Institut für Energetik und Umwelt
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Institute for Energy and Environment

Excecutive Summary

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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Excutive 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 [1]. The studies cover the EU-28 countries [2] 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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[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-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[3]), the European Forest Sector Outlook Study conducted by the UNECE and the FAO (EFSOS[4]), and the Temperate and Boreal Forest Resources Assessment (TBFRA-2000[5]). The forest

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

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

[5] 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[6]). 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.

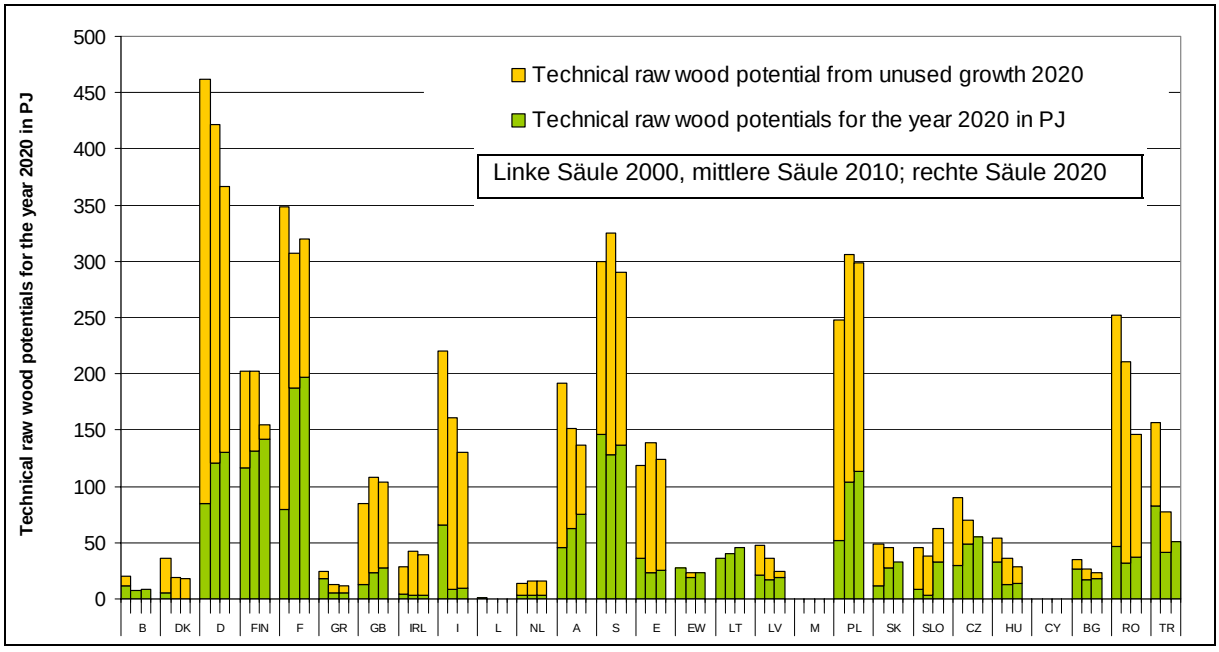

Figure I: Technical fuel potential from forestry in the EU-28 countries (2000 – 2010 – 2020)

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,

6 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

sources in the future.

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 under 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.

