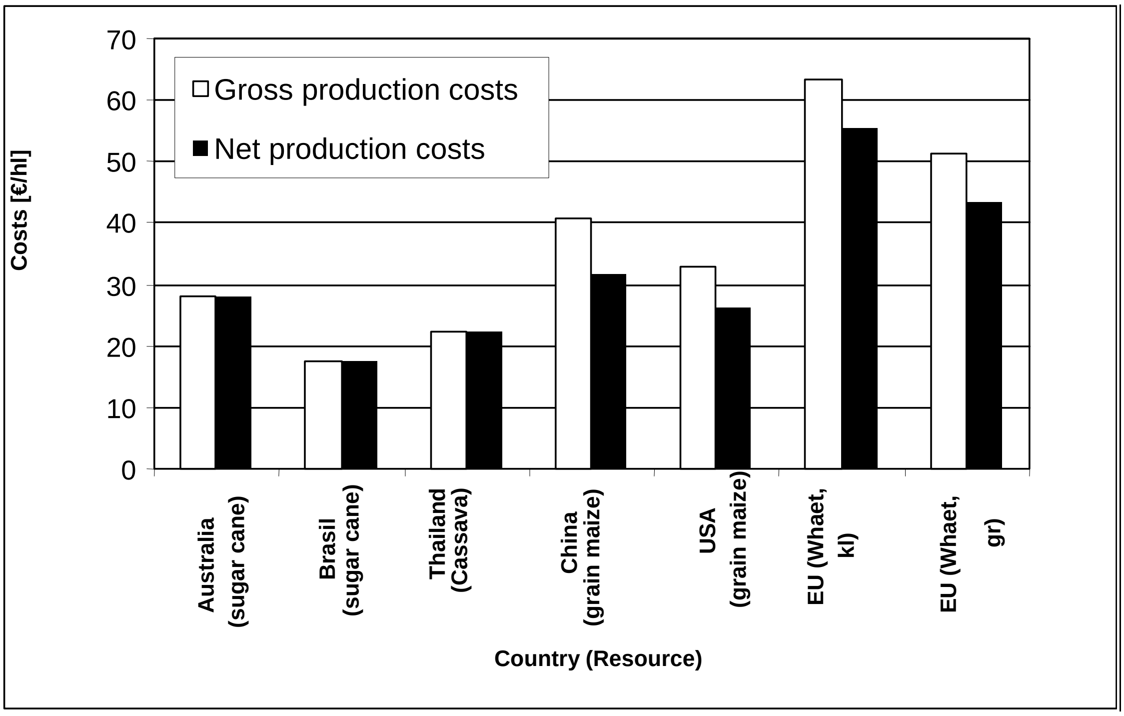

Figure 76: **International comparison of bioethanol production costs**
Source: /196/

6.5.4 Production costs of bioethanol in the EU

In the EU there is a tradition of bioethanol production in France. Here bioethanol is manufactured from wheat and sugar beet, which is mixed with petrol as so-called ETBE (ethyl tertiary butyl ether). By contrast, in Brazil up to 25% and in the USA on average 10% water-free ethanol is mixed with petrol.

In Germany, bioethanol production only started a few years ago. Cereal crops are used as raw materials; annex plants (as used in France in combination with sugar factories) are also of interest in Germany, once significant factory capacities and cultivation areas become available following reform of the EU sugar market regime.

The raw material price for wheat follows the market price of feed wheat which is approx. 10 € per dt. If sugar beet is used for ethanol production, one can only apply the price of 10 € per dt derived from the wheat price. This gives a maximum ethanol beet price of 25.8 € per t (production price from farm), at which the production costs for ethanol would be the same.

Table 71 shows the production costs per hl of two ethanol plants with differing capacities. Increasing the annual capacity from 0.5 to 2 million hl will reduce the net production costs from 55 to 48 € per hl. The most significant savings are labour-related as the required manpower will only increase slightly if capacity is increased.

Table 71: **Absolute and percentage composition of production costs for ethanol in Germany**
Source: own calculations

Annual capacity	**500, 000 hl**				**2,000,000 hl**			
Raw material chain	**Wheat**		**Sugar beet**		**Wheat**		**Sugar beet**	
	[€/hl]	[%]	[€/hl]	[%]	[€/hl]	[%]	[€/hl]	[%]
Building	1.28	2.1	1.28	2.1	0.82	1.5	0.82	1.5
Machines/Inventory	8.28	13.4	8.28	13.8	5.30	9.6	5.30	10.0
Sum of investment	9.56	15.5	9.56	15.9	6.12	11.1	6.12	11.5
Labour	4.26	6.9	4.26	7.1	1.40	2.5	1.40	2.6
Ins./fees/rep.	1.60	2.6	1.60	2.7	1.02	1.9	1.02	1.9
Raw material	26.40	42.7	23.55	39.2	26.40	48.0	23.54	44.3
Transportation	1.35	2.2	5.10	8.5	1.35	2.4	5.10	9.6
Resources	18.68	30.2	15.93	26.6	18.68	34.0	15.93	30.0
Gross production costs	61.85	100.0	60.00	100.0	54.96	100.0	53.11	100.0
Sales of by-products	-6.80	-11.0	-4.95	-8.3	-6.80	-12.4	-4.95	-9.3
Net production costs	**55.05**	**89.0**	**55.05**	**91.7**	**48.16**	**87.6**	**48.16**	**90.7**

Raw material costs are the largest component in the total cost. In order to produce 1 hl of ethanol one requires either 267 kg wheat or one ton of sugar beet. Transportation costs of 5.10 € per ton of raw material must be added to the above figure assuming an average distance of 50 km from the agricultural land to the processing site. Production costs are reduced by one-eighth due to the sale of by-products such as DDGS or beet pellets.

According to specialists, an additional cost reduction potential of 7 € per hl is expected in the coming years at a production cost level of 48 € per hl. This is due to technical advances at all stages of the production process and further economies of scale.

When considering the production of bioethanol from cereal crops, one must differentiate between bioethanol plants that only process cereal crops and annex plants connected to an existing sugar factory. In the latter case, one can utilise sugar beet as the raw material during the sugar beet campaign, which usually lasts 90 days, and cereal crops during the other 220 days. If the sugar beet campaign is utilised to its maximum potential, the proportion of raw materials is one-third sugar beet and two-thirds cereal crops.

In ethanol plants, the procurement costs ex-bioethanol plant and planned production of by-products is also decisive. In conventional plants with mash drying, the optimum plant size is primarily dictated by cost reductions related to transportation and cereal crop procurement. This optimisation is reached with an annual capacity of 2 million hl alcohol/year. It has been calculated that one can pay a maximum beet price of 23.54 € per t plus transportation costs (approx. 0.1 € per t and km) for a wheat price from farm of 105 € per t and a transportation distance of 50 km to achieve the same raw material costs per hl. For example, if one only calculates with a raw material price of 80 € per t including delivery to the plant, it is only necessary to pay a sugar beet price of 22 € per t for self-delivery, which equates to 17 € per t from the field at a distance of 50 km.

The cost-effective delivery of raw materials for the required quantities lies in the region of 500 000 t cereal cops per year, which is still more than 1500 t per campaign day, and corresponds to 60 HGV deliveries per day (transported by water). Previous experience has shown that large cereal crop consumers, such as isoglucose producer Cerestar, Krefeld (Germany), procure the required crops from EU countries with a surplus supply, i.e. France. These crops are mainly transported by rail to the Rhine and loaded onto ships and transported down the river. In this case it should be noted that the transferral of goods onto cheaper waterways is only worthwhile if a minimum distance is covered by water. If the central EU surplus region were to suddenly change and require additional supplies due to the increased conversion of cereal crops to alcohol, then cereal crops would be transported up the Rhine from the Rotterdam port of import. Collection transports for by-products and deliveries to the mineral oil industry would also tend to be less costly.

When considering the by-product dried mash (DDGS), one should be aware that the large quantities produced will either need to be used quickly as feed (within 3 days) or require elaborate drying.

Recent experiences in Germany have shown that investors are not prepared to cope with these quantities and that mash will be deposited as manure on fields of neighbouring agricultural farms; in this case there will not be any income generated from by-products.

In respect of the acquisition prices for raw materials, one must differentiate between a crop surplus and shortage situation in the EU. For example, until now there was always a surplus situation for relevant German sites. Not only because this was a surplus region for cereal crops, but also because it bordered on large French surplus regions. Large cereal crop consumers in Germany obtained their cereal crops from surplus regions in France via the Rhine. In German surplus regions, e.g. Bavaria, the prices are even less given these conditions. In future, prices can also be kept low thanks to low-cost freight shipments down the Danube (as far as Kehlheim) from the new EU acceding countries.

In case of a long-term cereal crop shortage in the European Union, which is hardly to be expected even if there is a sharp rise in cereal crop demand for bioethanol production, cereal crop prices will be lowest for those imports which can be transported along waterways. In contrast, the prices at decentralised inland consumer sites are likely to rise, whereby here the traditional surplus regions will still lie below the price level.

Competitiveness of ethanol compared to petrol on the German market

Apart from the international competitiveness of ethanol production, it also raises the question of how competitive ethanol is compared to petrol. For example, Table 72 shows the composition of the petrol price at the petrol stations in Germany. This is compared to a possible price structure for bioethanol. Experts assume that bioethanol will be sold at the same price as fuel, so that petrol with 5% bioethanol additive will also be sold at a price level between 113 and 150 euro cents per litre. This does not represent any benefit for consumers.

Table 72: Composition of sales price for petrol and bioethanol in Germany
Source: own calculations/

	Petrol		EU ethanol	
	[EUR/hl]			
Price (at petrol station)	113	150	113	150
- purchase price	25	56	50-70	50-70
- VAT	16	21	16	21
- mineral oil tax	65	65	0	0
- distribution	5	5	5	5
- dehydrate and mix in additives	0	0	5	5
= Profit margin	**2**	**3**	**17-37**	**49-69**

It therefore becomes apparent that the possible profit margin for bioethanol in Germany is dependent on the purchase price and lies between 17 and 37 € per hl (up to 70 E per hl) for a petrol price of 113 € per hl. Mineral oil companies therefore have a large motivation to use biofuels. The profit margin for imported bioethanol from Brazil is even higher. If petrol prices continue to rise towards 150 € per hl, one expects ethanol purchase prices in Germany not to rise significantly even at this level of petrol prices, as the mineral oil industry is not obliged to use bioethanol additives.

Furthermore it becomes clear that bioethanol production costs in Brazil are not only significantly lower than in the EU, but also less expensive than raw petrol. In addition there is large potential in increasing production and expanding the cultivation area. However, it must be considered that increased production will also give rise to higher marginal costs. On the whole, the import of bioethanol from Brazil makes sense from the point of view of the mineral oil companies. Ethanol prices in Brazil will also increase and possibly reach the level of petrol purchase prices (70 € per hl) if petrol prices continue to remain high.

These quantitative considerations allow one to deduce that bioethanol production in Europe, as desired by the political institutions, could only be achieved through significant tax relief and the levy of high import duties.

The question of who should profit from the tax relief in Europe remains open. From a European point of view, it makes little sense to tolerate a reduced domestic income in favour of fewer Brazilian companies or international oil companies.

If the biofuel use targets set by the EU commission can be reached by means of tax-exemption rules, this would clearly reduce the tax income in the budgets of individual countries. This must be weighed up against the potential added value generated by domestic bioethanol production. Given that the European bioethanol industry is still in its infancy, it is paramount that the favourable tax conditions remain (even if only partially) to permit its establishment.

Investor uncertainty

Three uncertainty factors discourage potential investors. Europe only has a low external protection level of 19.2 € per hl on undenatured bioethanol[37]:

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[37] external protection for denatured ethanol is at a price level of 10.2 € per hl; in Germany this is not exempt of mineral oil tax in the fuel sector.

- The production costs stated for Brazil (and the USA) are more than 19.2 € per hl below German prices even when considering transportation costs. The enormous annual production capacity of 120 million hl in Brazil, low production costs and the weak exchange rate of the Brazilian Real could lead to the EU being swamped with cheap bioethanol from South America.

- There is no statutory requirement that biofuels must be supplied from domestic production. An increase in import duty can only be implemented within the WTO negotiations on deregulated markets if bioethanol production is declared as an environmental measure and assigned to the “green box”. This has previously not been the case. Furthermore the green box is now coming under criticism following the latest WTO proposals. Brazil is currently expanding its port capacity for exporting bioethanol.

- The fact that the use of additives is not mandatory for mineral oil concerns is a further reason for uncertainty. This means that bioethanol sales figures are not guaranteed. There are also further uncertainties regarding future mineral oil tax policies in Germany and the EU and their division of responsibility.

Potential investors in production will therefore continue to wait until the statutory conditions in Germany and Europe are clearly defined in terms of bioethanol use.

6.5.5 Market model

In principle a market model describes all the exchange relationships between offered and demanded economic objects. Bioethanol is not a free market where prices are set without any state intervention; instead it is a regulated market. In respect of the number and size of market participants, the bioethanol market represents an oligopoly of suppliers and buyers. There will initially be few overseas suppliers and a small number of bioethanol suppliers from the domestic market or the EU member states. Demand will be made up of a few mineral oil companies.

Supply-demand curves and pricing are determined from the graphs shown in Figure 66. If one derives the supply curve from the production costs of bioethanol, the lowest-priced imported bioethanol will be in the scope of any agreed import quota as defined in the Mercosur contracts. An initial volume of 1 million t per year has been used for the negotiations. The extrapolated import supply curve (dashed line) shows a potential supply curve if import quotas are increased. It is possible to produce bioethanol domestically and under favourable conditions at a price level slightly below 50 euro cents per l. This has previously not been needed by the domestic EU food production market and has either been exported or classified as inferior.

Further supply increases may be achieved by processing sugar beet to produce bioethanol; this has previously been exported as C-sugar or cultivated in sugar beet plants at a price corresponding to the conversion of cereal crops, and which lies under the marginal costs for the production of bioethanol from imported cereal crops. Further supplies in bioethanol from imported cereal crops may be considered to be elastic in comparison. The supply curve for bioethanol from the EU domestic market has a stepped shape. In addition to duty-free bioethanol imports, the market model also considers that bioethanol on which normal duty has been paid (dashed line) can enter the EU domestic market. The offer price including duty is approximately 50 euro cents and only slightly higher than domestically produced bioethanol from surplus cereal crops (status 2004).

