SRU German Advisory Council on the Environment

# Climate Change Mitigation by Biomass

## Special Report

July 2007

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**German Advisory Council on the Environment (SRU)**

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| | | |
|---|---|---|
| BauGB | = | Baugesetzbuch (Federal Building Code) |
| BBA | = | Biologische Bundesanstalt für Land- und Forstwirtschaft<br>(Federal Biological Institute for Agriculture and Forestry) |
| BBodSchG | = | Bundes-Bodenschutzgesetz (Federal Soil Protection Act) |
| BfN | = | Bundesamt für Naturschutz (Federal Office for Nature Conservation) |
| BHKW | = | Blockheizkraftwerke (micro CHP plant) |
| BImSchG | = | Bundes-Immissionsschutzgesetz (Federal Immission Control Act) |
| BImSchV | = | Verordnung zur Durchführung des Bundes-Immissionsschutzgesetzes<br>(Federal Immission Control Ordinance) |
| BioKraftQuG | = | Biokraftstoffquotengesetz (Biofuel Quotas Act) |
| BiomasseV | = | Biomasseverordnung (Biomass Ordinance) |
| BMELV | = | Bundesministerium für Ernährung, Landwirtschaft und Verbraucherschutz<br>(Federal Ministry of Food, Agriculture and Consumer Protection) |
| BMU | = | Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit<br>(Federal Ministry for the Environment, Nature Conservation and Nuclear Safety) |
| BMWi | = | Bundesministerium für Wirtschaft und Technologie<br>(Federal Ministry of Economics and Technology) |
| BNatSchG | = | Bundesnaturschutzgesetz (Federal Nature Conservation Act) |
| BtL | = | Biomass-to-Liquid |
| BVerfG | = | Bundesverfassungsgericht (Federal Constitutional Court) |
| BVerfGE | = | Entscheidungen des Bundesverfassungsgerichts<br>(decisions of Federal Constitutional Court) |
| BVerwG | = | Bundesverwaltungsgericht (Federal Administrative Court) |
| C | = | carbon |
| C2H4 | = | ethene |
| CARMEN | = | Centrales Agrar-Rohstoff-Marketing- und Entwicklungs-Netzwerk e. V.<br>(Central Agricultural Raw Material Marketing and Development Network) |
| CH4 | = | methane |
| CITES | = | Convention on the International Trade in Endangered Species |
| CO | = | carbon monoxide |
| CO2 | = | carbon dioxide |
| CO2e | = | carbon dioxide equivalents |

| | | |
|---|---|---|
| CP | = | Current Policies |
| DENA | = | Deutsche Energie-Agentur (German Energy Agency) |
| DirektZahlVerpflG | = | Direktzahlungen-Verpflichtungengesetz (Direct Payment Obligations Act) |
| DirektZahlVerpflV | = | Direktzahlungen-Verpflichtungenverordnung<br>(Direct Payment Obligations Ordinance) |
| DLG | = | Deutsche Landwirtschafts-Gesellschaft (German Agricultural Society) |
| DLR | = | Deutsches Zentrum für Luft- und Raumfahrt (German Aerospace Centre) |
| DüngeV | = | Düngeverordnung (Fertilisers Ordinance) |
| DüngMG | = | Düngemittelgesetz (Fertilisers Act) |
| DVL | = | Deutscher Verband für Landschaftspflege<br>(German Landscape Maintenance Association) |
| ECMT | = | European Conference of Ministers of Transport |
| EEA | = | European Environment Agency |
| EEG | = | Erneuerbare-Energien-Gesetz (Renewable Energy Sources Act) |
| EEV | = | Endenergieverbrauch (final energy consumption) |
| EJ | = | etajoule |
| EU | = | European Union |
| EWI | = | Energiewirtschaftliches Institut der Universität zu Köln<br>(Energy Institute of the University of Cologne) |
| FAO | = | Food and Agriculture Organization |
| FFH | = | Fauna-Flora-Habitat (Habitats Directive) |
| FNR | = | Fachagentur für Nachwachsende Rohstoffe<br>(Specialist Agency for Renewable Raw Materials) |
| FSC | = | Forest Stewardship Council |
| FVS | = | ForschungsVerbund Sonnenenergie (Solar Energy Research Network) |
| GATT | = | General Agreement on Tariffs and Trade |
| GfP | = | gute fachliche Praxis (good professional practice (Germany)) |
| GJ | = | gigajoule |
| GmbH | = | Gesellschaft mit beschränkter Haftung (limited liability company) |
| GW | = | gigawatt |
| H2 | = | hydrogen |
| H2O | = | water |
| H2S | = | hydrogen sulphide |

| | | |
|---|---|---|
| ha | = | hectare |
| HCl | = | hydrogen chloride |
| IBS | = | Institut für Bodenkunde und Standortslehre<br>(Institute for Soil Science and Land Evaluation) |
| IEA | = | International Energy Agency |
| IE-Leipzig | = | Institut für Energetik und Umwelt gemeinnützige GmbH<br>(Leipzig Institute for Energy Systems and the Environment) |
| IFEU | = | Institut für Energie- und Umweltforschung Heidelberg GmbH<br>(Heidelberg Institute for Energy and Environment Research) |
| ILO | = | International Labour Organisation |
| IPCC | = | Intergovernmental Panel on Climate Change |
| kg | = | kilogram |
| KrW-/AbfG | = | Kreislaufwirtschafts- und Abfallgesetz<br>(Closed Substance Cycle and Waste Management Act) |
| kt | = | kilotonne(s) |
| KUP | = | Kurzumtriebsplantagen (short-rotation plantations) |
| kW | = | kilowatt |
| kWh | = | kilowatt hour |
| kWhel | = | kilowatt hour electrical energy |
| KWK | = | Kraft-Wärme-Kopplung (combined heat and power – CHP) |
| LCA | = | Life-cycle assessment |
| LfL | = | Bayrische Landesanstalt für Landwirtschaft<br>(Bavarian State Institution for Agriculture) |
| LfU | = | Bayrische Landesanstalt für Umweltschutz<br>(Bavarian State Institution for Environmental Protection) |
| lit. | = | letter |
| LVLF | = | Landesamt für Verbraucherschutz, Landwirtschaft und Flurneuordnung<br>(State Office for Consumer Protection, Agriculture and Land Reorganisation) |
| m. w. N. | = | mit weiteren Nachweisen (with further references) |
| $m^2$ | = | square metres |
| $m^3$ | = | cubic metres |
| MAP | = | Marktanreizprogramm für erneuerbare Energieträger<br>(market incentives programme for renewable energy sources) |
| MELFF | = | Ministerium für Ernährung, Landwirtschaft, Forsten und Fischerei<br>(Ministry of Food, Agriculture, Forests and Fisheries) |
| Mg | = | megagram |

| | | |
|---|---|---|
| mg/l | = | milligrams per litre |
| Mgatro | = | megagram absolutely dry |
| Mio. | = | million(s) |
| MJ | = | megajoule |
| Mrd. | = | billion(s) |
| Mt | = | megatonne |
| MW | = | megawatt |
| MWel | = | megawatt electrical |
| N | = | nitrogen (element) |
| N2 | = | nitrogen (molecule) |
| N2O | = | nitrous oxide (laughing gas) |
| NawaRo | = | Nachwachsende Rohstoffe (renewable raw materials) |
| NawaRo-Bonus | = | (Bonus system for renewable raw materials) |
| NH3 | = | ammonia |
| NOX | = | oxides of nitrogen |
| NuR | = | Natur und Recht (periodical) |
| NVwZ-RR | = | Neue Zeitschrift für Verwaltungsrecht - Rechtsprechungsreport (periodical) |
| OECD | = | Organisation for Economic Cooperation and Development |
| ORC | = | Organic Rankine Cycle |
| PCB | = | polychlorinated biphenyls |
| PCDD/F | = | polychlorinated dibenzodioxins and -furans |
| PCT | = | polychlorinated terphenyls |
| PEC | = | primary energy consumption |
| PflSchG | = | Pflanzenschutzgesetz (Crop Protection Act) |
| PJ | = | petajoule |
| PJ/a | = | petajoule per annum |
| PM10 | = | particulate matter (particles with a diameter of ≤ 10 µm) |
| PO4 | = | phosphate |
| ppmv | = | parts per million (volume) |
| PSM | = | Pflanzenschutzmittel (crop protection agent) |
| RL | = | Richtlinie (Directive) |