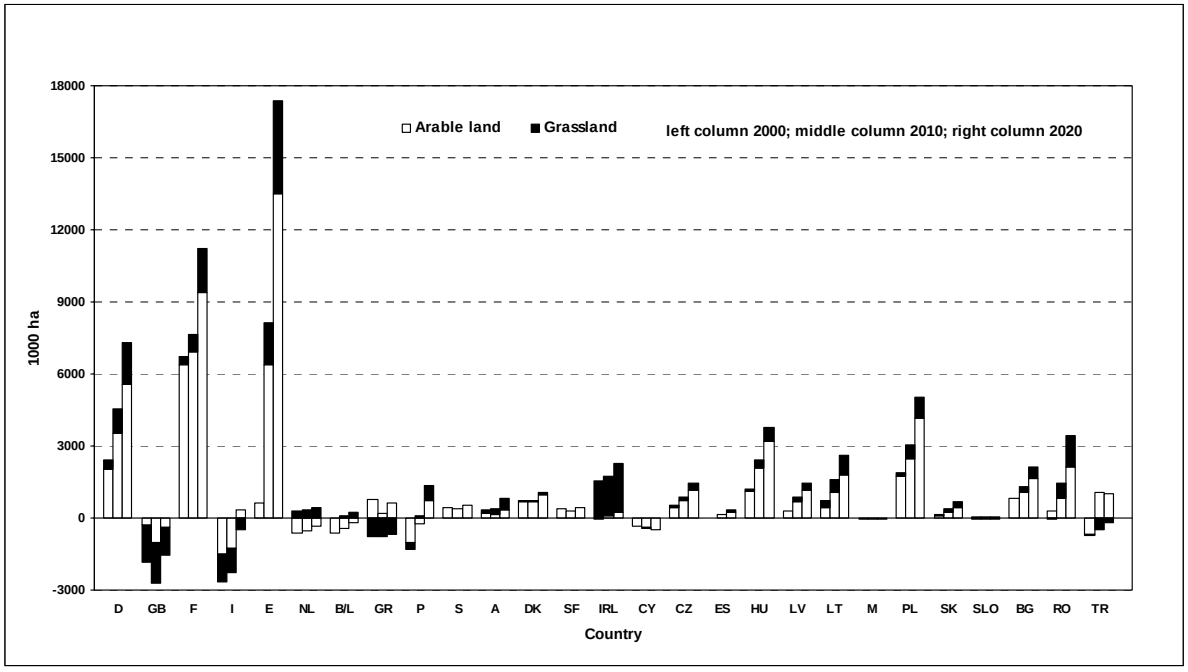

Figure II: Potential of agricultural areas in the EU-28 countries in the CP scenario (2000 – 2010 – 2020)

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.

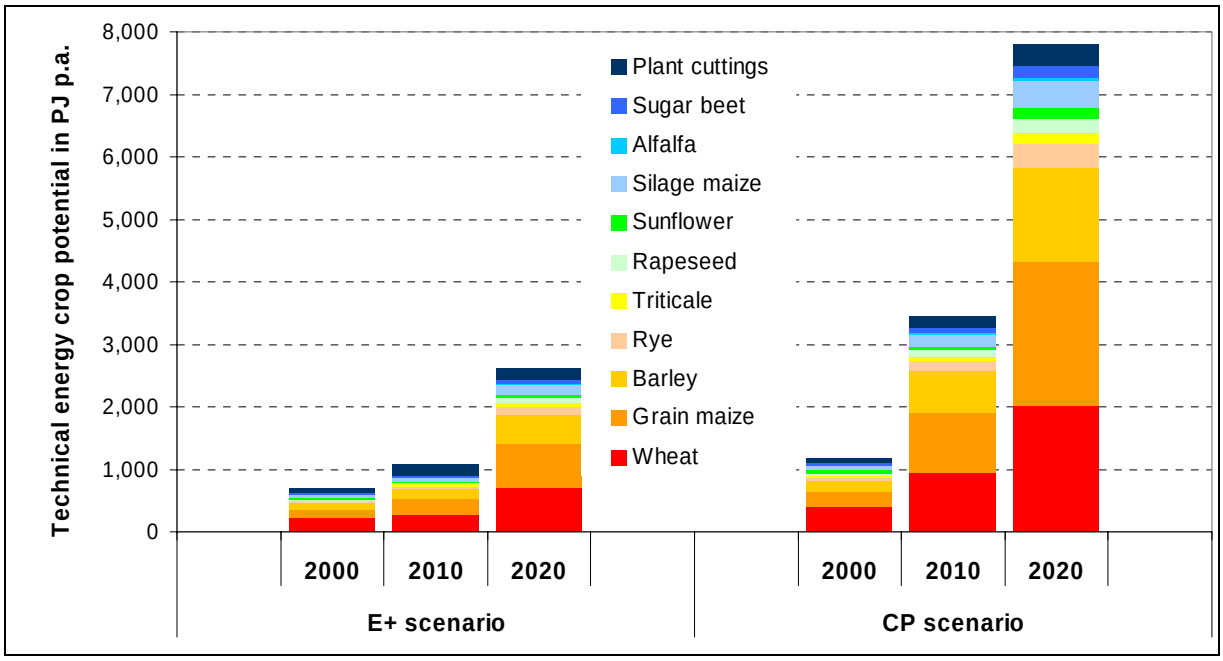

Figure III: Potential for energy sources from energy crops in PJ p.a. for the EU-28 countries in the E+ and CP scenarios

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[7].
- 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.

[7] 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.