Fuel producers will first revert to duty-paid imported ethanol before using sugar beet and expensive imported cereal crops to produce bioethanol. This will also become more expensive if demand in the producing countries increases, because raw sugar production on the global market will become successively tighter, thereby resulting in global price rises and better utilisation of sugar cane. On the other hand, the availability of bioethanol on the domestic markets of exporting countries will also become tighter and result in price rises. If one shifts the supply curve for bioethanol ex-refinery by the costs for distribution, denaturing, additives and VAT to the level of petrol station prices, then Figure 66 shows that sufficient bioethanol is available to cover the demand for bioethanol as required by the EU directive. This comes from duty-unpaid imported bioethanol (import quota), bioethanol produced from surplus cereal crops obtained on the EU domestic market and imported overseas duty-paid bioethanol.

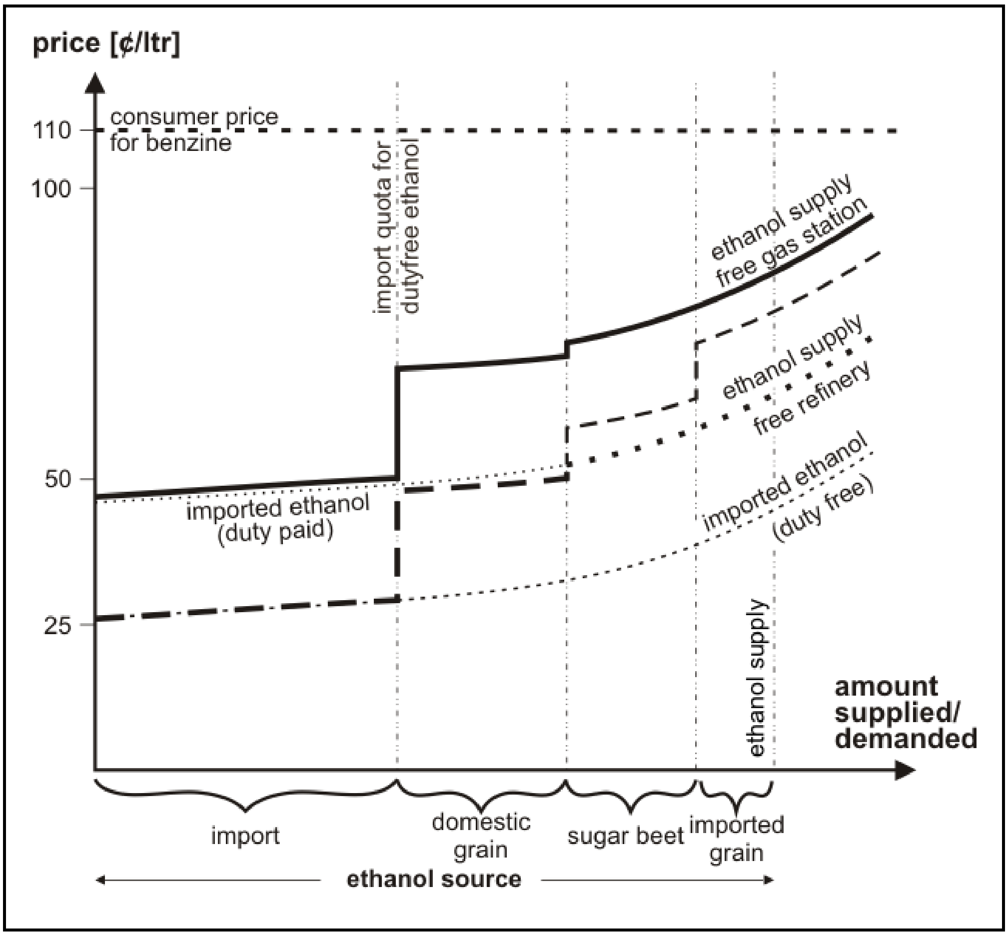

Figure 77: **Market model for bioethanol (Status 2004) Source: own calculations**

The demand curve for bioethanol is derived from the reference price for fossil-based petrol. Bioethanol will continue to be in demand as long as the levels of mineral oil tax exemption or relief are greater than the difference between fossil-based petrol and the bioethanol purchase price. If the state changes the underlying conditions, for example by only granting mineral oil tax exemption or relief on the target quantities set out in the EU directive, the total bioethanol supply is restricted to this amount.

In any case it comes down to an allowance determined by the difference between the consumer fuel price and the supply price of bioethanol, which is initiated through the tax exemption or tax relief on mineral oil, and on the price difference between the acquisition prices for fossil-based petrol and bioethanol as well as the level of mineral oil tax relief. At the present time the allowance is more than 30 euro cents per litre.

On the whole, the chart for 2004 indicates that the most cost-effective way to supply bioethanol is by means of overseas imports, and that the domestic production of bioethanol is only viable when bioethanol is granted partial or full mineral oil tax relief; in the case of full mineral oil tax exemption it is possible to achieve a significant substitution of fossil-based fuels. This is also achieved through the use of domestic cereal crops, domestic sugar beet and foreign, i.e. imported, cereal crops. Hereby it must be considered that additional domestic bioethanol supplies are only possible by constructing conversion plants which represent a significant investment. Market participants will only be prepared to do this if there is little risk of market disturbances due to increased import quotas, reduced external protection for bioethanol imports and/or the phase-out of mineral oil tax exemption/relief in the medium- and long-term. Such investment restrictions would be less significant if the bioethanol producers were to provide an acceptance guarantee or minimum fee.

6.5.6 Price relationships

The cost calculations and market models described above are based on data from the reference period, which was characterised by relatively stable prices in the energy and agricultural product markets. A continuing trend in rising crude oil prices can be observed on the global market since the beginning of 2004. The effect of these price changes on the price of biogenic fuels and agricultural materials for bioenergy sources can, for example, already be observed in Brazil. The following analysis therefore concentrates on the price relationship between the crude oil market, the price of biogenic fuels and those of the agricultural products used in their production.

Initially the vertical price relationship between global crude oil prices and acquisition prices for petrol from the refinery will be considered. In a next step, equivalent output curves between bioethanol and fossil-based petrol are shown which are based on the assumed cost calculations; these show the price relationships at which an equivalent product substitution is possible. Next the utilisation functions for the most important agricultural raw materials used in the production of ethanol are shown in relation to bioethanol price. Economic conclusions may be drawn from these price relationships. Finally, some examples are shown to discuss the effects of rising prices of fossil-based petrol on the bioethanol price and the global market price of sugar.

Global crude oil price and acquisition price of petrol ex-refinery

In early 2004 crude oil prices climbed from approx. 35 US$/barrel to a 2004 peak of roughly 50 US$/barrel in October and in September 2005 to almost 70 US$/barrel (Figure 78). There is a close market relationship between the prices of crude oil, heating oil and petrol, although there is a significant gap between the price of crude oil and that of heating oil and petrol. Heating oil prices (ex-consumer) and acquisition prices of crude oil (ex-refinery) do not differ greatly. The easily obtainable heating oil prices (ex-consumer) in Germany in the period from 2004 to November 2005 varied from 35 euro cents/litre to over 50 euro cents/litre in October 2004 and approx. 65 euro cents/litre in September/October 2005 (Figure 79). In making any further analysis and in view of the strong price fluctuations over the last two years, one assumes that the prices of crude oil will vary in a range between 35 and 70 US$/barrel.

– The left-hand graph shows the calculated average price for a mixture of North Sea and Arabic oil.

Figure 78: **Development of worldwide crude oil prices**
Source: /197/

Figure 79: **Development of heating oil prices in Germany**
Source: /197/

Price relationship between petrol and biogenic fuels

In the following considerations one has assumed that biogenic fuels, which are available on the market, will be used when they are offered at the same price conditions as fossil-based petrol incl. taxes. This results in the curves (Figure 80) for bioethanol prices (ex-works) and petrol acquisition prices. Although the chart abscissa indicates the prices of fossil-based petrol (ex-refinery), i.e. without considering mineral oil tax, VAT and additional charges to the fuel pump, these are considered in the price relationship between the curves. Petrol prices before tax have fluctuated in the range between 30 euro cents and 70 euro cents/litre over the last two years. The four curves shown on the chart indicate the acquisition prices of bioethanol given a number of different assumptions. The upper line represents the maximum payable acquisition price for bioethanol under the assumption of full tax exemption for a substitution of 1 litre bioethanol to 1 litre of petrol. At a petrol price of 30 euro cents/litre, a price of approx. 80 euro cents could be paid for bioethanol assuming full tax exemption. This would completely overcompensate the calculated production costs for bioethanol from cereal crops in Germany (50 - 60 euro cents/litre). At a basic petrol price of 70 euro cents/litre, one could pay approx. 1.20 euros for bioethanol. The line immediately below assumes full mineral oil tax relief for bioethanol and a substitution corresponding to an energy density of 1 litre of petrol to 1.5 litres of ethanol. At a petrol acquisition price of 30 euro cents/litre, the substitution value of 1 litre bioethanol is then roughly 0.75 euro cents/litre, whereby production costs are on average covered.

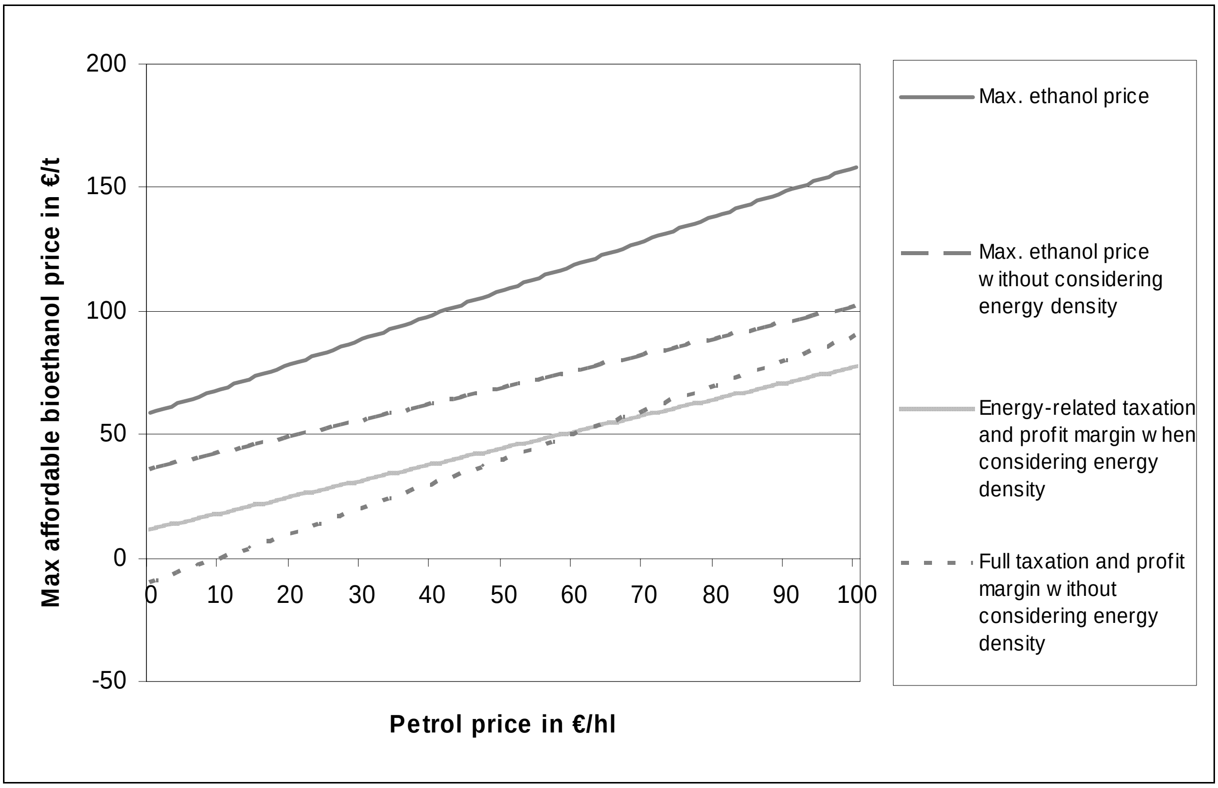

Figure 80: **Maximum payable bioethanol price (ex-works) in relation to petrol acquisition price (without taxes)**
Source: /198/

The two curves below indicate the prices payable for bioethanol given the assumption that bioethanol is fully taxed in the same way as petrol, i.e. by volume (substitution 1:1) and on the basis of energy (1:1.5). The chart shows that it is virtually impossible to cover the costs of producing bioethanol when this is fully taxed, even when fossil-based petrol is at an acquisition price level of 70 euro cents/litre. It therefore follows that bioethanol production in Germany can hardly be competitive in an international market even when global crude oil prices are relatively high; this is due to the relatively high production costs.

Price relationship between bioethanol and agricultural raw materials

The price relationship between bioethanol and the agricultural raw materials used in its production are illustrated in Figure 81 and Figure 82. The utilisation functions for sugar beet in Figure 81 also apply for a substitution ratio of 1:1 between bioethanol and fossil-based petrol. Given an ethanol price of 50 euro cents/litre, it will only be possible to pay 20 €/t for sugar beet from the field. If one considers an energy-related substitution between ethanol and fossil-based petrol, the utilisation of the raw material will be significantly lower. In contrast, the maximum payable price of sugar beet from the field is 60 €/t given a current price of 70 euro cents/litre for fossil-based petrol ex-refinery and a substitution relationship of 1:1 between bioethanol and fossil-based petrol. Even when assuming energy-related substitution, it is still possible to achieve very lucrative payments for sugar beet, which would roughly lie at the current price levels of sugar beet used in sugar production; this price is supported by the sugar market regime.