| | | |
|---|---|---|
| ROG | = | Raumordnungsgesetz (Regional Policy Act) |
| RSPO | = | Roundtable on Sustainable Palm Oil |
| RWI | = | Rheinisch-Westfälisches Institut für Wirtschaftsforschung<br>(RWI Essen – scientific research institution) |
| SG | = | Sondergutachten (special report) |
| SO2 | = | sulphur dioxide |
| SRU | = | Sachverständigenrat für Umweltfragen<br>(German Advisory Council on the Environment) |
| t | = | tonne(s) |
| THG | = | Treibhausgas (greenhouse gas) |
| TJ | = | terajoule |
| TS | = | Trockensubstanz (dry matter) |
| TUM | = | Technische Universität München (Technical University of Munich) |
| Tz. | = | Textziffer (Item – numbered text block) |
| UAbs. | = | Unterabsatz (sub-paragraph) |
| UFOP | = | Union zur Förderung von Energie- und Proteinpflanzen<br>(Union for the Promotion of Energy and Protein Crops) |
| UNCTAD | = | United Nations Conference on Trade and Development |
| UNEP | = | United Nations Environment Programme |
| UNFCC | = | United Nations Framework Convention on Climate Change |
| VGH | = | Verwaltungsgerichtshof (Administrative Court of Justice) |
| VO | = | Verordnung (Ordinance) |
| WBGU | = | Wissenschaftlicher Beirat der Bundesregierung Globale Umweltveränderungen<br>(Federal Government's Scientific Advisory Council on Global Environmental Change) |
| WI | = | Wuppertal Institut für Klima, Umwelt und Energie<br>(Wuppertal Institute for Climate, Environment and Energy) |
| WTO | = | World Trade Organisation |
| WWF | = | World Wide Fund for Nature |
| YLBH | = | Indonesian Legal Aid Foundation |

# 1 Introduction

**1.** Certainly since the latest assessment report by the Intergovernmental Panel on Climate Change (IPCC 2007), climate change mitigation has become not only by far the most important issue in environmental policy, but also a central challenge for the community of nations. Besides massive improvements in energy efficiency, the use of renewable energy sources to replace fossil fuels will make a major contribution to answering this challenge. To this end, the European Union (EU) plans to step up the proportion of primary energy consumption accounted for by renewables to 20 % by the year 2020. In April 2007 the German government confirmed its commitment to meeting this target, stating that by 2020 some 14 % of the energy used in heat production, 17 % used for motor fuel and 27 % used in electricity generation was to come from renewable energy sources. With a share of 70 %, biomass is the most important fuel among the renewable energy sources. In view of the German government's extremely ambitious targets, there will be a very sharp increase in the use of biomass.

It is an undisputed fact that among the renewable energy sources, biomass offers great potential for climate change mitigation. The German Advisory Council on the Environment (SRU) therefore welcomes the fact that the EU Commission and the German government attach great importance to such possibilities in the context of an ambitious climate strategy.

Nevertheless, the fact that increased use of biomass for energy production is so plausible does not rule out the possibility of undesirable developments. It could even encourage a thoughtless or irresponsible approach to the issue, reflected in notions of 'inexhaustibility' and unlimited availability The widespread impression that biomass will permit climate-friendly replacement of a large proportion of fossil raw materials in the foreseeable future is scientifically untenable. The ambitious plans for expansion of biomass utilisation and the associated potential for misguided developments have prompted the SRU to issue this special report.

Among other things, undesirable developments could arise from the fact that the expansion of bioenergy is determined by three central political concerns with differing prospects of implementation: Besides climate mitigation, the main considerations are the promotion of rural areas and the security of fuel supplies. These basic goals are legitimate and frequently generate positive synergies.

It is nevertheless possible for conflicts of objectives to arise between agricultural, energy and climate policy, and these may in particular be reflected in the parallel existence of multiple uncoordinated funding instruments. One aspect missing from these funding instruments is orientation to a paramount objective that is intended to be the deciding factor in the event of conflicts of objectives. Without such a paramount objective, it is almost impossible to imagine an integrated biomass strategy with goal-oriented use of funds and optimised utilisation of the scarce resource of biomass. In view of the threat that climate change poses for our very existence and the efficiency benefits of such use of biomass, priority should be given to climate change mitigation (Chapter 5).

It should be noted that biomass utilisation is subject to definite limits imposed by the available potential. Numerous studies indicate that nationally produced biomass as a percentage of German primary energy requirements can be increased from the present 5 % to a maximum of 10 % by 2030. In view of the political targets, such as admixture of biofuels, there is a clear need to import biomass, both from EU states and from overseas (Chapter 2). The admixture target of 6.75 % by 2010 will in itself tie up the entire area available for renewables until then.

Massive expansion of bioenergy gives rise to increased risks to soil, water and biodiversity. This can put a different perspective on the existing and assumed environmental advantages of biogenic energy sources (Chapter 3). At both national and international level, therefore, biomass production and use must be designed to ensure protection of the natural basis for life. They should satisfy the criteria of robust sustainability (Chapter 4).

There is a need for 'guard rails' and concrete standards at national and international level, in order to prevent negative impacts on production and use. Basically such standards are the same as for the production of food and animal feeds. To this end the existing national environmental standards contained in the best-practice provisions of national legislation and in EU cross-compliance requirements must be implemented in a determined manner and advanced where appropriate. But appropriate standards for biomass-specific impacts are also necessary.

Standards are necessary at international level in particular to limit the environmental risks. Private-sector certification systems are already offering important conceptual approaches. They must however be developed into viable standards and incorporated in binding conventions under international law. This involves a lengthy negotiation process, which must therefore be initiated without delay.

Such multinational conventions are clearly the solution of choice. In addition – in the event of failure of such conventions – there are unilateral means of setting standards and implementing them in accordance with WTO rules (WTO – World Trade Organisation).

Not only the environmental, but also the social impacts of biomass production have to be taken into account. At national level these are not serious. At international level, however, there are many reasons for concern, especially as regards changes in the living conditions of the poorer sections of the population in the relevant countries. On the other hand, expansion of demand for biomass generates additional sources of income.

It is also necessary to investigate which of the various usage paths – electricity, heat or motor fuel – can make the best and most efficient contribution to mitigating climate change. It is not an optimal strategy if the motor fuel sector – and hence the usage path with the lowest relative efficiency – receives the greatest assistance. This results in biomass applications with greater climate mitigation potential remaining unused. In future, therefore, criteria of climate-friendliness, energy efficiency and cost-effectiveness should have a more decisive influence on the development and use of biomass (Chapter 6).

In its special report, the German Advisory Council on the Environment recommends a concept comprising not only environmental requirements for biomass production, but also a bioenergy expansion approach that is optimised for climate change mitigation. Targeted funding of the market introduction of technologies for energy recovery from biomass with the priority objective of promoting climate change mitigation is therefore justified until these technologies are sufficiently well developed for the market. In the long term the SRU recommends the adoption of an over-arching strategy, if possible with an integrated emissions trading system at the primary trade level which also embraces bioenergy.

# 2 Biomass use, demand and supply

## 2.1 Biomass and possible basic uses

**2.** Biomass for recovery of energy and material can be produced by growing renewable raw materials, but it also occurs in the form of biogenic waste. Table 2-1 provides an overview of biogenic raw materials and biogenic waste (see also Table 2-5).

The biomass use chain encompasses production and supply of the raw materials, various treatment stages, and subsequent use. Figure 2-1 shows the biomass supply chain and the two usage paths for energy and materials. Use for materials is concerned with the supply of power, heat and electricity, whereas substance-oriented applications result in products for use in their material form. Since the two usage paths make use of essentially identical raw materials, a situation of competition exists between them. In the case of agricultural raw materials there is also inevitably competition between these two usage paths and the production of food and animal feeds.