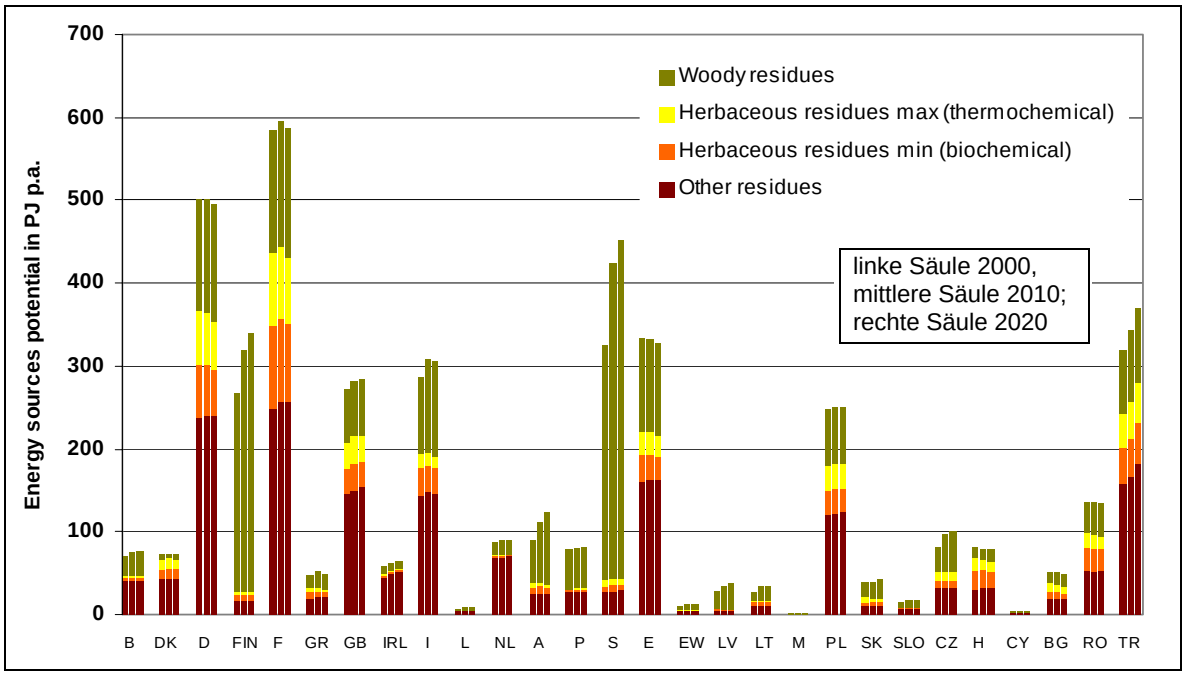

Figure IV: **Energy source potential from residues in the EU-28 countries (2000 – 2010 – 2020) (averages of industrial residues, harvest residues, other agricultural residues and sewage sludge)**

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.