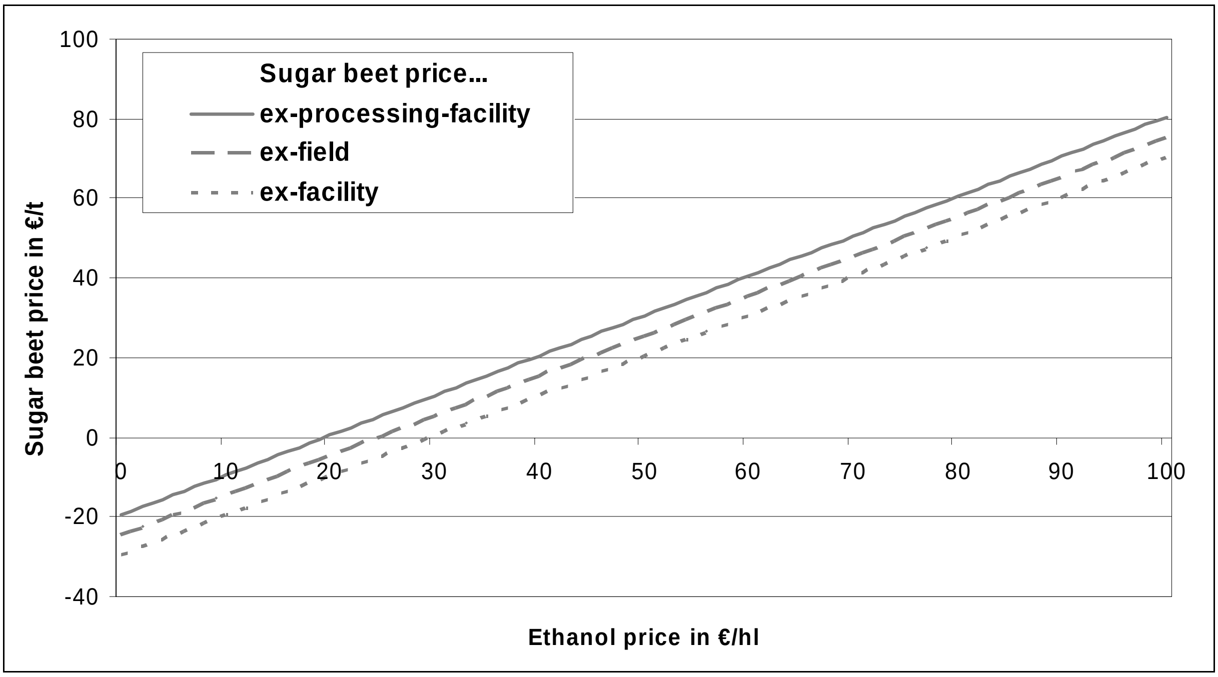

Figure 81: **Maximum payable sugar beet price in relation to the bioethanol price (ex-works) Source: /198/**

The corresponding utilisation functions for wheat used in the production of ethanol are similar as shown in Figure 82. For low ethanol acquisition prices of 50 - 60 euro cents/litre ex-refinery, it is only possible to charge the current wheat price of 100 €/t for a substitution ratio of 1:1 between bioethanol and fossil-based petrol. Should the ethanol price double, which is feasible given the current acquisition price of crude oil and assuming a substitution of 1:1, it would be possible to charge 2.5 times the current basic price for wheat.

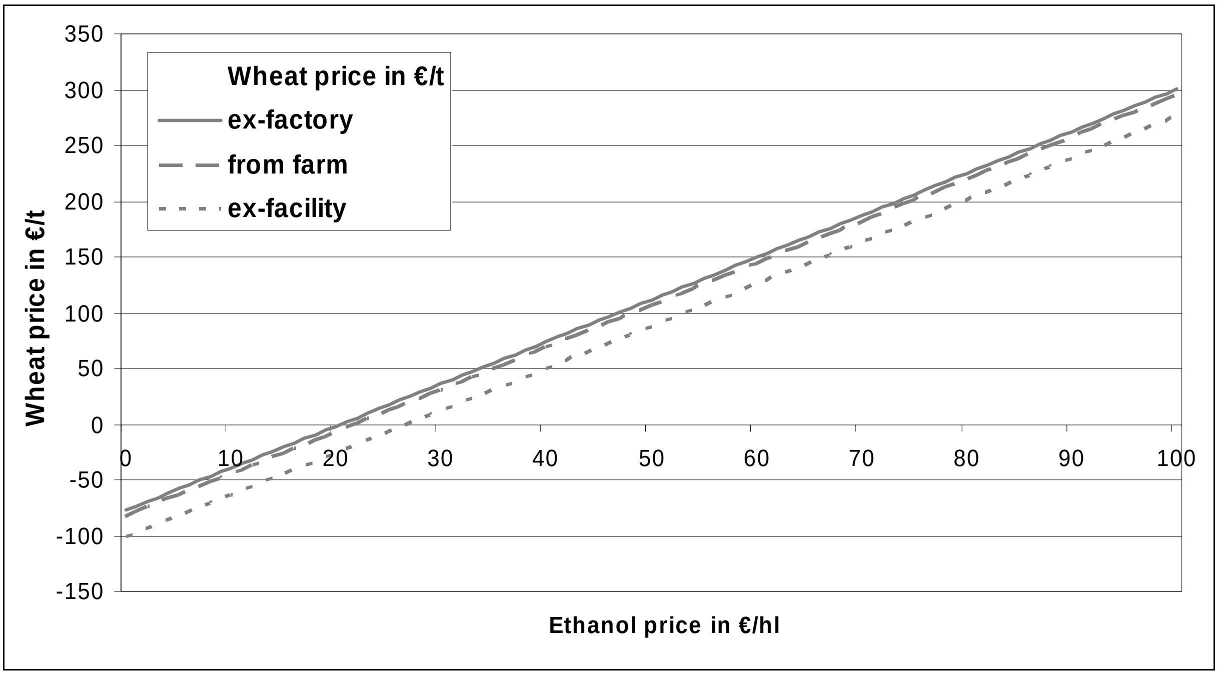

Figure 82: **Maximum payable wheat price in relation to the bioethanol price (ex-works)**
Source: /198/

It follows from the calculations that the utilisation of agricultural products for biofuel can be very lucrative if global crude oil prices continue to remain high and mineral oil tax exemption remains in force. If full mineral oil tax levels are applied to bioethanol it will only be possible for bioethanol to be fully competitive against fossil-based fuel, and to achieve lucrative payments for agricultural products, when global crude oil prices are 100 US$/barrel.

It must be pointed out that the charts only indicate price relationships. They cannot be used to determine price changes to agricultural raw materials as a result of rising crude oil prices. Prices are affected by changes in supply / demand and are influenced by corresponding price elasticity in Germany, the EU and on the global market.

On the international agricultural markets, changes in global crude oil prices mainly affect the prices of bioethanol and sugar in Brazil as well as the global sugar price. Known reactions are depicted in Figure 75. This clearly shows the effect of rising fossil-based petrol prices (at petrol station) on the pump price of bioethanol, as well as the close relationship between rising fossil-based petrol prices and the global sugar price. Figure 83 shows the trade-off between the prices for fossil-based fuel, bioethanol, sugar cane and sugar from Brazil in relation to the acquisition price for fossil petrol and based on the cost calculations for bioethanol produced from sugar cane in Brazil. Since Brazil dominates the global market price for sugar, one can deduce from the chart that higher worldwide sugar prices are to be expected if the global price of crude oil continues to rise. For example, if the crude oil price continues to remain at 60 US$/barrel, the price of sugar on the global market may rise to 360 US$/t depending on the supply/demand situation and therefore climb up to 80% above the consistently low global sugar prices (around 200 US$/t). All the calculations and considerations show that if global crude oil prices continue to remain high, one would expect higher prices for agricultural products on the global market.

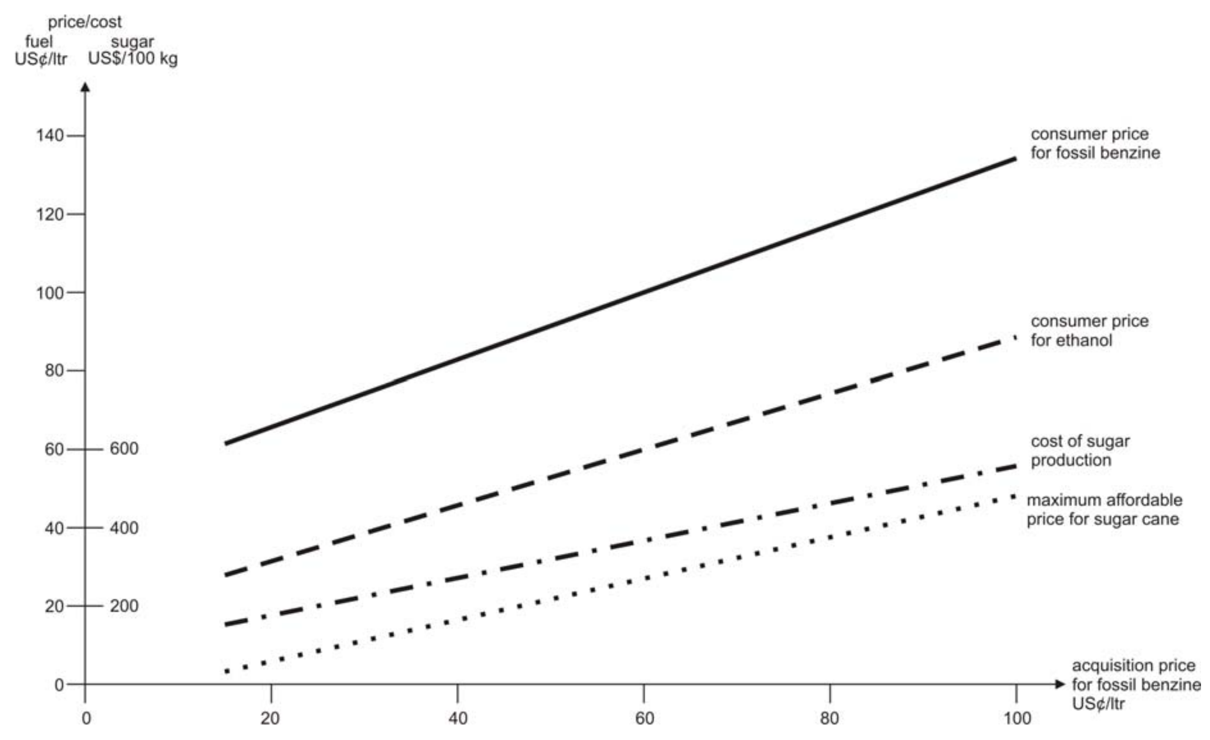

Figure 83: Price dependency of bioethanol, sugar cane and sugar on the acquisition price of fossil-based fuel in Brazil
Source: /198/

6.6 Biodiesel

Biodiesel has been produced in Germany since 1993. Demand in biodiesel as a final energy source grew in the 1990's when biodiesel produced from rapeseed, sunflowers and other oil plants was declared 100% mineral oil tax free in Germany. Since biodiesel in Germany was almost exclusively produced from rapeseed oil, one refers to the transesterified final-product as rapeseed methyl ester (RME). Rapid investments were made in conversion facilities, a sales network was established and there was an enormous expansion in domestic production and the import of rape seeds for RME production. Initially, the rapeseed required to manufacture RME was primarily grown on set-aside land. The cultivation of rapeseed as a renewable raw material meant that one could apply for the set-aside premium. The costs for re-planting the fallow land effectively became a credit for cultivating rapeseed. The use of this potential area meant that more and more biodiesel rapeseed was cultivated as opposed to other food and energy crops, particularly cereal crops. The import of rape seeds was also expanded[38] as there is no self-sufficiency in plant oils in Germany or the rest of the EU. In 2004/05 almost 1.20 million t of rapeseed were imported into Germany, whereby France and the Czech Republic dominated with shares of 68% and 16% respectively. At the same time there were also exports (mainly to the Benelux states, Denmark, Great Britain and Mexico), amounting to 0.5 million t. This resulted in a net import volume of 0.70 million t per a /226/. The following section will discuss in detail the markets for oilseeds in Germany and worldwide (section 6.6.5).

The existing production plants in Germany now have an annual biodiesel capacity of approx. 2.0 million t. Additional plants with a capacity of 900 000 t are being planned and should be completed in 2006 /229/. In addition a further 500 000 t of rapeseed is processed in roughly 250 mostly smaller plants to produce biodiesel. The industry is even expecting 3 million t of rapeseed oil from transesterification plants and decentralised oil mills by the end of 2006. An important fact in this respect is that, despite the significantly higher quantities of rapeseed meal, prices tend to remain at a stable level and increasing quantities are used as a relatively inexpensive source of egg white in mixed feed instead of soya meal. This market will only be discussed relatively briefly below since this trade sector is already established and there are numerous existing analyses and literature.

6.6.1 Demand

Rapeseed biodiesel has a lower density, lower energy content and efficiency when compared to previous fossil-based diesel fuels. Approximately 1.075 t of biodiesel are required for an equivalent substitution of 1 t of fossil-based diesel fuel. Special problems relating to quality and standardisation as well as compatibility with engines will not be discussed here.

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[38] The degree of self-sufficiency for rapeseed and turnip rape in Germany in the economic year 2003/04 was almost 80 %.

Depending on the region, the volume-based market price for pure biodiesel is approx. 7 - 22 euro cents/l lower than fossil-based diesel fuel. The use of up to 2% rapeseed oil additive in fossil-based diesel fuel hardly has any effect on reducing the price. This price gap means that biodiesel demand is relatively elastic. It is currently limited by the capacity of transesterification plants.

Forecasts predict that approx. 30.8 million t of fossil-based diesel will be sold in Germany by 2010. According to the biofuel directive, 5.75% of fossil-based diesel must be replaced by biodiesel, i.e. Germany will need almost 2.05 million t of biodiesel in 2010. In order to produce 2.05 million t of biodiesel, one requires approx. 5.4 million t of rape seeds, i.e. at an average yield of 3.5 t/ha, an additional 1.5 million ha of rapeseed must be cultivated to achieve self-sufficiency. In the economic year 2004/05, approximately 1.4 million ha of rapeseed were cultivated in Germany. This rapeseed is used for “food” and “non food” purposes, i.e. not all of it is available for biodiesel production. Due to the increased demand in rapeseed oil for producing biodiesel, one can observe a shift in rapeseed oil use from the food sector to the biodiesel sector (non-food).