The main focus of this report is on biomass utilisation for energy. Only a brief explanation of its use for materials is provided below. On a very long-term perspective, however, use for materials should be given preference over use for energy. At least equally favourable treatment for material use should be given, since biogenic raw materials are the only substitute for fossil resources for use as raw materials. By contrast, energy from fossil fuels can be replaced by other forms of renewable energy.

Table 2-1

**Overview of origins of biomass**

| Renewable raw materials | Biogenic waste |
|---|---|
| - Energy crops (e.g. maize, rape, sugar beet, grasses, grain, sunflower, poplars, willows etc.)<br>- Biogenic raw materials for materials recovery (oil crops, fibre crops, starch crops)<br>- Pasture vegetation<br>- Forest wood | - Agriculture: Crop residues (straw), slurry etc.<br>- Forestry: Smallwood, residual wood from forestry etc.<br>- Timber and paper industry: Waste wood, paper sludge etc.<br>- Landscape maintenance: Green and woody prunings etc.<br>- Animal carcass disposal: Slaughter waste, animal fats etc.<br>- Food and luxury food industry: Potato slops, brewer's grains, molasses, marc<br>- Waste management: Biogenic component of residual waste, food waste, landfill gas from landfill sites<br>- Wastewater management: Sewage sludge, sewage gas |

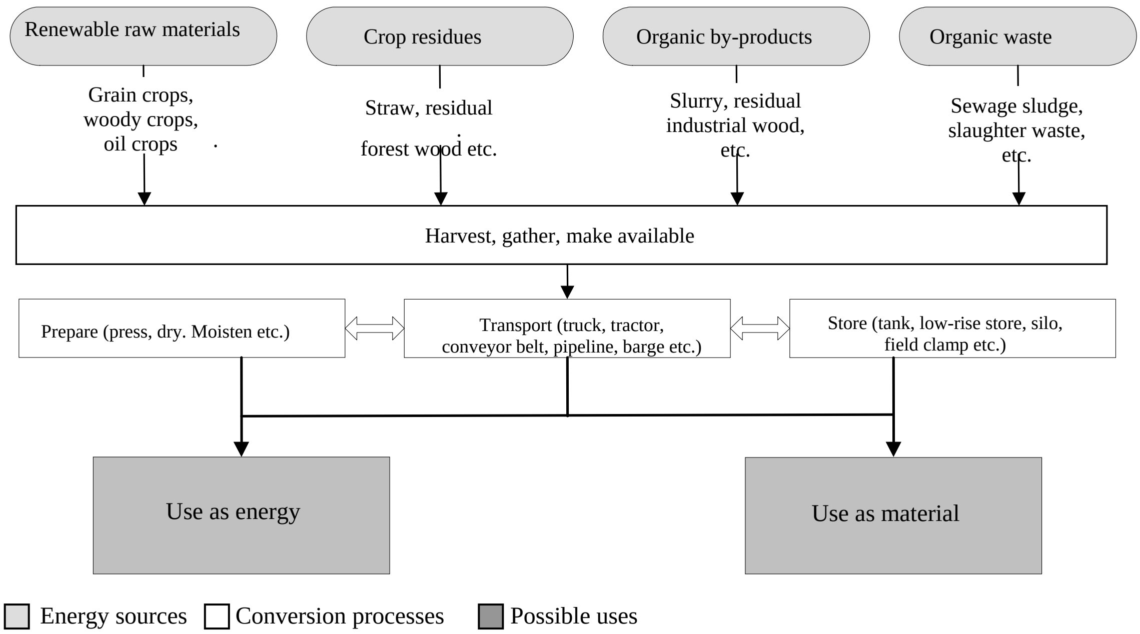
SRU/SG 2007-2/Table 2-1; data source: KALTSCHMITT and HARTMANN 2002; KNAPPE et al. 2007

### 2.1.1 Use for energy

**3.** There are many ways for energy supply from biomass. In principle, the possibilities are physicochemical processes, such as pressing and extraction, biochemical conversion processes (enhancement processes using micro-organisms, e.g. to produce ethanol or biogas), and the thermochemical processes pyrolysis, gasification and combustion (KALTSCHMITT and HARTMANN 2001). Figure 2-2 shows the various conversion pathways. Apart from direct incineration and aerobic degradation, all processes output gaseous, liquid or solid fuels. Depending on the purpose, these are also burned in furnaces, engines, turbines or – in future – fuel cells. This means that biomass can be used to replace all forms of energy (heat, electricity and motor fuels). Another advantage of biomass compared with other renewable energy sources is the fact that the good storage properties of biomass and of the resulting biofuels permit flexible supply of the required energy, in terms of both time and place (KALTSCHMITT and HARTMANN 2001; 2002; FNR 2005b).

Figure 2-1

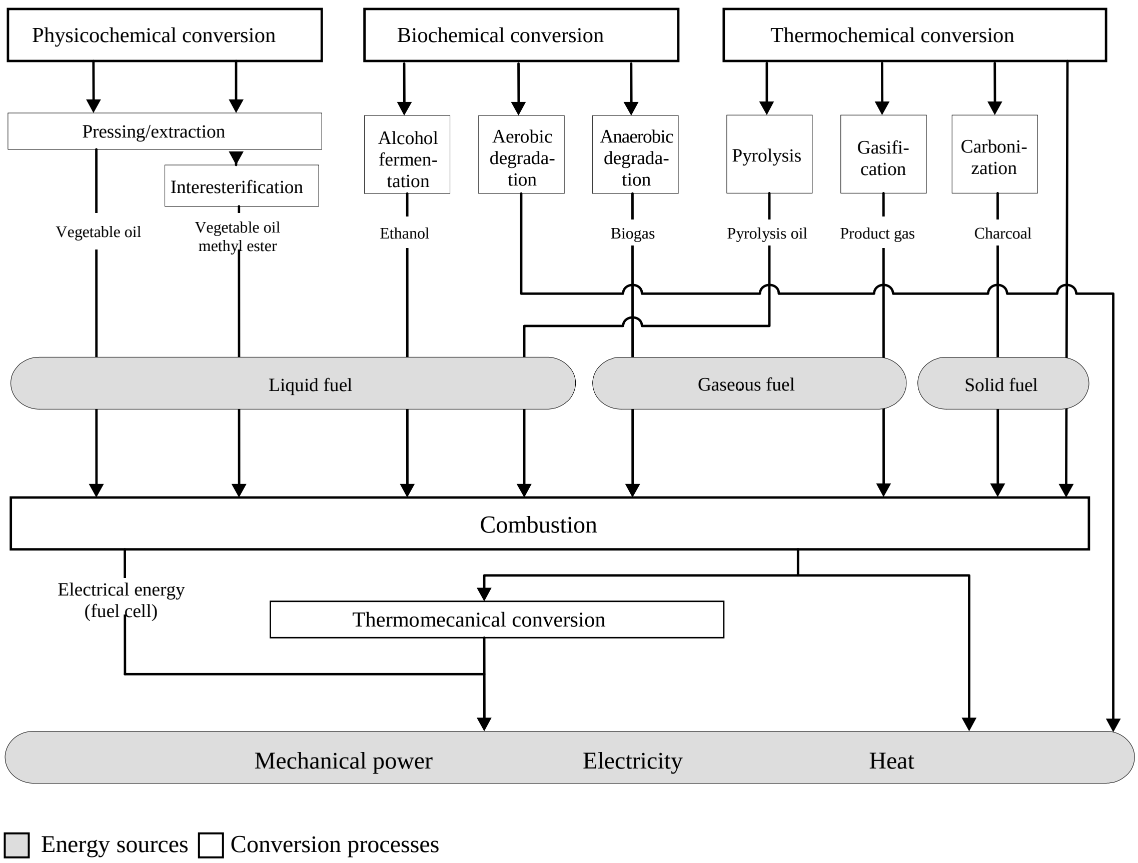
**Supply chains and possible biomass use**




SRU/SG 2007-2/Fig. 2-1; data source: KALTSCHMITT and HARTMANN 2001

Figure 2-2

**Pathways of producing energy from biomass**




SRU/SG 2007-2/Fig. 2-2; data source: KALTSCHMITT and HARTMANN 2001

Physicochemical conversion processes are used to produce liquid energy sources or motor fuels. The simplest way of obtaining vegetable oils is by pressing or crushing. Even here, however, a certain amount of treatment is necessary to clean and treat the input materials and the resulting oils. To make it possible to use vegetable oils in engines, it is necessary either to adapt conventional diesel engines or to perform chemical interesterification of the oils to obtain vegetable oil methyl ester (‘biodiesel’), since they differ considerably from conventional fuels with regard to viscosity in particular.