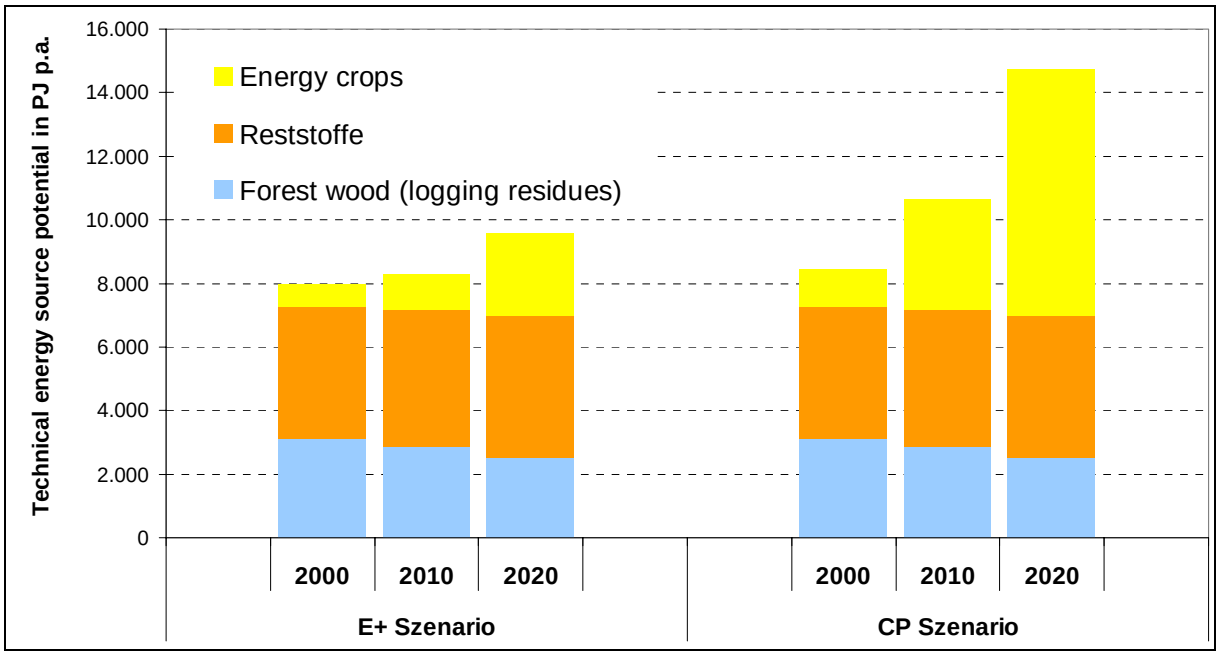

Figure V: Potential for bioenergy sources for the EU-28 countries

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[8] 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

[8] 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.