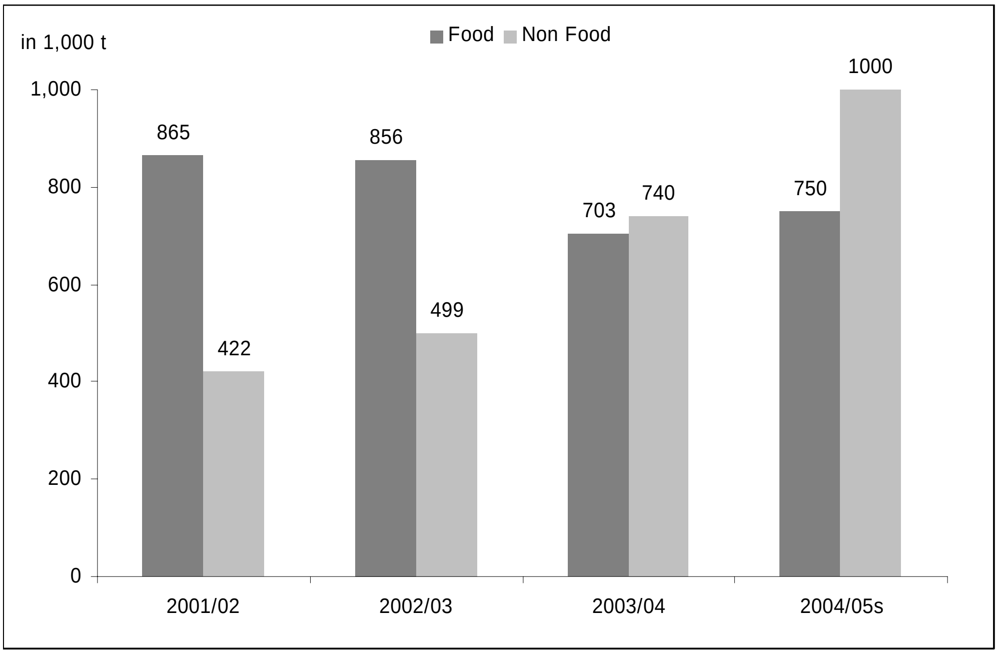

Figure 84: **Rapeseed oil use in Germany**
Source: /228/

Generally the price of biodiesel in south-west Germany is 10 euro cents/l lower than in the north-east, the main cultivation region for the raw material rapeseed, which is due to the imports of rapeseed and biodiesel from France.

6.6.2 Supply

Germany is the global leader in the biodiesel sector. In 2005, the raw materials for rapeseed biodiesel were cultivated on approx. 322 000 ha of set-aside land. In addition, there are approximately a further 122 000 ha of rapeseed cultivation as an energy crop on land which has not been taken out of productive use, as well as a further 877 000 ha of consumer rape (2005). Given an average yield of 3.8 t/ha in 2005, this leaves roughly 1.7 million t of rape seeds for biodiesel production. A further 3.3 million t of rapeseed will come from land areas used for consumer rape. Together with net imports of 0.70 million t p.a., approx. 2.2 million t of rapeseed oil will be produced in Germany. Approximately 0.4 million t of the extracted rapeseed oil will be exported. The remaining 1.8 tons will be used as follows together with the 0.3 million t of imported rapeseed oil and 0.3 million t of surpluses: 1.5 million t will be used for technical applications and 0.7 million t of rapeseed oil will be processed to produce rapeseed salad oil and cooking fats. More than 80% of the rapeseed oil produced for technical purposes is used to produce biodiesel (approx. 1.3 million t) /226//229//230/.

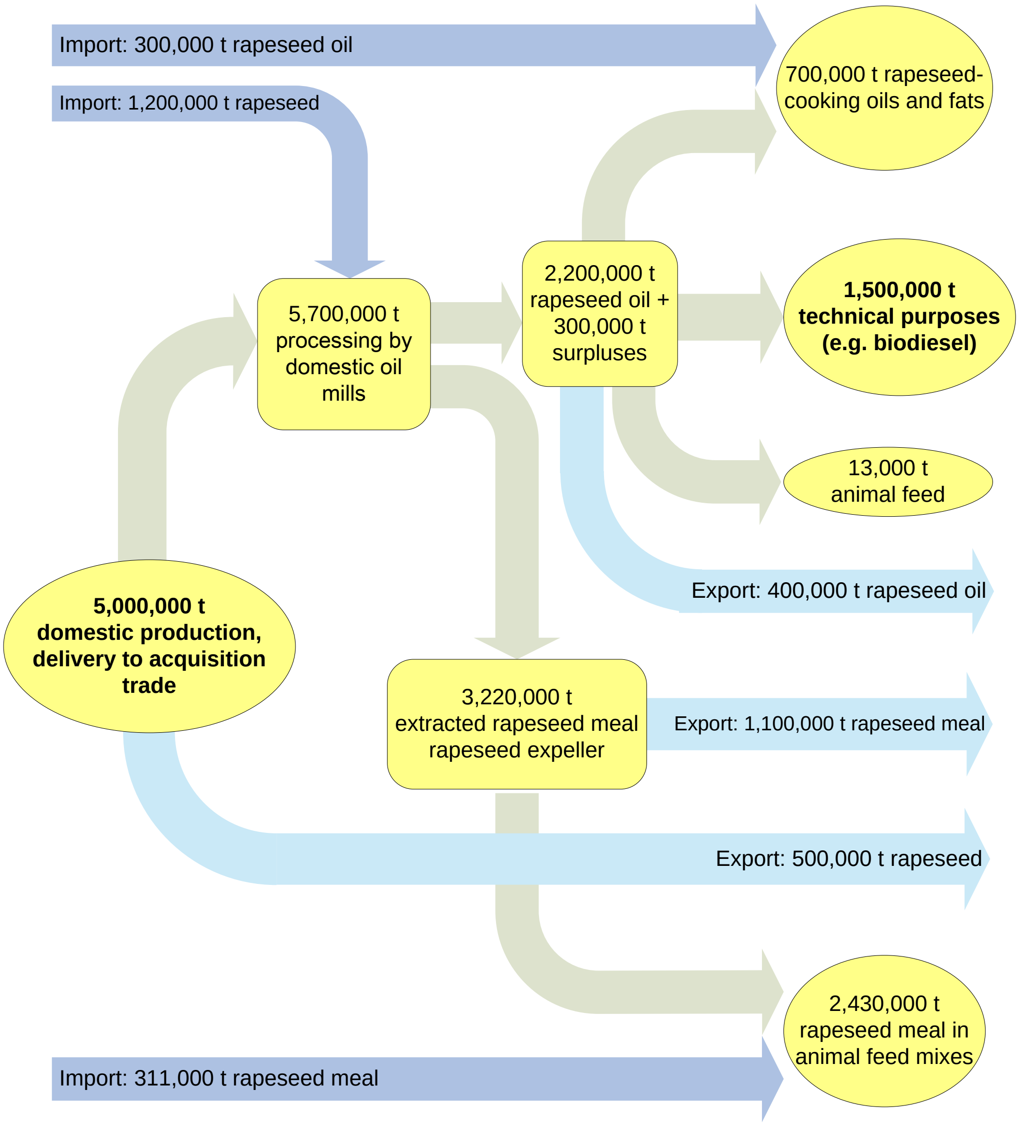

Figure 85: Sales markets for rape seeds and products processed from rapeseed in 2005
Source: Data from /226//229//230/

Until a few years ago the price paid for rapeseed as a renewable raw material was significantly lower than that for consumer rape. Increased demand and an ever-decreasing supply means that the prices paid for rapeseed which is intended for biodiesel production are now the same as those for consumer rape.

Apart from rapeseed oil, approx. 2.3 million t of rapeseed meal are produced as a by-product; higher production quantities mean that it is increasingly used as animal feed at the expense of soya meal from Brazil and the USA. Furthermore approx. 150 000 t of glycerol result during biodiesel production. Economic studies have concluded that the production costs of rapeseed biodiesel are 0.49 €/l at a rape seed market price of 20 €/dt (Table 73) This considers all by-products, processing costs and other expenses. If one adds a further 5 euro cents/l for distribution and 12 euro cents/l for VAT, this results, compared to prices at petrol stations, in a satisfactory price level of rape seeds as raw material and adequate profit margins for the processing companies and dealers. The profit level is currently above 25 euro cents/l (Table 74)

Table 73: Absolute and percentage composition of production costs for rapeseed biodiesel in Germany
Source: /198/

Capacity: 100,000 t (1.124 million hl) raw material: 271,000 t rapeseed			
Expenditures on	€/t	€/hl	%
Building (B)	4.0	0.4	0.5
Machines/Inventory (M)	25.9	2.3	3.3
Investment costs (B+M)	29.9	2.7	3.8
Labour	9.0	0.8	1.1
Ins./fees/rep.	5.0	0.4	0.6
Raw material	542.0	48.2	68.8
Resources	201.5	17.9	25.6
Gross production costs	**787.4**	**70.0**	**100.0**
Sales of by-products			
Rapeseed cake	168.0	15.0	21.0
Glycerol	70.7	4.0	5.7
Net production costs	**587.8**	**52.3**	**73.3**

Table 74: Composition of sales prices for diesel and biodiesel in Germany in €/hl
Source: /198/

	Diesel		**Biodiesel**			
			Pure fuel		**As additive**	
Price level	medium	high	medium	high	medium	high
Price (at petrol station)	95	120	85	110	95	120
- purchase price	28	48	55-65	55-65	55-65	55-65
- VAT	13	17	12	15	13	17
- mineral oil tax	47	47	0	0	0	0
- distribution	5	5	5	5	5	5
- mix in additives	0	0	0	0	2	2
= Profit margin	**2**	**3**	**3-13**	**25-35**	**10-20**	**31-41**

6.6.3 Market model

The market model is very similar to that already described for bioethanol (Figure 86). The supply of rape seeds as a raw material in Germany stems mainly from the cost-effective production of rapeseed on land which has had to be set aside. These areas (in 2005 approx 321 000 ha) are not influenced by the usage costs of a competitive fruit as it is not permitted to cultivate these on such land. In addition, one also saves any land maintenance costs when cultivating rapeseed for biodiesel on set-aside land. The cost advantage of rapeseed cultivation on set-aside land when compared to alternative utilisable cereal crop cultivation areas amounts on average to approx. 200 €/ha (160 € contribution to the displaced fruit, 40 € land maintenance costs). An average yield of 3.8 t rape seeds/ha results in a cost advantage of 5.26 €/dt rape seeds. Figure 86 shows that the most inexpensive biodiesel in Germany can be produced at 14.74 €/dt rape seeds on set-aside land. If one uses these production costs in the calculations (Table 73) instead of 20 €/dt rape seeds at a convertible oil content of 41%, this results in raw material costs for RME of 36 euro cents/litre (or €/hl) and corresponding net production costs of 36 euro cents/litre RME. The supply curve in the figure rises slightly as it has been assumed that less high-yield sites will be used for rapeseed cultivation due to the increasing use of set-aside land. The remaining 50% of the current supply is obtained from land areas which are otherwise used for food production. If one were to abandon rapeseed biodiesel production, these land areas would mainly be used for cereal crop production with a proportion of consumer rape for crop rotation, whereby in the past one had to intervene with cereal crops and apply subsides so that they could be exported on the global market. The supply of rapeseed from set-aside land can result in prices which lie under the market price for rape seeds. The rather low prices paid for this product over several years, were determined by the old price levels for rape seeds, so that the rape farmers were able to enjoy some of the profits.

The cultivation of rapeseed on cereal crop land for biodiesel generation is not profitable for farmers, as this does not fulfil the conditions for energy crop cultivation on set-aside land. There are also no price differences to consumer rape. The cultivation of rapeseed for producing biodiesel will only be performed in those areas where a higher profitability can be achieved in comparison to rapeseed cultivation for the consumer market. It therefore follows that this type of rapeseed cultivation has slightly lower production costs when compared to consumer rape. The supply curve tends towards the market price level for rape seeds (20 €/dt) when considering border producers of rapeseed cultivation for biodiesel on cereal crop land. Theses are identical to the RME raw material costs of 48.2 euro cents/litre (€/hl) given in Table 73.

The difference between domestic rape seed demand and supply is covered by imports, which until now have been relatively elastic in terms of price. If production were to exceed current domestic supply levels of approx. 1.5 million t rapeseed oil (approx. 3.8 million t rape seeds from around 1 million ha), the supply curve for domestic rapeseed could rise sharply as further expansion in rapeseed cultivation would result in higher opportunity costs for the displacement of food cultures and ultimately reach the limits of crop rotation. Apart from the domestic production of rape seeds, a share of the demand, in particular for the margarine industry is covered by imports of rape seeds and rapeseed oil. The raw material would have to be imported from EU member states or overseas regions if demand in rapeseed biodiesel were to sharply increase and there was increased availability of even bigger plants for transesterification. It is difficult to predict the future price development of rape seeds in Germany; this is because the global rapeseed market is relatively small and the production of plant oils from other plants such as soya, palm oil etc. is in comparison much larger, even though this can only be used for biodiesel to a limited extent (section 6.6.5).

If one shifts the rape seed supply curve (ex-buyer) by the costs of distribution and VAT, one obtains the supply curve (ex-consumer) for a biodiesel consumer price at the petrol station of 95 euro cents/l. The higher supply curve ex-consumer (dashed line) applies to a biodiesel consumer price at the petrol station of 120 euro cents/l (4 euro cents/l additional VAT). The difference between each of the supply functions (ex-consumer) and the consumer price at the petrol station may be considered as profit earned by the operators of conversion facilities and mineral oil companies. If the consumer price of biodiesel were to rise, the potential profit would also rise proportionately, however, it also reduces pro rata due to the increased VAT.

The chart shows that the market introduction instruments used in Germany (mineral oil tax exemption) will only provide low profits to producers of bioenergy raw materials, and is limited to set-aside land. This is related to the fact that the prices of agricultural raw materials with high elasticity are covered by imports and that global prices dictate domestic agricultural production prices. Nevertheless the operators of conversion facilities and mineral oil providers will be able to achieve significant profits.