Biochemical conversion processes such as those used in bioethanol or biogas production are based on fermentation processes. From a technological point of view these production processes are relatively simple, though in the case of biogas substantial cleaning of the gas is necessary, depending on the intended use. The gaseous fuel biogas is used mainly to generate electricity in small-scale power stations with combustion engines, and to some extent in combined heat and power (CHP) generation processes. Bioethanol is increasingly being used as a biogenic motor fuel.

Possible thermochemical conversion processes for biomass are pyrolysis, gasification or combustion. In heat production, combustion processes are the standard technology. Electricity from biomass is usually generated in boiler and turbine systems downstream of the combustion unit. Alternative technologies for electricity generation which are still at the testing or development stage are the ORC (organic Rankine cycle) process, the gasification process, the Stirling engine or the open gas-turbine cycle (QUICKER et al. 2004; KALTSCHMITT and HARTMANN 2001). Another possibility using thermochemical conversion is the production of synthetic motor fuels based on biomass (biomass-to-liquid – BtL).

| | |
|---|---|
| - **Explanation of important terms**<br>- **Biomass:** Biogenic residues and renewable raw materials<br>- **Included and excluded biomass within the meaning of the German Biomass Ordinance** | |
| - **Included biomass**<br>(Section 2 Biomass Ordinance) | - **Excluded biomass**<br>(Section 3 Biomass Ordinance) |
| - Plants and parts of plants<br>- Fuels made from plants or parts of plants<br>- Waste and by-products of plant and animal origin from agriculture, forestry and commercial fish production<br>- Biological waste<br>- Gas produced from biomass by gasification or pyrolysis<br>- Alcohols produced from biomass<br>- Waste wood<br>- Vegetable oil methyl ester<br>- Flotsam from water body management and shoreline management and cleaning<br>- Biogas produced by anaerobic fermentation<br>- | - Fossil fuels<br>- Peat<br>- Mixed municipal solid waste<br>- Waste wood with a PCB/PCT content in excess of 0.005 % by weight, mercury content in excess of 0.0001 % by weight<br>- Paper, cardboard, pasteboard<br>- Sewage sludge<br>- Port sludge and other water-body sludges and sediments<br>- Textiles<br>- Animal carcasses not suitable for human consumption<br>- Landfill gas<br>- Sewage gas |

- **Bioenergy:** Energy from biomass

- **Biogas:** Various micro-organisms, mainly bacteria, are involved in the fermentation process which converts biomass into biogas. The process can be broken down into several successive stages that the material for fermentation passes through. The organisms in the individual stages are interdependent and rely on the metabolic products of the preceding stages. Biogas contains 55 to 70 % methane (CH4). Its second main component is carbon dioxide (CO2), and it also contains various minor and trace components, of which hydrogen sulphide in particular (H2S) can cause serious problems in the use of biogas for energy. The calorific value of biogas is – depending on its methane content – between 5.5 and 6.5 kWh/m3N. Biogas as a gaseous fuel is used primarily for electricity generation in small-scale power stations plants in the range 0.1 to 5 MWel, and to some extent in combined heat and power generation. The main focus is on electricity generation because of the limited opportunities for local use of the heat produced. Before being introduced into the natural gas grid or used as a motor fuel, the biogas has to be cleaned, thereby raising its methane content from between 40 and 75 % to over 96 %. This involves removing carbon dioxide (CO2), hydrogen sulphide (H2S), water (H2O), ammonia (NH3), and other components if necessary (FNR 2005a).

- **First-generation biofuels:**

- Vegetable oil fuels: Vegetable oils for use as motor fuels are obtained from sunflower, rape, linseed etc. by means of extraction. Vegetable oil can be used in unchanged form in modified diesel engines. The expeller cake can be used as an animal feed in bull fattening, for example. Owing to technical difficulties, the market for vegetable oil as a motor fuel is very limited. Specifications for rape oil as a motor fuel are defined in the preliminary standard DIN V 51605. Vegetable oils also form the starting point for biodiesel (vegetable oil methyl ester – VOME) (FNR 2005b).

- Biodiesel: Biodiesel is produced by interesterifying vegetable oils with methanol. Today it is firmly established on the German market as a diesel substitute and is standardised in accordance with DIN EN 14214 (FNR 2006a).

- Bioethanol: First-generation bioethanol is obtained by fermenting sugars that occur in plants. In Europe and the USA the main raw materials used for this purpose are wheat, rye, maize and sugar beet. In tropical regions such as Brazil, bioethanol is largely produced from sugar cane. After fermentation with yeast, the resulting bioethanol is concentrated to a strength of over 99 % by volume in three subsequent stages. Slops or solubles are obtained as a by-product. Processing these to produce animal feeds uses about 30 % of the process energy. The situation could be improved by using the residues to produce energy (e.g. via biogas) (WAGNER and IGELSPACHER 2003; SCHMITZ 2005).

- **Second-generation biofuels:**

- Compared with the first generation of biofuels, the second generation has the advantage that it is possible to use not only parts of the energy crops (e.g. fruits containing oil), but also the entire plant including its lignocellulosic structures.

- BtL fuels (synthetic fuels): The first step in producing synthetic fuels from solid biomass is to obtain the ‘synthesis gas’ (mixture of H2 and CO) by thermochemical conversion (gasification), followed by gas purification and conditioning. Hydrocarbons are then synthesized from the synthesis gas by means of catalytic hydrogenation (Fischer-Tropsch (FT) synthesis). Possible products are a diesel-like fuel (FT diesel) or motor gasoline and FT naphtha, methanol or dimethyl ether. BtL fuel is not expected to make a significant contribution to overall motor fuel consumption before 2010 (KAVALOV and PETEVES 2005; DENA 2006; REINHARDT et al. 2006).

- Bioethanol from lignocellulose: The second-generation biofuels include bioethanol from lignocellulose. It is obtained using a microbiological fermentation process which is basically similar to that used in production of first-generation bioethanol. The difference lies in the additional complexity of making the raw materials available for microbiological conversion. To ensure maximum possible conversion of the polysaccharides present in the lignocellulose to bioethanol, ethanologenic micro-organisms are modified using bioengineering techniques (WYMAN 2001; INGRAM et al. 1999). Like the BtL technology, bioethanol production from lignocellulose has been developed to pilot-plant scale, but cannot yet be described as state of the art (IGELSPACHER et al. 2006).

- **Renewable raw materials:** Raw materials from agriculture and forestry that are not used for food or animal feeds, but for producing energy or materials.

- **Short-rotation plantations (SRP):** Production of fast-growing tree species (e.g. willow or poplar and their hybrids) on agricultural land. The harvesting (clear-cutting) intervals for SRPs are between 1 and 10 years. Crop areas may be fertilised and irrigated ready for growing, and weed control during early growth may be ensured by mechanical or chemical means. The rotation periods for such plantations are 20 to 25 years (FNR 2005b).

- **Theoretical potential:** This is based on the physically usable supply of biomass and represents the theoretical maximum (FRITSCHE et al. 2004).

- **Technical potential:** Describes the proportion of the theoretical potential that is capable of being used in view of the current technological possibilities. Its calculation takes account of the available utilisation technologies, their efficiency, site availability (including with regard to competing uses), and ‘insurmountable’ structural, environmental and other non-technical constraints (FRITSCHE et al. 2004). It does not take account of cost-effectiveness criteria.