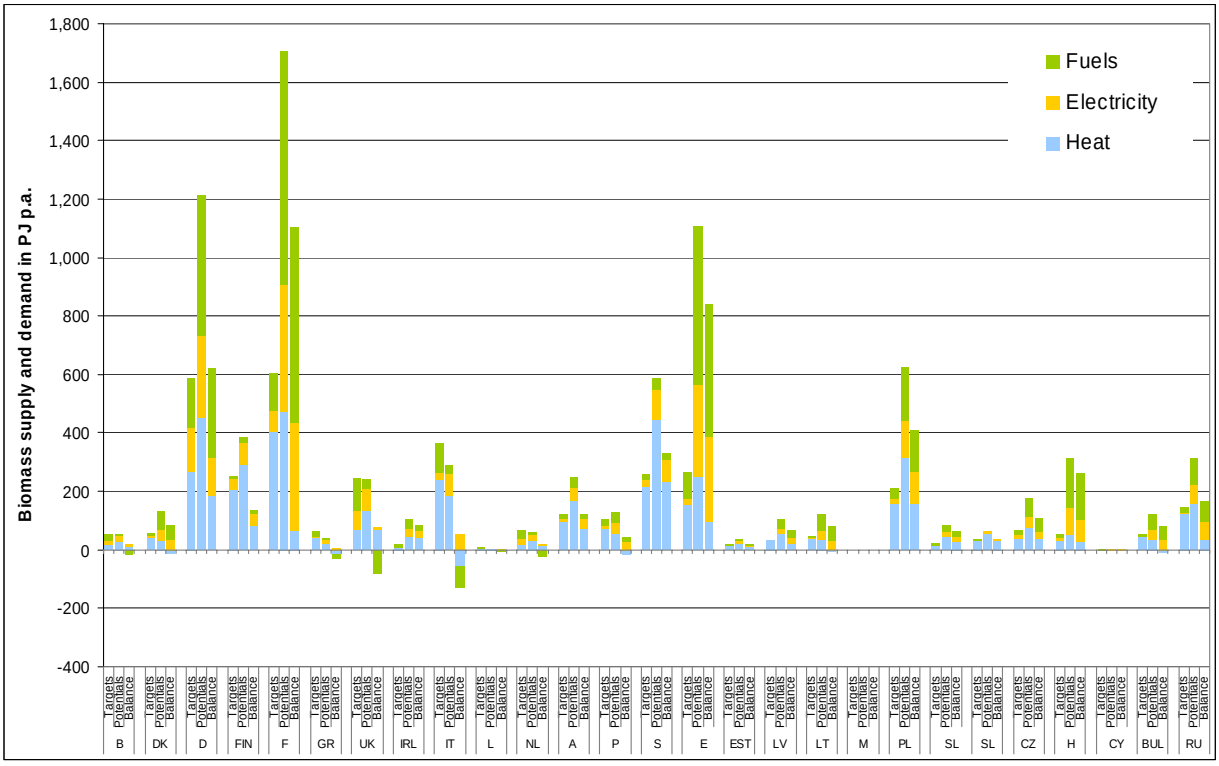

Figure VI: Supply balance for final energy sources in the CP scenario in 2020

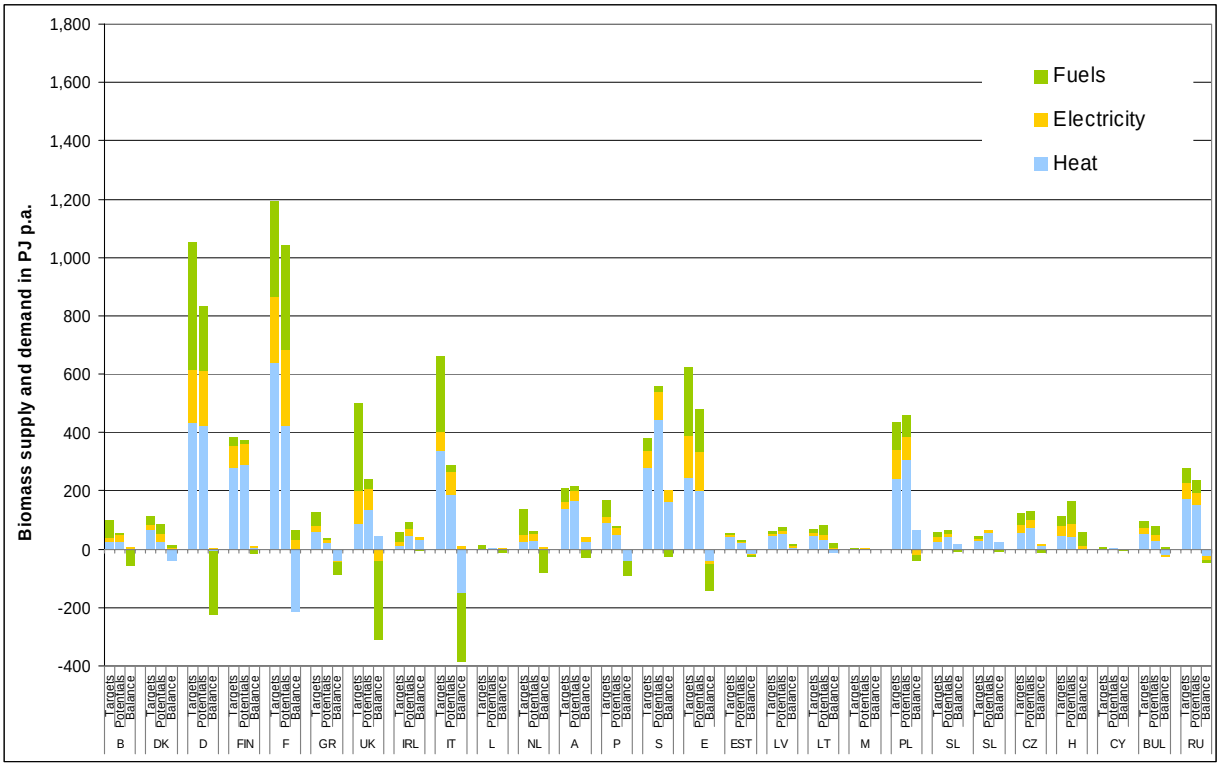

Figure VII: Supply balance for final energy sources in the E+ scenario in 2020

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.