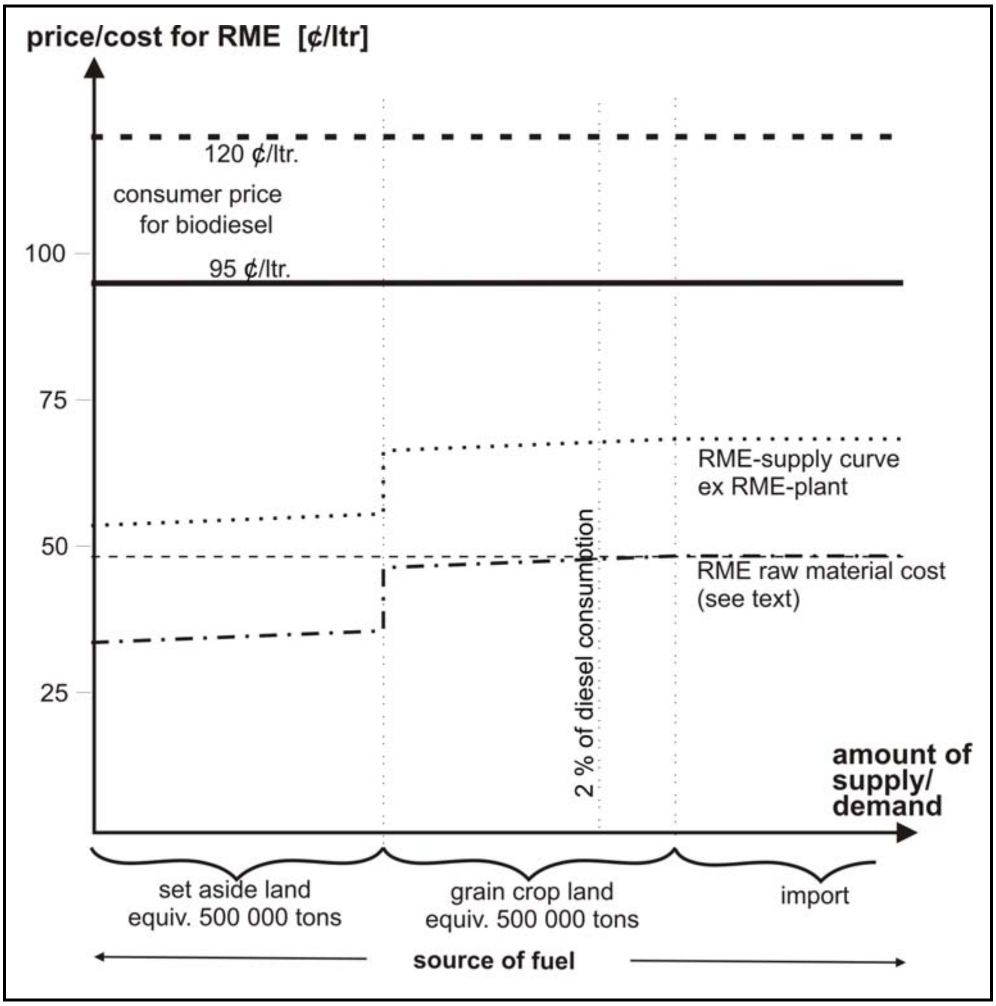

Figure 86: **Market model for biodiesel (RME) (Status 2004)**
Source: own calculations/

6.6.4 Price relationships

The cost calculations and market models shown are, as far as rapeseed biodiesel is concerned, also based on data from the reference period, i.e. relatively stable prices in the energy and agricultural product markets. The price relationship between the global crude oil price, the price of biodiesel and the price of rape seeds are therefore also shown below. Figure 87 shows the price relationship in relation to the global crude oil price, i.e. the derived price of fossil-based diesel fuel before tax in Germany. Assuming a more or less stable price level of 30 euro cents/litre for fossil-based diesel fuel (before tax) until 2004, this fuel was available at a price level of 95 euro cents/litre. The calculations in Figure 87 show that VAT and mineral oil tax account for approx. 60 euro cents/litre. In this price situation, biodiesel could be sold as a pure fuel to end-consumers at an average reduction of 20 euro cents given the lower energy density and marked down prices due to lesser performance. If one assumes the global crude oil prices from the second half of 2005 and a derived acquisition price for fossil-based diesel fuel of approx. 50 euro cents/litre, one obtains an end-consumer price incl. taxes, distribution costs and profit margin of approx. 120 euro cents/litre. After deducting the markdown for biodiesel one obtains an end-consumer price of approx. 100 euro cents/litre. Whereas rape seeds can still be converted at prices of 20 €/dt when the prices of crude oil, fossil-based diesel fuel and biodiesel are low, it would be possible to pay a maximum 30 €/dt at higher price levels assuming that the price-induced profits are fully passed onto the rapeseed producers. However, this will only occur on the market when global rape seed prices rise due to limited supply elasticity abroad.

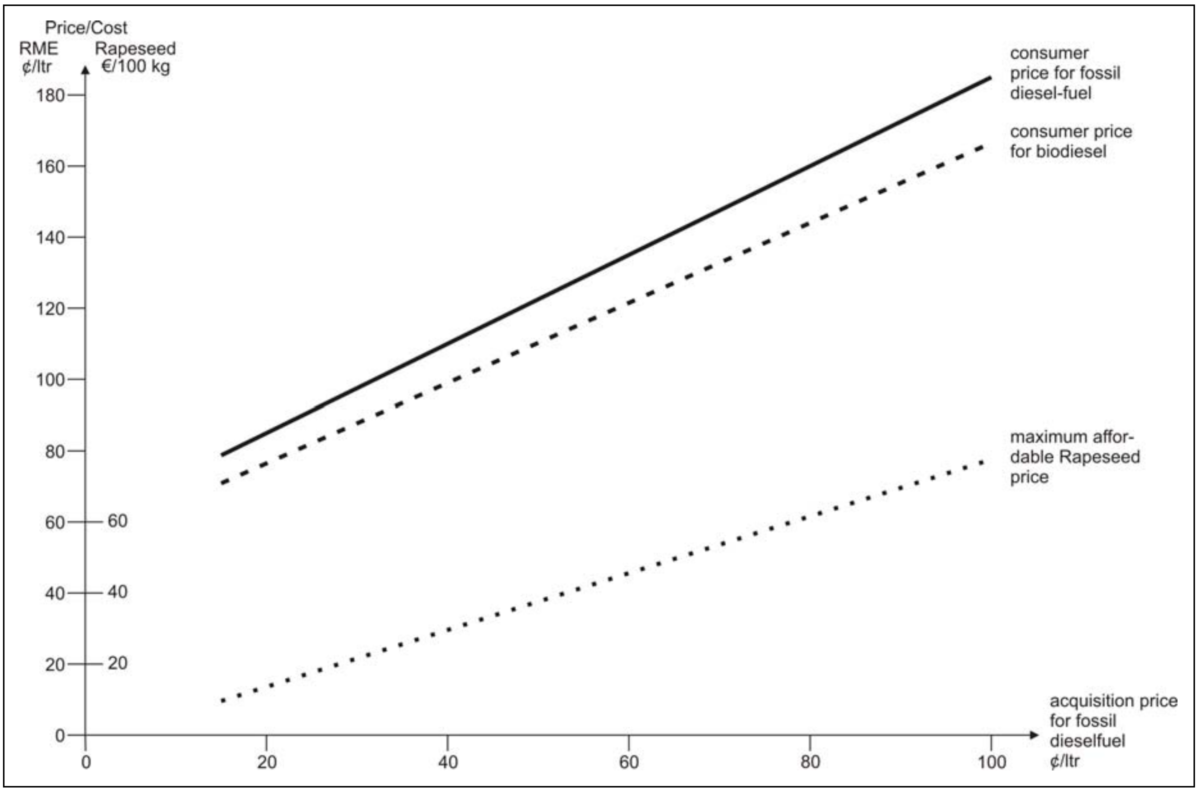

Figure 87: **Maximum payable biodiesel and rapeseed price in relation to the acquisition price for fossil-based diesel fuel**
Source: /198/

Similar to bioethanol, biodiesel will not be competitive if it is taxed in the same way as fossil-based fuels even at high crude oil prices.

6.6.5 Excursus: Global markets for plant oils

In the area of agriculture, the oil and fat industries are among the fastest growing global growth sectors. In the last 20 years the worldwide consumption of oils and fats has risen by an average of 4% per year. The increased demand in oils and fats is largely due to consumer growth in the food sector in newly industrialised countries such as China and India[39] /227/. In contrast, there is a rising demand to use plant oils as raw materials for producing biodiesel in the industrialised countries. For example, the demand for plant oils has markedly increased in the European Union since the introduction of EU Directive 2003/30/EC to promote the use of biogenic fuels. At the present time, almost all the raw material used for biodiesel production in the EU is rapeseed oil. As a result of this rapid growth in demand, it has been predicted that the production of rapeseed in the EU for energy applications cannot increase sufficiently fast, especially since the expansion of cultivation areas is limited by crop rotation restrictions. One therefore expects that the EU will become a net importer of rape seeds and rapeseed oil over the coming years. It is also conceivable that other raw materials such as soya or palm oil will be used by European manufacturers to produce biodiesel. At present already 10 to 15% of biodiesel is produced on the basis of other oils /238/. However, the chemical characteristics of soya or palm oil limit their use in the European climate.

Plant oils are composed of unsaturated and single- or poly-saturated fatty acids. These primarily determine the characteristics of the biodiesel produced. The fatty acid patterns of various oils are shown in Figure 88.

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[39] Globally speaking approx. 80 % of oils and fats are used in the food sector.

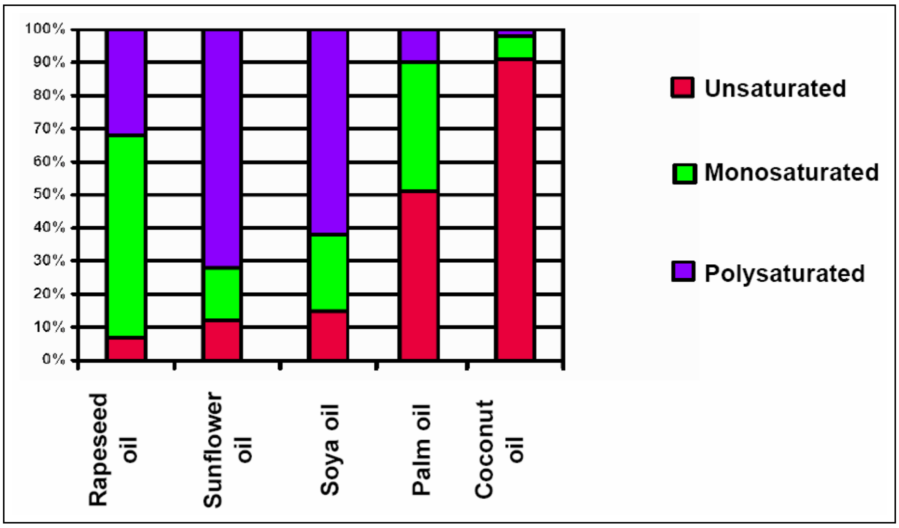

Figure 88: **Fatty acid patterns for various plant oils**
Source: /232/

The DIN EN 14214 quality standard for determining the fuel characteristics of biodiesel came into effect in the EU in 2003. The cold filter plug point (CFPP) and iodine value are the two parameters primarily determined by the chemical characteristics of the oil being used. The iodine value indicates the unsaturated fatty acid content. The use of biodiesel with an excessively high iodine value may result in the formation of deposits on the piston rings and grooves in the engine. Furthermore, if the limit values are exceeded this will have a detrimental effect on its storage stability. The CFPP describes the low-temperature behaviour of fluids, i.e. the filterability limit in relation to the temperature. One of the characteristics of biodiesel is that it forms crystals at low temperatures.

The biodiesel parameter requirements as specified in DIN EN 14214 and other raw materials used in biodiesel production are shown in Table 75.

Table 75: **Characteristics of fatty acid methyl esters according to DIN 15 214**
Source: /234//233/

	CFPP [in °C]	**Iodine value** [-]
DIN 15 214	Winter -20 Summer 0	max. 120
Rapeseed oil methyl ester	-10	115
Soya oil methyl ester	-2	130
Sunflower oil methyl ester	-2	135
Palm oil methyl ester	9	55

Above all, the “cold filter plug point” parameters specified in DIN EN 15 214 mean that only selected raw materials can be used to produce biodiesel. For instance, biodiesel for winter operation can virtually only be produced from rapeseed oil. In summer, as well as when using biodiesel as an additive in fossil-based diesel, it is also possible to use a mixture of rapeseed oil and e.g. soya oil to produce biodiesel. Flowability can also be improved by blending additives. In principle it also possible to adapt the fuel to winter conditions, however this is not viable for all types of biodiesel from an economic perspective.

If one considers countries such as the USA and Brazil where the expansion of biodiesel production is also stimulated by financial incentives, biodiesel is almost exclusively produced on the basis of soya oil. However, biodiesel production is also possible using numerous other oils such as palm oil, coconut oil or jatropha oil. These are increasingly being used as raw materials for biodiesel production in countries such as Malaysia, Thailand, Japan and the Philippines.

It is therefore expected that the efforts of various countries to increasingly use plant oils to produce biodiesel will have a significant effect on the global oil and fat markets.

The following section therefore serves to synoptically illustrate the global markets for oilseeds and its processed products. This should show the situation of the developing European biodiesel industry in the context of the global oilseed markets.

6.6.5.1 Supply and demand

In the economic year 2004/05 approx. 379 million t of oilseeds were produced. Roughly 57% of these oilseeds were covered by the production of soya beans, which are mainly cultivated in North and South America. Some distance behind this is followed by rapeseed production with 12% of the global production volume. Peanuts supply 9% (35 million t) and sunflower seeds 6% (25 million t) of worldwide oilseed demand (Figure 89).