- **Combustion:** Oxidation of a fuel with the release of energy. To permit high efficiency and low pollutant emissions, the firing technology must be tailored to the specific properties of the biogenic solid fuels. These special properties include in particular their relatively high content of volatile substances, but also their relatively high moisture content and low ash fusion temperature. These factors must be taken into account when designing or selecting combustion equipment. In the case of biofuels, the focus is on solid biogenic woody fuels. The application of solid-fuel combustion systems ranges from small combustion systems with an output of 2 to 30 kW for domestic purposes, through use exclusively for heat production in biomass power plants with an output of 100 MW, and co-incineration for power generation only or combined heat and power generation in coal-fired power stations with an output of 1 GW (performance range figures are for wood. Combustion systems designed specifically for stalk-type fuels reach outputs ranging up to 20 MW) (KALTSCHMITT and HARTMANN 2001; 2002; THRÄN et al. 2005; FNR 2005b).

- **Gasification:** Gasification achieves the maximum possible conversion of biomass to product gas at high temperatures under oxygen-deficit conditions. The product gas consists of the combustible gases CO, H2, plus small quantities of CH4 and higher hydrocarbons, CO2, N2 and steam. Owing to the large proportion of non-combustible components, the product gases have a very low calorific value ranging from 3 to 15 MJ/ $m^3$N. The gas requires purification before use, especially when used in a steam turbine for power generation or in a Stirling engine or indirect-fired gas turbine. One advantage of gasification compared with combustion is the higher electrical efficiency (30 to 40 %). Production of transportable and storable fuels (motor fuel production) may also result in greater added value than is possible with direct combustion (KALTSCHMITT and HARTMANN 2001; 2002).

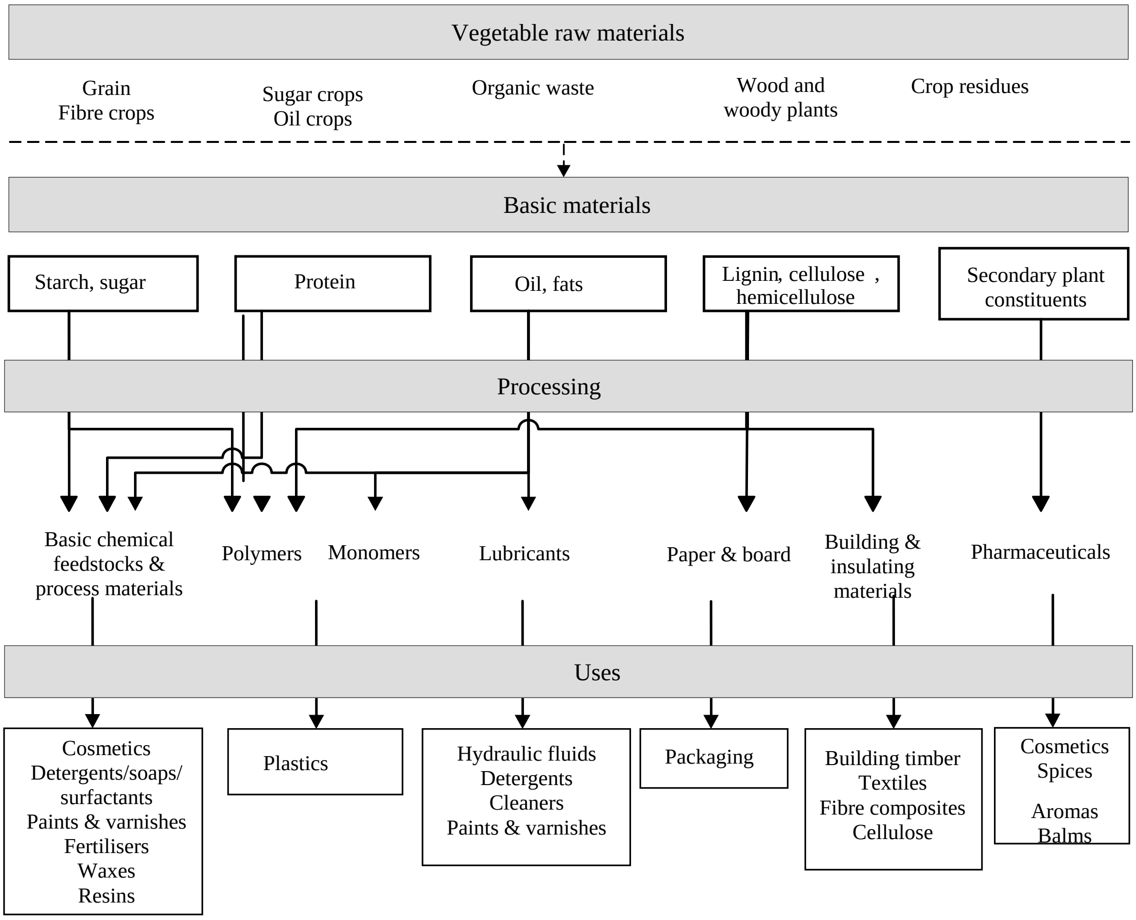
### 2.1.2 Use for materials

**4.** Use for materials offers a greater variety of possible applications than use for energy. A broad spectrum of industries are involved in the use of biomass. These industries include wood processing, building materials and insulation, textiles, paper, and chemicals.

In view of the complex composition of biomass, it makes sense to separate it into the basic materials before embarking on further processing. The basic substances of plant biomass are carbohydrates (starch, sugar, cellulose), lignin, proteins and oils or fats, plus various secondary vegetable substances such as vitamins, colours, flavours and odours of widely differing chemical structure. These basic substances are used to produce basic chemical and process materials, polymers (plastics), lubricants, paper and board, building and insulating materials, and pharmaceuticals. Figure 2-3 shows examples of the biomass utilisation chain in the case of use for material. By contrast with use for energy, the quantity of biomass used is relatively small, with the exception of he wood-processing industry (CARMEN 2004; KAMM et al. 2006; MENRAD 2006; FNR 2006c).

Figure 2-3

**Utilisation chain in the case of use for material**




SRU/SG 2007-2/Fig. 2-3; data source: CARMEN 2004; KAMM et al. 2006; MENRAD 2006; FNR 2006c

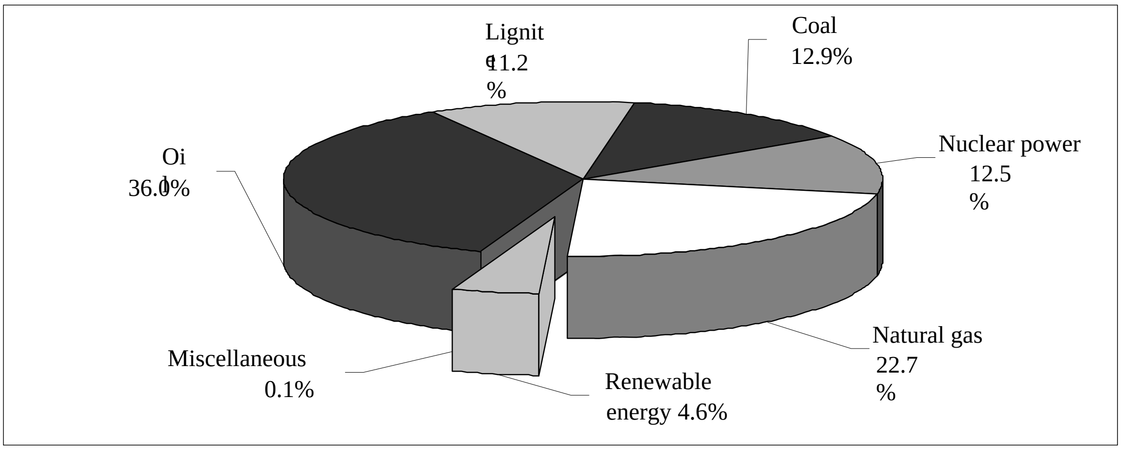
## 2.2. Biomass demand

### 2.2.1 Use for energy

**5.** Primary energy consumption (PEC) in Germany came to 14,236 PJ in 2005 (BMWi 2007). According to current estimates, this demand could fall to between 12,000 and 10,500 PJ/a by 2030 (NITSCH 2007; EWI and Prognos 2006). Primary energy consists of as yet unconverted raw materials such as crude oil, coal and lignite etc. Figure 2-4 shows the structure of primary energy consumption in Germany for the year 2005, broken down by energy sources. As much as 36 % of primary energy requirements is covered by petroleum. The form of energy available for use by the consumer after various conversion operations is known as final energy. Examples of final energy sources are briquettes, petrol, heating oil, electricity etc. The form of energy arising from its use, such as light and heat, is called useful energy. Final energy consumption is only about two thirds of primary energy consumption. In 2005 the figure for Germany was 9,173 PJ/a. This means that energy losses of the order of some 36 % occur during the conversion of primary energy sources to final energy sources (BMWi 2007). Figure 2-5 shows the structure of final energy consumption, broken down by the following consuming groups: trade, commerce and services, households, industry and transport. With the exception of trade, commerce and services, the shares accounted for by these consuming groups are roughly equal, in the region of 27 to 29 %.