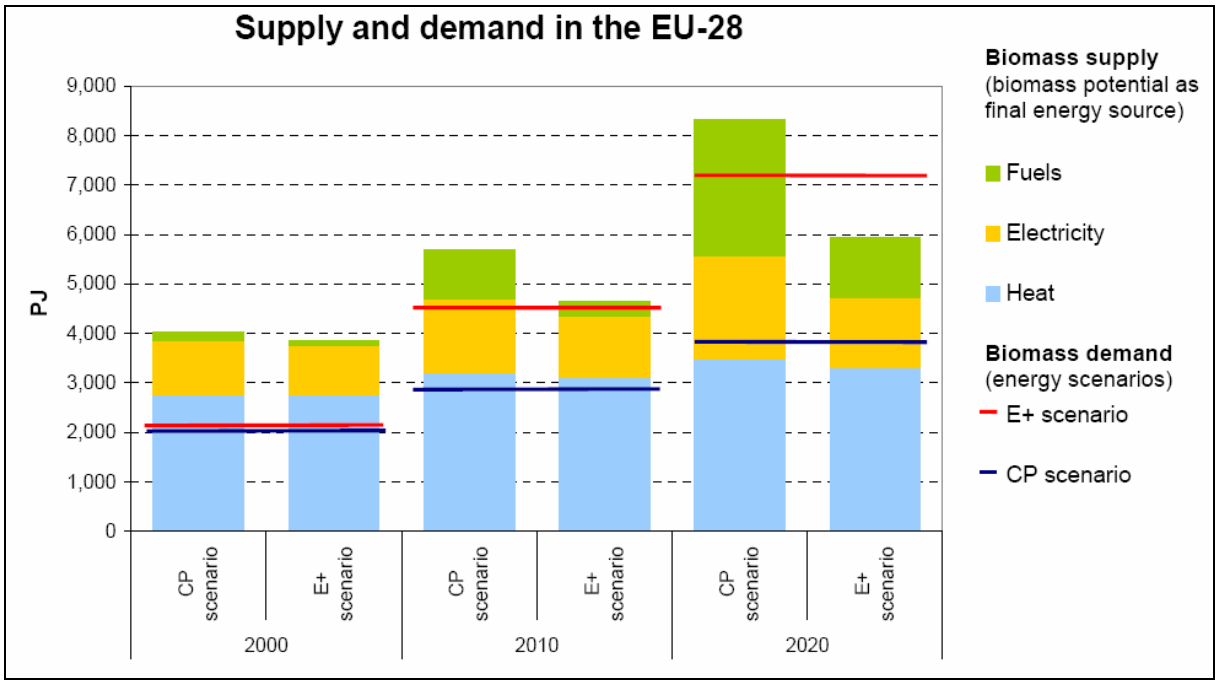

Figure VIII: Supply and demand in the EU-28

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 (GG), expressed in CO2 equivalent units, as well as acidifying air pollutants (in SO2 equivalent units), which are modelled on the basis of the GEMIS computer model[9].

[9] 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).

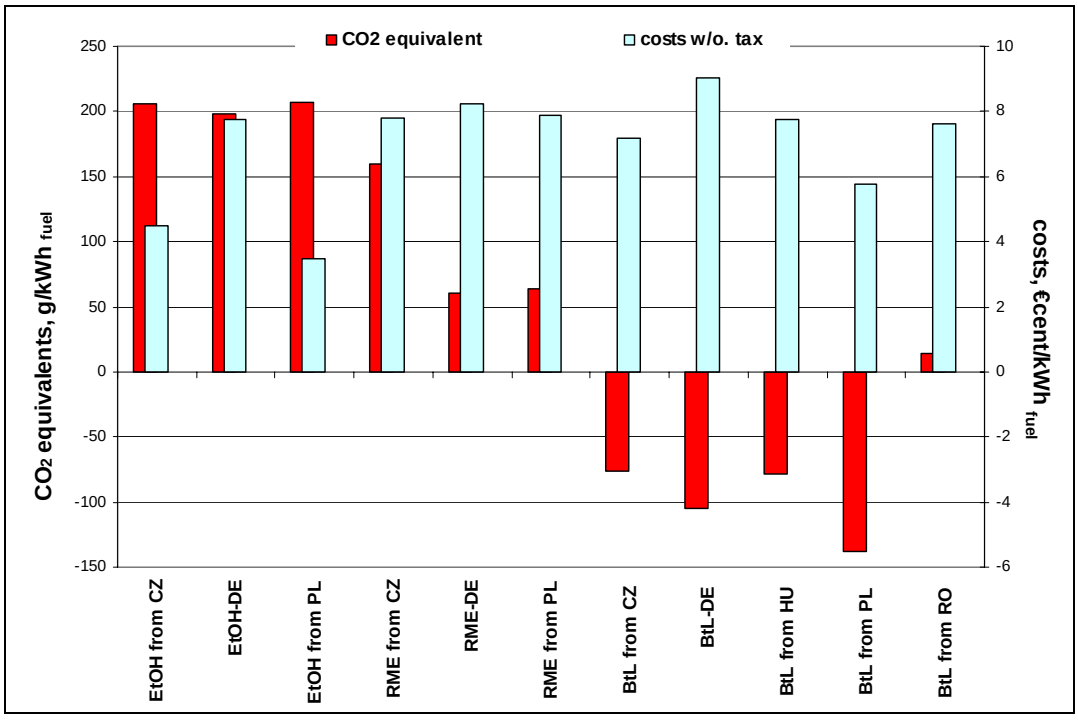

Figure IX: Greenhouse gas and cost figures for biofuel variants in 2020

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.