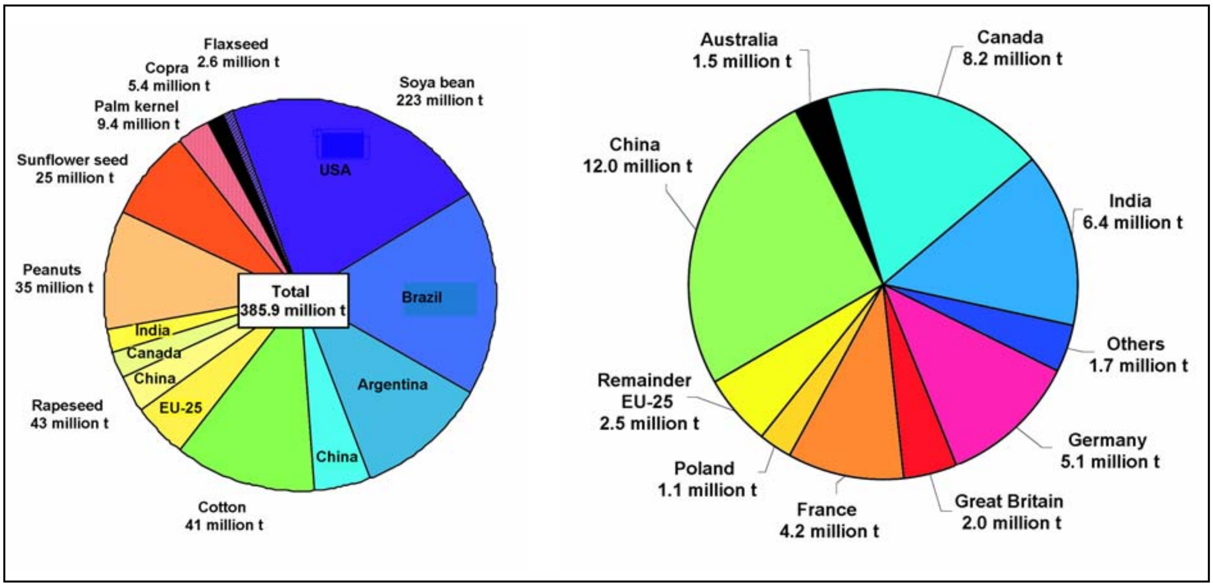

Figure 89: Global market for oilseeds and market for rape seeds in million t
Source: /226/

Almost all of the oilseed harvest is used to produce oils and fats. The overall consumption of plant oils and fats over the last five years has risen by approx. 26% to a current level of approx. 110 million t, whereby China has experienced the largest growth in consumption of more than 40% /226/. In contrast with seed production, the high yield per area means that the production of palm oil is most common followed closely by soya oil production.

Each of the supply and demand markets will be discussed in greater detail below.

USA

In the USA, cultivation is almost exclusively restricted to soya beans, whereby the USA produces a harvest of roughly 77 million t which corresponds to almost 40% of global production. The proportion of GMO soya beans exceeds 80% in the USA. The USA is the most important soya oil producer (approx. 8.5 million t) due to its high harvest volume /226/.

Argentina and Brazil

In Brazil and Argentina, cultivation is also largely restricted to soya beans. In the economic year 2004/05 the harvest volume was 60 million t in Brazil and 39 million t. in Argentina. Together with the USA, Brazil and Argentina produce over 80% of the global soya bean volume of approx. 216 million t, whereby the South American market has become increasingly significant over the last few years. The cultivation area in Brazil has been expanded by more than 10% per year over the last 5 years. In Argentina one also predicts a further expansion in the cultivation area which is currently estimated to be approx. 14 million ha, especially as soya beans are the most profitable culture plant in Argentina. The proportion of GMO soya beans is almost 100% in Argentina. In Brazil the GMO share is estimated to be 20-25% /226/. The expansion of soya area can have some negative social and ecological consequences, such as the clearing of rain forests, which in turn can lead to erosion processes, as well as the alienation of small-scale farmers /236/.

PR China

Large amounts of soya beans are also grown in the PR China. The rapidly increasing demand of 44 million t of soya beans when compared to a domestic production of 17 million t has lead to a greater dependency on imports over the last few years. Domestically produced soya beans are processed with imported soya beans to produce approx. 6 million t of soya oil, which is almost five times the production level in the early 90's. Approx. a further 2.4 million t are imported in addition to this soya oil production volume.

The PR China is the largest global rape seeds and rapeseed oil producer with roughly 27% (12 million t.) and 26% (4.2 million t) of global production volumes of 43 million t and 16.1 million t. respectively. A further 0.4 million t is imported in addition to domestic rapeseed oil production.

India

Another important seed producer is India with production quantities of 6.5 million t of soya beans and 7.0 million t of rape seeds. These rape seeds are used to produce 2.2 million t of rapeseed oil which is mainly used in the domestic market. A further 5.9 million t. of plant oils are imported into India, mainly comprising 3.7 million t of palm oil and 2.1 million t of soya oil /226/.

Malaysia and Indonesia

Due to the high oil yield per fruit, palm oil is the most heavily produced type of oil worldwide with a production volume of almost 35 million t. Roughly 85% of global palm oil production is accounted for by Indonesia (12.6 million t) and Malaysia (15.5 million t). Higher profits driven by largely very attractive global prices resulted in an unusually high expansion of cultivation areas for oil palms; this meant there was a double-digit growth rate in the mid-90’s /226/. Due to the rapid growth of the palm oil industry in Malaysia and Indonesia, large areas of rain forest were cleared to make space for cultivating oil palms[40]. This has already been deplored by various environmental organisations, especially since landslides and top soil removal are direct consequences of clearing /236/. Growth is currently relatively moderate at a level of roughly 4%. This is mainly due to the fact that there are few additional areas in Western Malaysia available for additional expansion. This means that production growth is only achievable by increasing the yield. Further expansion in production capacity is mainly expected in East Malaysia and above all in Indonesia /Mielke/. The extracted palm oil is exported to PR China (4.7 million t), the EU-25 (4.5 million t) and India (3.7 million t).

Canada

Canada produces approx. 8.2 million t of rape seeds and 3.0 million t of soya beans. This makes Canada the second largest rapeseed producer with 18.5% of global production. The rapeseed oil production volume in Canada for the economic year 2004/05 is estimated to be approx. 1.4 million t. /226/. The export capability of Canadian rapeseed to the EU is largely limited due to the numerous types of genetically modified cultivars.

EU-25

In the EU-25 approx. 19.7 million t of oilseeds are produced on 7.0 million ha, three-quarters of which are rape seeds. The EU-25 therefore produce roughly 34% (15.2 million t) of the global rape seed supply[41]. In the last two years the rapeseed cultivation area in the EU-25 was extended by more than 10%. In the economic year 2004/05 roughly three-quarters of production was accounted for by the EU-15 with the remaining quarter coming from the new acceding countries. However the yields of 2.5-2.9 t/ha are relatively low when compared to the European average of 3.2 t/ha. Germany is the largest rapeseed producer in the EU. The cultivation area for rapeseed in Germany at the time of the 2005 harvest had been expanded by approx. 5% to 1.35 million ha, whereby winter rapeseed is grown on almost 100% of the

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[40] This clearing process has already destroyed 70% of the former rain forest in Indonesia.

41 Approximately 94% of global rapeseed is cultivated in PR China, Canada, India and the EU-25 economic zone.

cultivation area. A total of about 5 million t of rapeseed was harvested in Germany (Figure 90). The second largest producer is France with approx. 4.4 million t, which corresponds to an increase of 9% /228/.

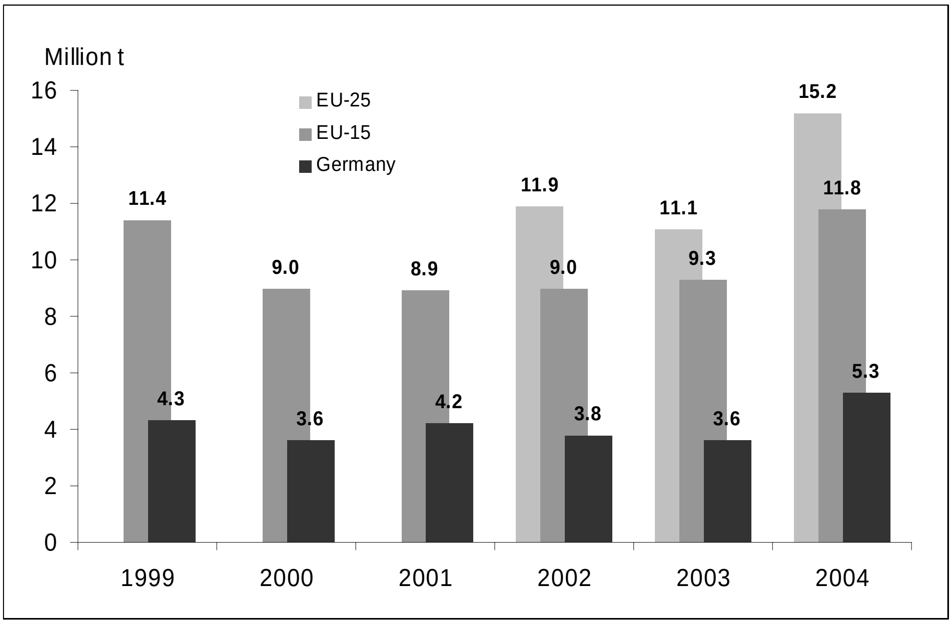

Figure 90: **EU rapeseed production in the economic year 2003/2004**
Source: /228/

Sunflower is the second most common oilseed in the EU-25 with 19% of European seed production; this is mainly concentrated in France, Spain and Hungary. In contrast to rapeseed production, the new EU acceding countries accounted for about 40% of the cultivated sunflower seed. Soya bean cultivation in the EU-28 with a volume of 283 million t in the economic year 2004/05 is mainly located in Italy (52%) and France (20%) //228//226/.

Despite the increased demand for rapeseed oil in the EU-25, rapeseed oil production could only be increased by 2% to 5.5 million t. This is mainly the result of a bottleneck in the processing capacity of oil mills. The global sunflower oil production volume remained stable at 1.7 million t due to the high utilisation of oil mills and the low availability of sunflower seed.

6.6.5.2 Global trade

The worldwide trade of oilseeds and its processed products is restricted to a few export/import countries and products. As with most agricultural products, the global trade flows of oilseeds and its by-products are largely determined by domestic foreign trade policy (customs duties) and the market mechanism for supply and demand.

Approx. 79 million t of oilseed and 42.2 million t of plant oils were traded in the economic year 2004/05. Soya bean is the most important traded product and constitutes 85% of all traded oilseeds. The main export countries are USA, Brazil and Argentina which sell a major part of their produced seeds in PR China (27 million t) and the EU-25 (15.2 million t). On the one hand, the PR China has a large processing capacity; however, the available land for the further expansion of cultivation areas is limited. In particular, the continued increase in livestock numbers results in a rising demand for soya meal feed; this inevitably creates a dependency on imports /226/.

Canada is the leading rapeseed exporter (3.5 million t), whereby Canadian rape seeds are mainly exported to Japan and Mexico. The USA also mainly meets its rapeseed demand through imports from Canada. Canadian rapeseed is characterised by a high GMO-content, which prevents any exports to the EU as the use of GMO rapeseed in the food industry is prohibited by law. The use of genetically modified rape seeds for biodiesel production in the EU is also not conceivable, as the cost-effective production of biodiesel is determined by the sale of extracted rapeseed meal; the use of GMO rapeseed meal as feed is also forbidden in the EU. The second largest global rapeseed exporter is Australia with 1.1 million t of rapeseed. In the economic year 2004, Australian rapeseed was mainly exported to Japan and Pakistan, whereby small quantities were also exported to the EU. India, a further large rapeseed producer, hardly exports any of its produce /235/.

Palm oil accounts for roughly half the trade in plant oils. This is followed by soya oil and sunflower oil with trading volumes of 10 million t and 2.6 million t respectively. The trading volume of rapeseed oil is only 1.4 million t, of which roughly 70% is exported from Canada to mainly the USA (70%) and China /226/. In principle it is also conceivable that the exports of Canadian rapeseed oil to the EU will increase as a result of the European Biofuels Directive and its goal of processing 5.4 million t of rape seeds by 2010. Since trading volume at the present time is relatively low, this can only cover future demand to a lesser extent. Nevertheless it is expected that various countries such as the Ukraine, Russia, Argentina, Australia, India and probably also China will in future boost its production of rapeseed. This will result in new potential rapeseed exports.

6.6.5.3 Prices of plant oils

Over the last few years the price of rapeseed oil in Germany has fluctuated in a relatively narrow range from approx. 480 to 670 € per ton of rapeseed oil. The rapeseed oil price is relatively independent of the prices for mineral oils and biodiesel, which in the past has tended to match the development of diesel prices. As shown in

Figure 91, the daily price for rapeseed oil in previous years has been on average 550 € per ton (50 euro cents/l). As mentioned in the introduction, in order to meet the biodiesel standard and its parameters, a large proportion of rapeseed oil must be used in biodiesel production. As a result the prices of the various oil types have developed differently. For example, whereas rapeseed oil in 2000 was on average 10 US$/t more expensive than soya oil, this price gap rose to 46 US$/t in 2003 and 113 US$/t in 2005. However, this development may be viewed as excessive in the medium term. Also when compared to palm oil, rapeseed oil was on average 37 US$/t more expensive in 2000. This premium rose to an average of 156 US$/t in 2003 and an average of 237 US$/t in 2005 /228//238/.

Despite the further expansion of land for rapeseed cultivation in the EU (Germany, France, Hungary) one expects that the average price of rapeseed oil will lie above that for the previous decade and in the long term stabilise at a high price level. A price squeeze on plant oils would seem unlikely. Simply based on the described price difference between rapeseed oil and soya oil, one can assume that German and European biodiesel producers will show increased interest in utilising soya oil. However, its use is only possible within certain technical limits (see above description).

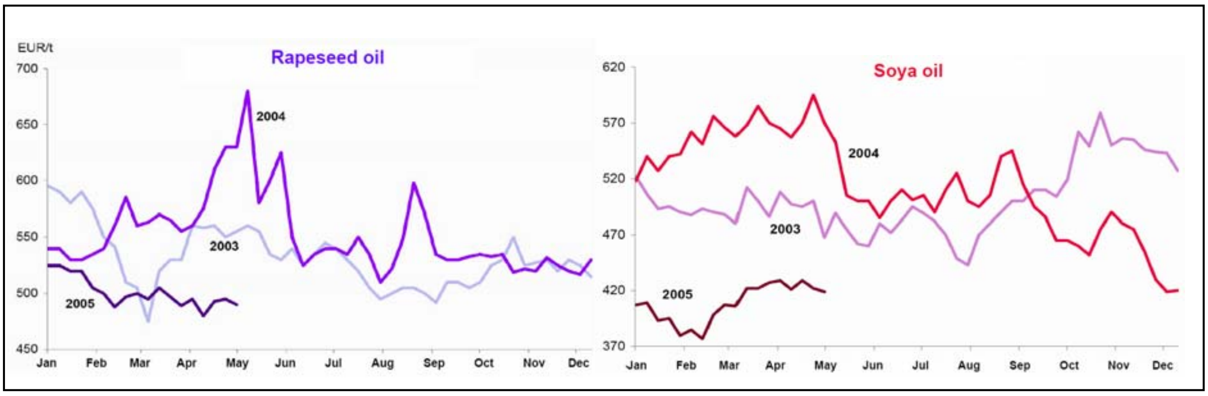

Figure 91: **Daily prices for rapeseed and soya oil**
Source: /228/

6.6.5.4 Summary

Due to the ambitious goals set by the EU regarding the introduction of renewable fuels and the relatively limited area available for rapeseed production (crop rotation limits), one can assume that the imports of plant oils and oilseeds will increase over the coming years. In future one can assume that B100 will almost only be produced from rapeseed oil. However, since mineral oil companies are increasingly favouring the use of biodiesel additives, one cannot rule out that in future less expensive oils such as soya oil will be used in biodiesel production. This may lead to some negative ecological effects in countries such as Malaysia or Brazil (clearing of forests).