Figure 2-4

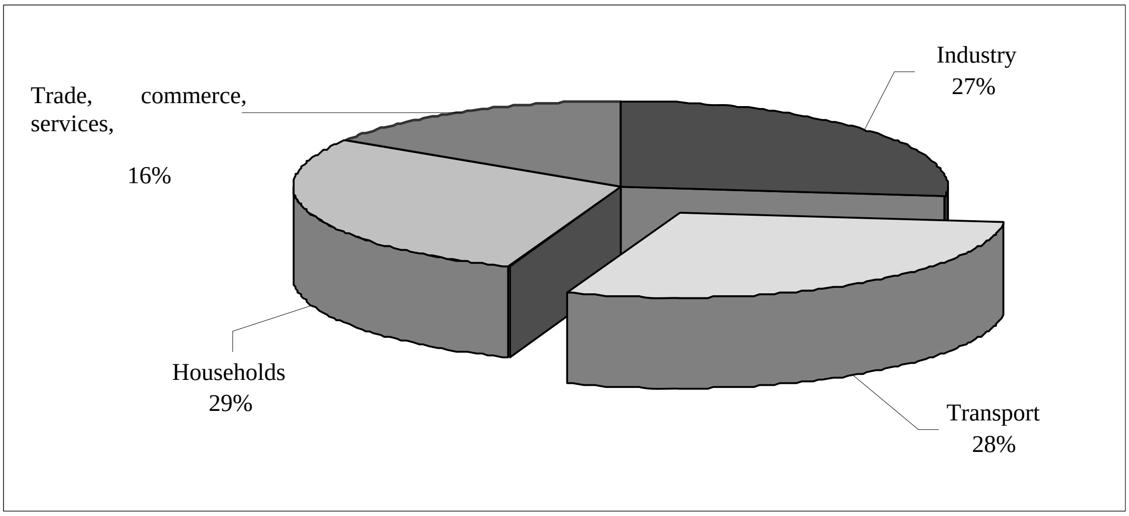
**Structure of primary energy consumption in Germany in 2005 (primary energy consumption (PEC) 14 236 PJ)**




Source: BMWi 2007

Figure 2-5

**Structure of final energy consumption by consuming groups for the year 2005 (final energy consumption 9 173 PJ)**



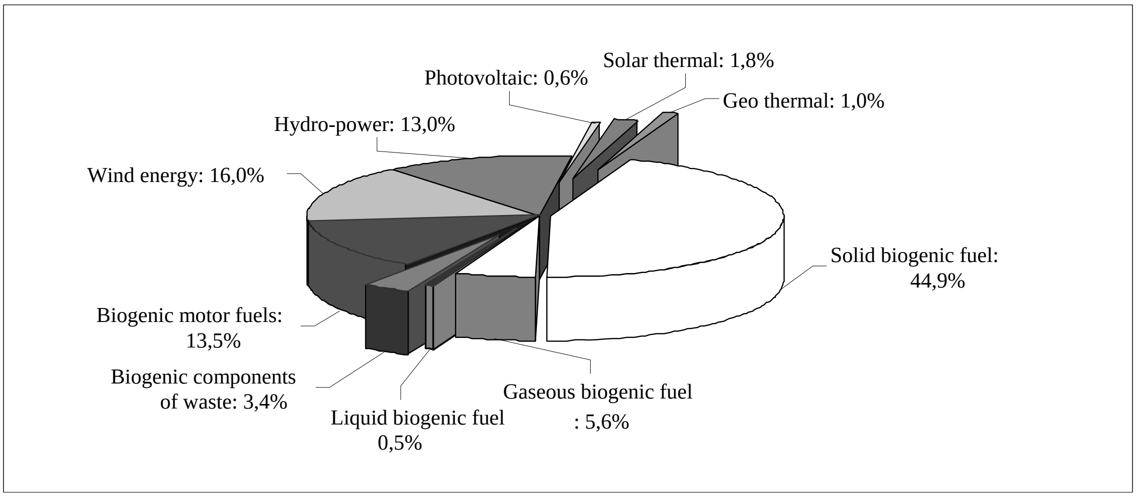

Source: BMWi 2007

**6.** Renewable energy sources covered 4.6 % of primary energy requirements and 6.4 % of final energy consumption in 2005 (BMU 2007b). Latest figures indicate that in 2006 renewable energy sources accounted for 5.3 % of primary energy consumption and 7.4 % of final energy consumption (BMU 2007a). Figure 2-6 shows the shares of final energy supplies in Germany due to the various renewable energy sources in 2005. Biomass accounted for 68 % of the renewable energy sources. In terms of heat supply alone, the share of renewable energy sources due to biomass was as high as 94 % (BMU 2007b). As can be seen from Figure 2-6, solid fuels account for the largest share of biogenic energy sources. Accordingly, bioenergy is the most important component in the renewable energy mix. Forecasts indicate that biomass as a share of the renewable energy mix will remain more or less constant in the future (for the period until 2030) (NITSCH 2007).

Figure 2-7 shows the trend in the share due to renewable energy sources during the period 2000 to 2006 for electricity, heat and motor fuel consumption. It shows that there was a marked increase in the share due to renewable energy sources in 2005 and 2006, especially in the electricity and motor fuel sectors. The saving in fossil fuels resulted from the use of biogenic fuels in the form of diesel substitute (93 %) and substitution of motor gasoline (7 %) (BMU 2007b). In total, bioenergy met 3 % of primary energy requirements (466 PJ) in 2005. Some 60 % of this figure was used to provide heat, 24 % for motor fuel and 14 % for electricity (BMU 2007b). According to forecasts by EWI (Energy Institute of the University of Cologne) and Prognos (2006), the proportion of primary energy consumption met by renewable energy sources could to rise to 15.4 % by 2030. NITSCH (2007) expects that by 2030 as much as 25.1 % of PEC could be covered by renewable energy sources. As far as biomass is concerned, this would mean that its share of primary energy consumption would have to reach between 8 and 18 %.

Figure 2-6

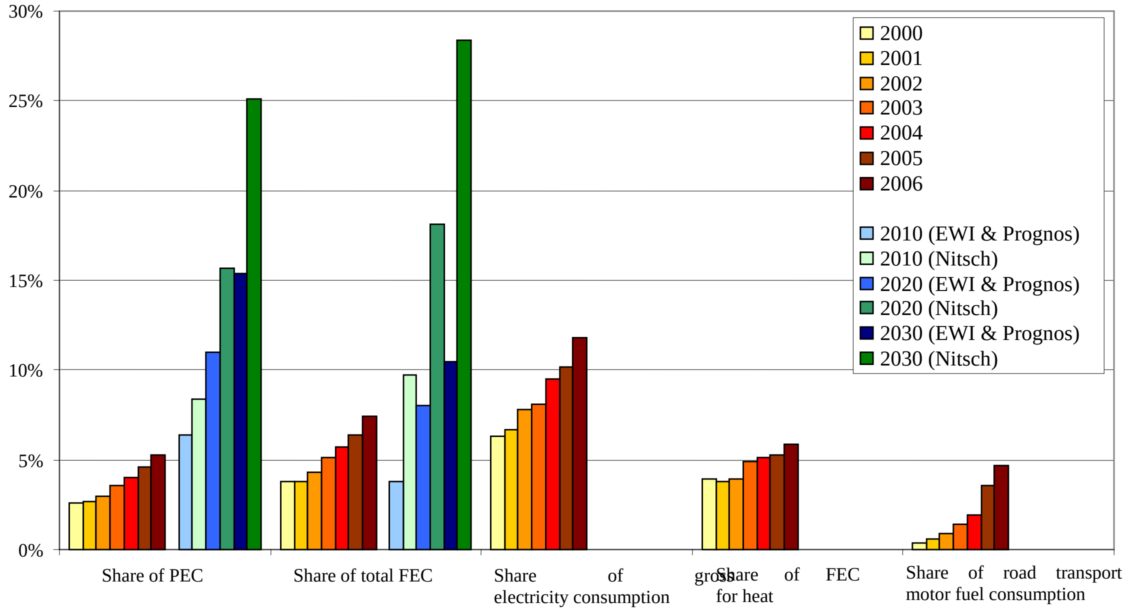
**Structure of final energy supply from renewable energy sources in Germany in 2005**