At present it is difficult to say which plant oils will be used in the future production of biodiesel and how the increasing demand in Germany and the EU will be satisfied.

In any case, the global market for oils and fats will experience significant changes as a result of the worldwide expansion in biodiesel production and the rising demand for oils and fats in the food industry.

6.7 Synthetic fuels and bioethanol from lignocellulose

Lignocellulose-based fuels include ethanol from lignocellulose as well as synthetic fuels. The production technologies are currently not available, which means the markets are not yet established. Car manufacturers are particularly interested in synthetic fuels due to their very high quality. Furthermore the utilisable biomass potentials in Europe and across the world are very high; large capacities could therefore be established in a short space of time. Due to the limited transportability of solid biogenic fuels, production facilities will tend to be placed near the sources of raw materials for economic reasons. Sites all across the world could be of interest which would encourage the establishment of large forest plantations. For example, one could use the globally available degradation area of 100 million ha to provide significant resources, which are then transported as refined products over longer distances (appendix J).

The time frame over which these new markets will be established is difficult to estimate at present, however it will not be of relevance before 2010 and 2020 for ethanol from lignocellulose and synthetic fuels respectively.

6.8 Bioelectricity

The high potentials of generating electricity from biomass pose the question of whether it can be transmitted and freely traded between European countries. In order to make a statement, one needs to consider the capacity of the European electricity grid.

The European electricity grid is sub-divided into the UCTE, Nordel, UESR/UES, GB and COMELEC regions; Figure 92 shows which countries belong to the various grid systems.

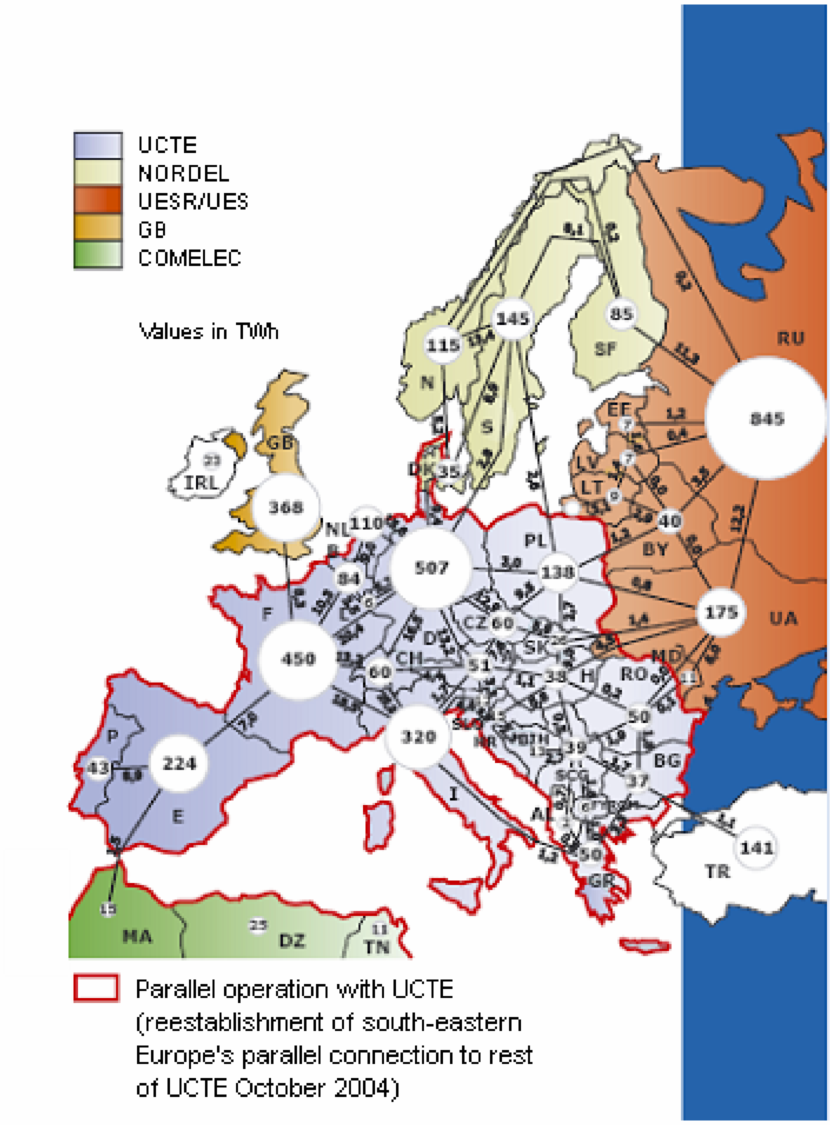

Figure 92: **European grid systems, electricity consumption and exchange between countries, Status 2003**
Source: /218/

The following table lists the available transmission capacity based on previous cross-border electricity trade figures (Table 76). Furthermore the free cross-border capacity in the whole UCTE network will reduce from a current level of 60 GW to roughly 20 GW by 2015 (also see Figure 93). In certain countries there will already be capacity shortages for trading electricity from 2006 in order to cover their own electricity demand.

Table 76: Available free grid capacity in UCTE network on third Thursday of each month Source: /217/

Remaining grid transmission capacities in the UCTE grid
[Values in GW]

Country	2005			2006			2007			2010			2015		
	January		July	January		July	January		July	January		July	January		July
	11:00	19:00	11:00	11:00	19:00	11:00	11:00	19:00	11:00	11:00	19:00	11:00	11:00	19:00	11:00
Belgium	0,3	0,1	1,9	0	-0,2	1,6	-0,2	-0,5	1,5	-1,9	-2,2	0,3	-5,2	-5,5	-2,6
Germany	8,2	8,4	3,4	7,5	8,1	4,7	7,7	8	4	5,5	5,7	3,5	1,4	1,7	-1,6
Spain	8,5	5,6	5,2	9,6	6,3	5,1	9	6,3	5,6	8,3	4,9	3,7	1,8	-1,5	-3,1
France	14,1	11,7	11,9	13,1	10,8	11,5	12,7	10,4	10,8	12	9,8	9,3	11,1	8,9	9,7
Greece	1,1	0,7	-0,1	0,9	0,5	-0,1	1,4	1	0,3	1,9	1,5	0,1	1,3	0,6	-1,1
Italy	5,4	5,3	5,4	5,7	5,5	5,6	5,7	5,5	5,7	6,3	6	8,5	0,6	0,6	-1,8
Slovenia	0,2	0,2	0,1	0,2	0,2	0,1	0,3	0,3	0,3	0,1	0,1	0	0	0	-0,1
Croatia	0,8	0,6	1,1	0,8	0,6	1	1	0,8	1,3	0,9	0,6	1,1	0,3	0,1	0,5
Macedonia	0,1	-0,1	0,1	0	-0,1	0,1	0	-0,1	0	0,1	0,1	0,1	0,3	0,1	0,2
Serbia and Montenegro	0,1	-0,1	0,8	0,1	-0,1	0,7	0,1	-0,1	0,7	0	-0,1	0,5	-0,5	-0,7	0
Luxembourg	0,8	0,9	0,8	0,8	0,9	0,4	0,7	0,9	0,4	0,6	0,8	0,3	0,4	0,7	0,2
Netherlands	1,3	1,5	1,7	0,9	1,1	1,3	1,5	1,7	1,9	-0,9	-0,7	-0,5	-2,8	-2,6	-2,4
Austria	5,4	5,5	5,1	4,9	5	4,6	4,8	4,9	4,5	4,2	4,3	3,8	3,2	3,3	3,2
Portugal	1,6	1,6	1,6	1,5	1,5	1,8	1,8	1,8	1,7	1,1	1,1	1,2	-2,1	-2,1	-2,2
Switzerland	3,3	3,9	4,9	3,1	3,7	4,7	2,9	3,5	4,6	2,3	2,9	4,1	1,8	2,4	3,6
Czech Republic	2,8	2,7	2,3	2,7	2,6	2,3	2,6	2,5	2,2	2,2	2,1	2	1,7	1,6	1,6
Hungary	0,6	0,2	-0,1	0,6	0,3	-0,1	0,5	0,2	-0,1	0,8	0,4	0,2	0,3	0	0
Poland	7,8	6,8	6,4	8,1	7,1	6,6	8	6,9	6,2	8,9	8	6,8	6,4	5,4	4,6
Slovakia	1	0,9	1	1,1	1	1	0,2	0,1	0,3	0,1	0	0,1	-0,4	-0,5	-0,3
Bosnia and Herzegovina	1,1	0,8	1,2	1,1	0,8	1,2	1	0,8	1,1	0,9	0,7	1	0,7	0,5	0,8
Romania	1,2	0,9	1,2	1,2	0,9	1,1	1,2	0,8	1	1,3	1	1,1	1,3	1,1	1,3
Bulgaria	1,2	0,7	1	1,3	0,9	1,1	0,5	0,1	0,9	2,1	1,6	1,9	3	2,5	3
Burshtyn Island 1)	0,7	0,6	0,6	0,7	0,6	0,6	0,7	0,6	0,6	0,7	0,6	0,7	0,7	0,6	0,7
UCTE Total	67,6	59,6	57,7	65,8	57,6	56,8	63,9	56,2	55,3	57,3	49	49,5	25,2	17,2	14,2

1)Part of the Ukraine

The first shortages can already be seen when analysing the past, for example the blackout in Italy in 2003. This development can be countered by expanding the number of cross-border connection points or by building new power stations in the relevant countries to reduce the amount of cross-border electricity trade (Figure 93).

The expansion in wind power also exacerbates the problem of transmission grid loads within a given country and to a certain extent for the international trade of electricity. In order to maintain current standards, investments are required in the transmission grids and power stations.

Based on these reasons, the European Union decided to introduce a series of guidelines in 2003 to expand the trans-European energy grid /214/. The transmission grids affected by the planned expansion of the trans-European energy grid were published in the Official Journal

176/11 of the European Union. However, the scope of expansion for the grid network still remains unclear /214/.

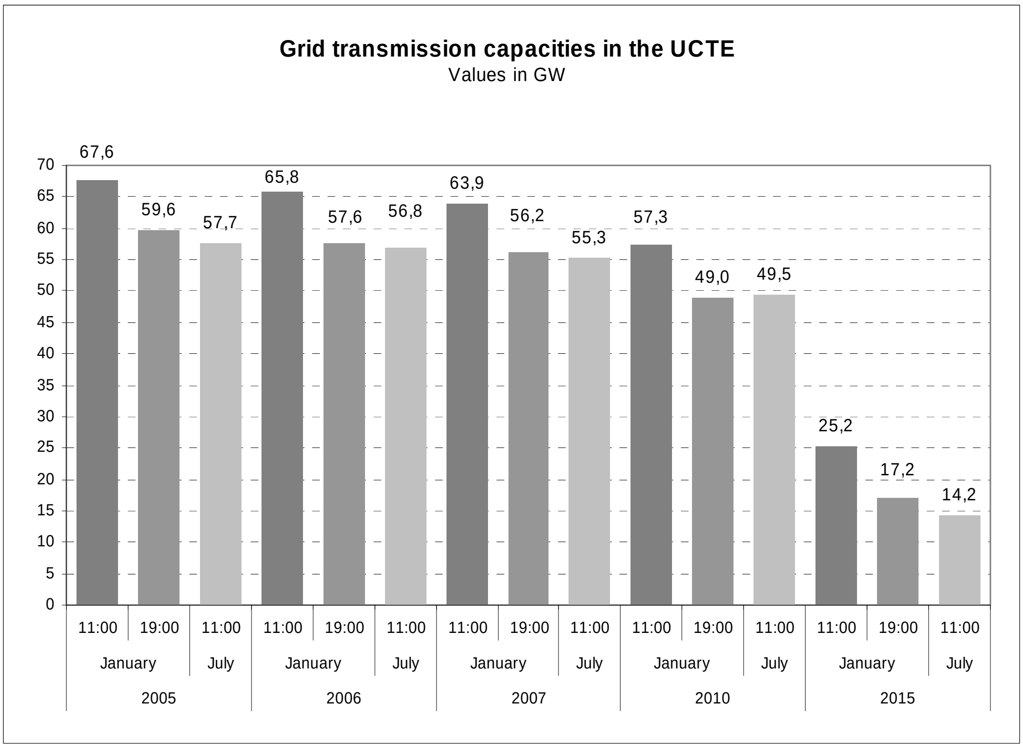

Figure 93: **Transmission grid capacity in UCTE network**
Source: /217/

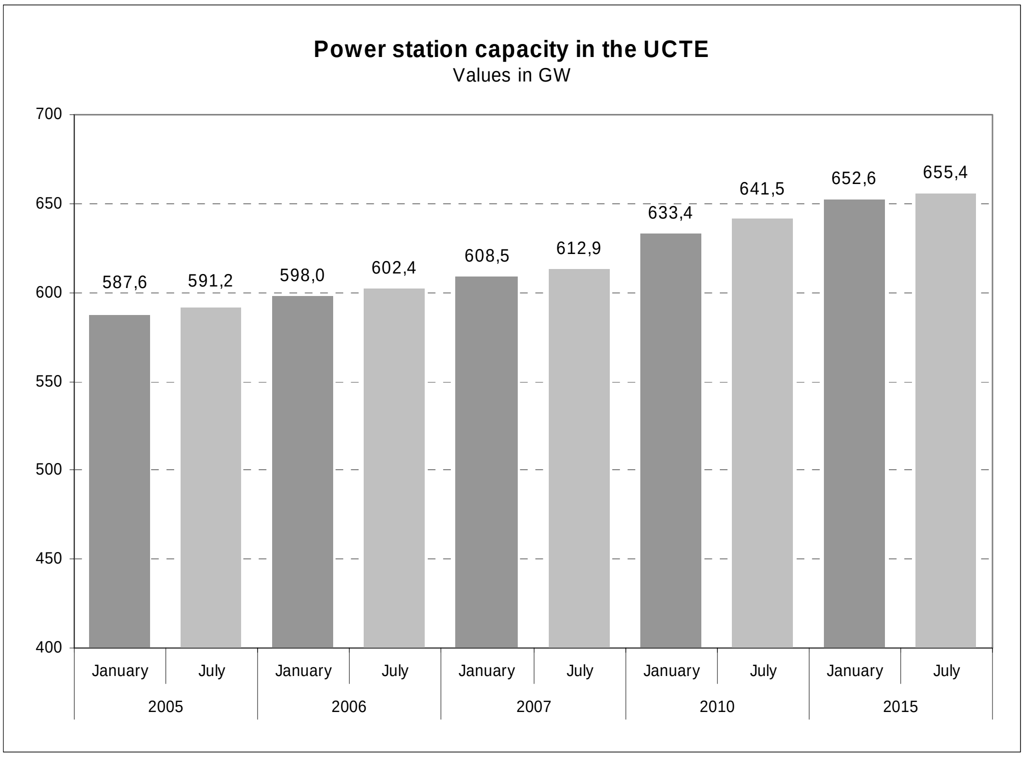

Figure 94: **Development of power station output in UCTE network**
Source: /217/

Germany, as well as most countries in Central and Southern Europe, belongs to the UCTE electricity grid. In principle the physical cross-border exchange of electricity can take place with all the countries neighbouring Germany (Figure 95). However, the volume of electricity exchanged is limited by the line capacity. It is therefore only possible to achieve a relatively limited physical exchange of variable electricity volume between individual countries, because the expansion concept for the UCTE network has previously mainly served to provide emergency reserves and improve network stability. A network which meets the demands of unrestricted goods traffic is not available.