Source: BMU 2007b

Figure 2-7

**Energy supply from renewable energy sources in Germany during the period 2000 to 2006 and shares of PEC and FEC up to 2030**




PEC = primary energy consumption, FEC = final energy consumption
Data for 2010 to 2030 based on forecasts by EWI & Prognos (2006) and NITSCH (2007)
Source: BMU 2007b; EWI and Prognos 2006; scenario high oil price NITSCH 2007; BMU 2007a

### 2.2.2 Use for materials

**7.** The quantity of renewable raw materials from the agricultural sector that is used for material is relatively small compared with use for energy. Only the share due to use of wood as material (raw material from forestry) is very high at 69 % compared with agricultural raw materials (Table 2-2). Table 2-3 shows the quantities of renewable raw materials used as material.

Table 2-2

**Shares of agricultural and forestry raw materials used for energy and as material**

| Raw material | Share used as material in % | Share used for energy in % |
|---|---|---|
| Wood (forestry) | 69 | 31 |
| Biomass (agriculture) | 8-10 | 90-92 |
| Source: MANTAU and SÖRGEL 2006; FNR 2006c; HIRTH 2004 | | |

Table 2-3

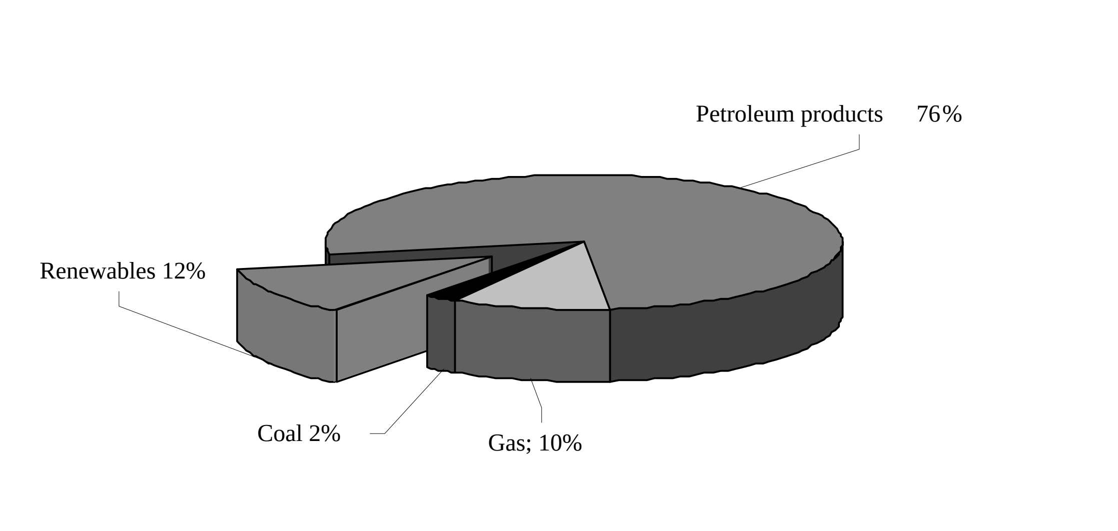
**Overview of quantities of renewable raw materials for use as material**

| Agricultural raw materials | million Mg | Forestry raw materials | million $Mg_{atro}$ |
|---|---|---|---|
| Vegetable oils | 0.8 | Sawmill industry | 15.3 |
| Animal fats | 0.35 | Wood and wood products industry | 0.4 |
| Chemicals and paper starch | 0.64 | Veneer and plywood manufacture | 3.3 |
| Cellulose/chemical celluloses | 0.32 | Paper industry | 2.4 |
| Sugar | 0.24 | Miscellaneous | 1.5 |
| Natural fibres | 0.20 | | |
| Miscellaneous | 0.12 | | |
| Total | 2.7 | Total | 23.0 |
| Note: Total wood felled in Germany 32.6 million Mg, of which 9.9 million Mg used for energy | | | |
| Source: FNR 2006c; KNAPPE et al. 2007 | | | |

Use of agricultural raw materials as material takes place mainly in the chemical industry. Figure 2-8 shows the structure of raw material input in the chemical industry in 2003. According to this, the share due to renewable raw materials comes to 2.3 million Mg. or 12 %. However, the share of petroleum used in the chemical industry, at 15 million Mg. is only around 4 % of total consumption in Germany (ROTHERMEL 2006). Although this makes the chemical industry one of the 'small consumers' of petroleum, the use of this raw material is absolutely essential for production in this branch of industry. Fossil raw materials can only be replaced by biogenic raw materials, whereas energy from fossil fuels can also be replaced by other kinds of renewable energy.

Figure 2-8

**Structure of raw materials input in the chemical industry in 2003**




Total 19.7 million Mg raw materials: 15 million Mg petroleum products, 2 million Mg gas, 0.4 million Mg coal, 2.3 million Mg renewable raw materials

Source: ROTHERMEL 2006

## 2.3 Biomass supply for use as energy

**8.** The available biomass depends partly on the usable biogenic waste and partly on the renewable raw materials that can be produced. Several studies have attempted to forecast the usable potential of biomass available in Germany for use as energy having regard to existing technical and environmental restrictions (technical potential), for the period to 2030.

Generally speaking, potentials are closely connected with framework conditions. Biogenic waste is connected above all with agricultural, forestry and waste management framework conditions such as crop and management forms, competing uses etc., but also with socioeconomic influences such as population development, age structure, environmental awareness, consumer habits etc. Renewable raw materials potential depends especially on the assumptions made in the field of agriculture and forestry (production increases), and also on assumptions about food supply (degree of self-sufficiency) and nature conservation. These framework conditions may change in the course of time. When forecasting potentials for different points in time it is necessary to make various assumptions about the future framework conditions, which give rise to different forecasts about potentials.

**9.** To make it possible to estimate future biomass potential, this chapter will consider the results of the following studies:

- Öko-Institut (FRITSCHE et al. 2004): Material flow analysis for sustainable use of biomass for energy purposes,
- Deutsches Zentrum für Luft- und Raumfahrt (DLR) (NITSCH et al. 2004): Ecologically optimised expansion of renewable energy utilization in Germany,
- Institut für Energetik und Umwelt gemeinnützige GmbH (IE-Leipzig) (THRÄN et al. 2005): Strategies for sustainable biomass use in the European context,
- European Environment Agency (EEA 2006): How much biomass can Europe produce without harming the environment?

The studies by the Öko-Institut and the DLR consider biomass potential in Germany only, whereas the studies by IE-Leipzig and the EEA set out the potential in Germany and at EU level. The following discussion examines the potential in Germany only. Starting from the base year 2000, the three studies determined this for the years 2010 and 2020, and the Öko and DLR studies for 2030 as well.

The individual studies looked at various scenarios. These are set out in Table 2-4. A basic distinction is made between

- a reference scenario that continues the existing trend,
- an environmental scenario designed to take special account of environmental and nature conservation requirements, and
- a scenario aimed at maximising biomass availability.

The Öko-Institut study is the only one to include a reference scenario. The Basic (DLR), Current Policies (CP) (IE-Leipzig) and Biomass (Öko-Institut) studies all focus on maximising the supply of biomass, and are intended to represent an upper limit for biomass utilisation. However, they do not conform entirely to existing legal provisions, especially with regard to nature conservation, for example the obligations of the Laender to create a biotope network in accordance with Section 3 Federal Nature Conservation Act (Bundesnaturschutzgesetz – BNatSchG), with the result that these scenarios overestimate the potential and cannot therefore be regarded as an upper limit as things stand at present. For this reason they should not be taken as a basis for drawing up political objectives with regard to biomass utilisation.