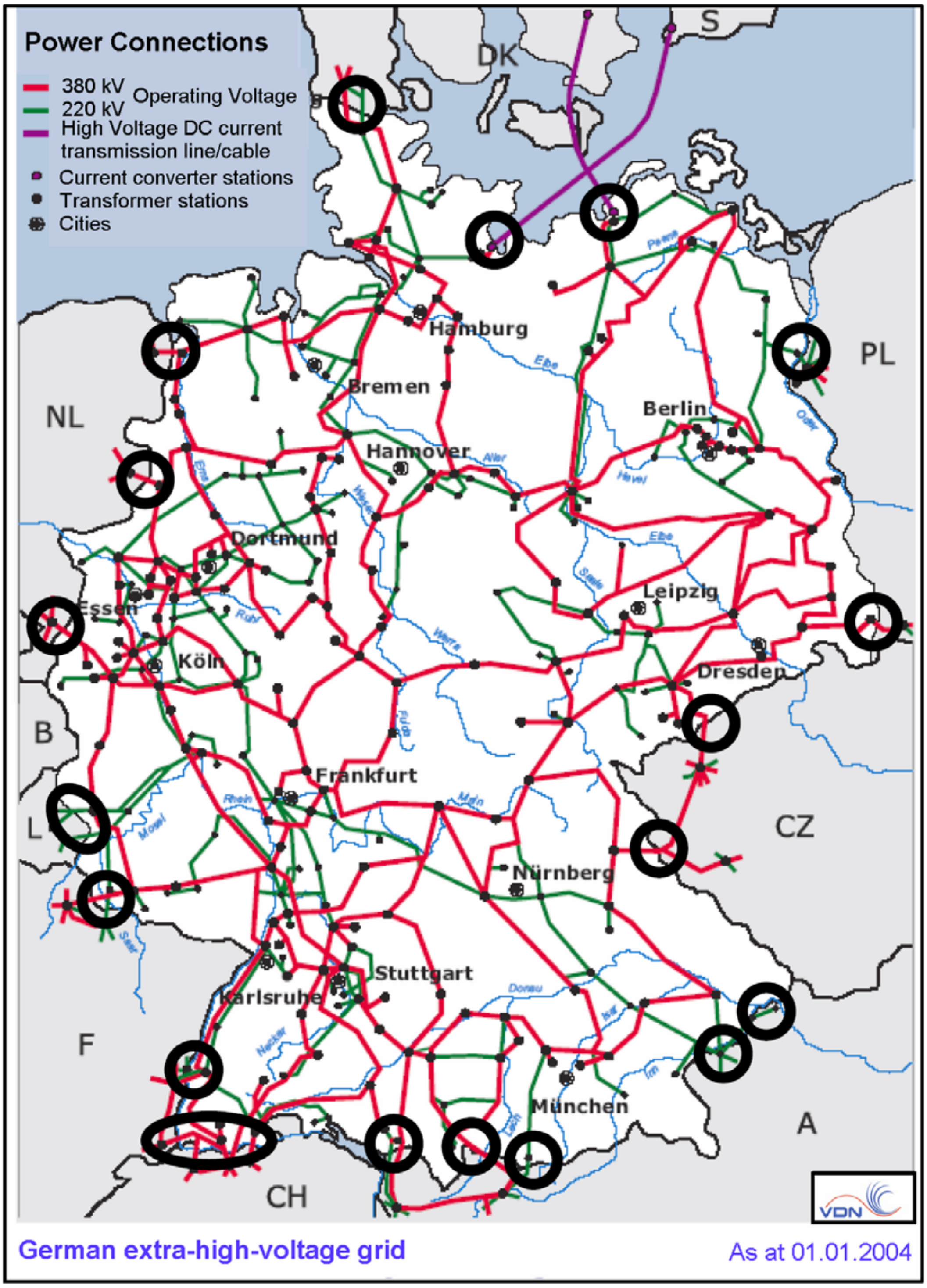

Figure 95: **High-voltage network and connection points in Germany**
Source: /219/

The risk of major power outages in Germany has until now been much lower than in other countries due to the almost balanced power figures as well as the tightly meshed structure of the German grid /218/. The trade of electricity will be limited to present levels unless additional connection points are built to the neighbouring countries.

It is not possible to provide any information on the capacities of the Nordel, UESR/UES, GB and COMELEC transmission grids, because these grid operators do not publish any data about their transmission network. However, it may be assumed that these transmission grids will in future also suffer from capacity shortages.

Conclusion:

Electricity generated from biomass may be traded similarly to electricity produced from other energy sources. Unless bioelectricity is somehow privileged, potential cross-border trades are dependent on available grid capacities. The indications are that an increasing bottleneck will occur, due on the one hand to the increased international trade of electricity, and on the other hand to the expansion in wind power which will lead to intermittent shortages in transmission grid capacity. Ultimately it will only be possible to achieve the free trade of electricity by expanding the cross-border networks. This is why in 2003 the European Union decided to expand the trans-European energy network over the coming years.

7 Consequences and conclusions

This study described options for the future development of biomass use in the EU-28 countries[42] up to the year 2020, and considered possible material flows between Germany and the European member states and beyond. The most important consequences and conclusions can be summarised as follows:

The policy framework for energy, agriculture, and forestry is relevant to the establishment of biomass use:

- At present, the **energy policy framework** for biomass use varies greatly between the individual member states, and the nature of future development is to some extent uncertain. In the medium term, the pressure to act is greater for the EU-15 (mainly due to the climate protection agreements) than for the new member states (EU-10) and the acceding and candidate countries. Nevertheless, the resulting activities are not restricted to the EU-15, but in principle can take place worldwide via the project-based mechanisms of the Kyoto Protocol.
- In contrast, due to the Common Agricultural Policy (CAP), the **agricultural policy framework** is relatively similar in each of the individual member states, but is, on the whole, difficult to predict for the period after 2012. Fundamental changes to the current pricing policy, though, are rather unlikely.
- The **forestry policy framework** is not part of the European Common Agricultural Policy, nor is it specifically included in the bioenergy discussion; the formulation and implementation of corresponding targets is still open. With regard to the potential situation, for a modified forestry policy to achieve effects, very long time spans must be involved.

The supply of biomass and bioenergy is determined by biomass potentials. The **potentials from forestry** and **from residues** are stable throughout Europe for the medium term (around

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[42] EU member states as of 01/01/2005 as well as Bulgaria, Romania and Turkey

7,500 PJ p.a. in the EU-28 countries) and can be realised in the short term; there are large potentials in Northern and Central Europe.

On the other hand, the **potentials from agriculture** are increasing markedly, due to agricultural yield increases and the corresponding release of land. Here, the following effects can be expected:

- The **degree of increase** will be decisively determined by the economic framework (crude oil price, CO_2 allowance price, feed-in tariff for bioelectricity, the shape of payments within the scope of the CAP, etc.) as well as by the development of ecological farming, conservation objectives, etc. This primarily applies to France, Spain, Germany, Poland, and Hungary. The energy crop potentials for 2020 were, depending on the assumed framework, between 2,600 and 7,800 PJ p.a., with 75% provided by the EU-15. The nature of development in the EU-10 is comparatively uncertain, so that for example in the event of an accelerated adjustment of agricultural production, but also in the event of insufficient competitiveness in the food sector, the energy crop potential in these countries may turn out to be considerably higher.

- Upon retention of the European **cultivation structure**, cereals offer the highest energy crop potential. Similar yields can be expected when substituting cereals with perennial crops, yet with different economic and ecological effects. Ecologically advantageous cultivation systems are also conceivable in the area of wet biomasses. The cultivation of energy rapeseed is as yet only of significance in Germany. In the European crop mix, rapeseed and sugar beet play only a minor role, although comparatively significant changes (strongly increasing or fundamentally uncertain demand) are possible.

- European energy crop potentials are not directly influenced by the **world food situation**, yet in the coming years changes can be expected on the agricultural markets, which may have indirect effects on the agricultural biomass potentials in Europe.

If the potential land area which is becoming available is not used for energy crop production, the likelihood that this land will be kept in the agricultural production system is slim. This would have considerable consequences for the agricultural sector, and for rural development prospects.

At present, the **demand for bioenergy** in the EU-28 is around 2,600 PJ p.a., and can be increased to over 8,000 PJ p.a. by the year 2020 if suitable energy policy instruments are established. Much like the supply of bioenergy sources, it is largely determined by the EU-15 countries, and here indeed by a sub-group (Germany, France, Italy, Great Britain, and Spain). Europe-wide trade, for which approximately one third of biomass is suitable, can contribute to meeting the demand. There are also particularly economical possibilities for biofuels.

When connecting supply, demand, and utilisation technologies in use scenarios, the following effects are noticeable:

- To some extent, the **market establishment** of biomass utilisation technologies is yet to come. The speed with which this can occur depends on system output, infrastructure requirements and fossil energy sources substitution potential; indeed, very high growth rates may become evident in a very short time, especially in the fuels sector. In the next 10 years, the supply of petrol substitutes (bioethanol) will clearly overtake the supply of diesel substitutes (biodiesel).

- If prospective technologies are available, which can convert manifold resources into all forms of final energy sources, the support measures for bringing them onto the market must include **decision criteria** to allow optimal allocation of the limited resources. Here, less attention needs to be paid to the application of the technologies to the final energy sources, than to the system design (e.g. CHP in power generation). The importance of this factor becomes greater still, if the supply of biomass proves to be more limited.

- With the biomass potentials available in Europe, a 6,000 – 8,500 PJ p.a. **contribution to the final energy supply** can be achieved by 2020. Upon simultaneous implementation of the objectives of energy policy, environmental policy and nature conservation policy, a clear demand for imports of biomass into Europe, of a magnitude of 1,000 – 1,500 PJ p.a., can be expected as of 2020, which primarily applies to the EU-15 countries.

- With regard to the greenhouse effect and production costs, the **economic-ecological analysis** detected no notable effects caused by biomass trade flows within Europe. Nevertheless, import of bioethanol from Brazil can be seen to be more economical than European production.

At present, European domestic trade, and indeed global **trade**, in the bioenergy sector is insignificant. Various markets may establish themselves in the future, whereby in Europe the trade flows largely depend on the implementation of general nature conservation objectives and political biomass objectives in selected countries (Germany, France, Spain and Poland). The more "unequally" development takes place, the greater the scale of material flows through Europe. The significant markets can be assessed as follows:

- **Biodiesel:** production of rapeseed and RME in Europe may see considerable development in the short term, and establish suitable European markets for the (limited) resources. Additional markets exist outside Europe if required, amongst the globally expanding markets for fats and oils, where strong growth can be seen, particularly for palm oil (Malaysia).

- **Bioethanol:** ethanol production in Europe will most likely see further expansion, and markets will establish themselves. Additional markets exist outside Europe, and may see considerable development in the future (Brazil).

- **Wood and wood products:** considerable quantities can be mobilised at short notice in Germany and in Europe, but have only limited transport-worthiness (energy density). Increased demand for forest wood as an energy source may lead to increased imports of wood for material recycling. The use of wood for energy is dominant around the globe, seeing high growth rates in developing countries. With the availability of BTL technology, increased fuel imports into Europe can be expected (with simultaneous export of technology).

- **Waste wood:** the waste wood markets are already established in Europe; trade flows outside Europe are not expected.

- **Pellets:** the pellet market has considerable short term growth potential, yet it is likely to remain coupled to selected residue resources (also globally).

- **Bioelectricity:** due to limited grid capacities, trade in bioelectricity will only be possible to a limited extent in Europe up to the year 2020.

In conclusion, it can be deduced that the following actions are to be recommended:

In Germany:

- For the further development of biomass, it is important to strive towards a coordinated market introduction strategy for electricity, heat, and fuels, with increased consideration of efficiency and environmental issues.
- Energy crop production, orientated towards diversity, should be supported by a broad spectrum of demand on the one hand, and on the other hand by the establishment of new cultivation systems.
- The further development of power generation from biomass should be more intensely focussed on CHP systems.
- The market introduction of biofuels should correspond to the speed of the release of agricultural land.
- The cooperation between France, Germany, and Poland should be intensified with regard to establishing policy objectives and promotion instruments.

Towards Europe:

- Europe-wide, the framework for energy policy, agricultural policy, and environmental policy regarding biomass use should be synchronised, and move harmoniously towards mandatory biomass activities.
- Much like for Germany, there should be further-reaching consideration of a market introduction strategy for bioenergy, guided by efficiency criteria and environmental criteria (e.g. with regard to the diversity of energy crop cultivation, significance of CHP electricity, speed of expansion in the fuels sector).
- Furthermore, a framework and standards for trade within Europe as well as for imports from outside Europe should be established.

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