The environmental scenarios Umwelt (Öko-Institut), Naturschutz-Plus (DLR) and Environment+ (IE-Leipzig) take special account of environmental and nature conservation issues. The EEA study (2006) looks exclusively at an environment-oriented scenario. They set out to take account of legal requirements, though this is somewhat doubtful in the case of the Environment+ scenario, since it does not entirely comply with the legal framework conditions either (see Section 2.3.2). More extensive nature conservation demands of the kind formulated by the German Advisory Council on the Environment (SRU) (for example that 5 % of the area under forest in Germany be designated as total reserves, and that in the medium term up to 15 % of the total area of Germany be set aside for nature conservation purposes (SRU 2002, p. 41)), are only partially taken into account in the EEA study, which means that the names Naturschutz-Plus and Environment+ suggest closer attention to nature conservation demands than is in fact assumed in these studies.

All studies indicate a more or less constant potential of biogenic waste up to 2030, though the potential varies depending on the scenario. With regard to renewable raw materials, the various scenarios show great differences in potential. The highly ambitious potentials aimed at maximisation of biomass would appear to be unrealistic, both for biogenic waste and for renewable raw materials, if the legal requirements with regard to nature conservation are to be respected. The following sections provide a detailed consideration of the results of the studies, separately for biogenic waste and renewable raw materials.

Table 2-4

**Overview of the potential studies examined**

| Institution, source | Scenarios | Assumptions |
|---|---|---|
| Öko-Institut (FRITSCHE et al. 2004) | Reference scenario | Continuation of trend with regard to political goals; current nature conservation and environmental requirements are taken into account partially (50 %) for 2020 and completely for 2030 (e.g. land requirements for nature conservation, according to KÖPPEL et al. (2004) some 7 % or arable land must be used for the biotope network) |
| | Environment scenario | Efficiency improvements and expansion of renewable energy sources; current nature conservation and environmental requirements are observed in full from 2020 onwards (see reference scenario) |
| | Biomass scenario | Maximum biomass supply; unlike the above scenarios, only 50 % of current environmental and nature conservation requirements are observed |
| DLR (NITSCH et al. 2004) | Basic scenario | Maximum biomass supply; minimum nature conservation requirements are observed; Starting point for waste potential is the Öko |

| | | |
|---|---|---|
| | | biomass scenario, additions are made for straw, unused forestry wood and landscape maintenance biomass; The starting point for the renewable raw materials potential is the Öko reference scenario, but no compensation areas or nature conservation areas are included; ploughing of pasture is not ruled out (as in other scenarios) |
| | Naturschutz-Plus scenario | Greater attention is paid to nature conservation demands on the basis of current environmental and nature conservation requirements (Section 3 and Section 5 Federal Nature Conservation Act (BNatSchG) – 6 % of agricultural and forestry land is to be used as biotope network; maintenance of or increase in pasture share, but increase in extensive use; open land biotopes, maintenance of coppice and composite forest uses);<br>Here too the starting point is the basic data from the Öko study on current land use, deductions and additions are made for the above mentioned nature conservation requirements |
| IE-Leipzig*<br>(THRÄN et al. 2005) | Current-policy scenario (CP) | Based on current political developments for the promotion of agriculture and renewable energies (existing EU agricultural and energy policy framework conditions for the period to 2020) and on political guidelines for future development:<br>Fallow land is 100 % available for energy crop production<br>Reduction in surplus production to free up land for energy crop production<br>Reallocation of settlement, transport and nature conservation land in accordance with current situation<br>Increases in plant and animal production yields |
| | Environment scenario (E+) | Based on more environment-oriented land use (increased attention to nature conservation requirements) and greater climate change mitigation efforts and funding of renewable energy sources:<br>Only 70 % of fallow land used for energy crop production<br>Reduction in surplus production to free up land for energy crop production<br>Additional reallocation of 2.5 % (2010) and 5 % (2020) of arable land for straight nature conservation purposes without any yield<br>Halving of yield increases for pasture |

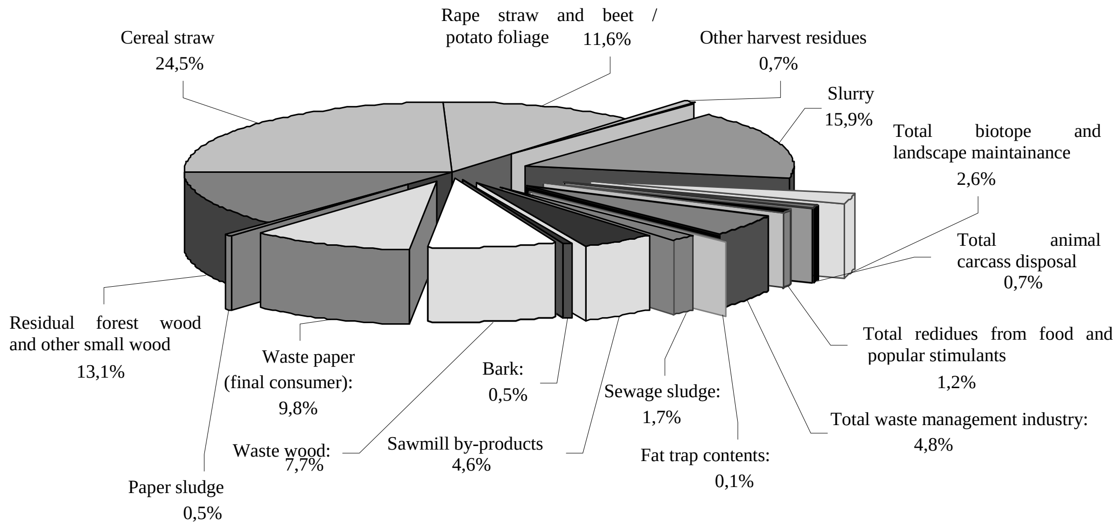
| | | |
|---|---|---|
| EEA<br>(EEA 2006) | No breakdown into scenarios | Framework conditions for agricultural potential:<br>30 % organic farming<br>3 % set-aside of existing arable land<br>Extensively farmed crops such as pasture are retained<br>Use of energy crops with low environmental impacts<br>Framework conditions for biogenic waste:<br>No use of root or leaf material<br>No intensified use of protected forest areas<br>Account taken of site-specific nutrient cycles<br>Additional 5 % of forest area placed under protection<br>Waste minimisation as supreme goal<br>Recycling of waste takes priority over use for energy<br>Biowaste composting discontinued in favour of use for energy<br>Increased organic farming share ties up more agricultural waste such as straw |
| *Distinction between scenarios based solely on agricultural land potential | | |
| SRU/SG 2007-2/Table 2-4; data source: FRITSCHE et al. 2004; NITSCH et al. 2004; THRÄN et al. 2005; EEA 2006 | | |

### 2.3.1 Biogenic waste

**10.** The use of biomass occurring in the waste management industry (within the meaning of the Closed Substance Cycle and Waste Management Act (Kreislaufwirtschafts- und Abfallgesetz – KrW-/AbfG) and as agricultural and forestry waste (outside the scope of the KrW-/AbfG) constitutes an important potential for biomass utilisation. On the basis of data from 2000 to 2002, KNAPPE et al. (2007) calculate a volume of nearly 110 million Mg dry matter per annum (theoretical potential), but the technical potential amounts to only about 65 % (approx. 70 million Mg dry matter per annum) of the theoretical potential (KNAPPE et al. 2007). However, even this technical potential has hitherto only been used to a small extent for energy (LEIBLE et al. 2003). Figure 2-9 and Table 2-5 show this theoretical potential of biogenic waste according to KNAPPE et al. (2007).

Figure 2-9

**Overview of the structure of total biogenic waste**




Source: KNAPPE et al. 2007

Table 2-5

**Theoretical and technical/environmental potential of biogenic waste in Germany**

| | Theoretical potential in 1,000 Mg dry matter/a | % | Technical potential in % |
|---|---|---|---|
| Waste from forestry, wood and paper industries | | | |
| Sawmill by-products | 5,761 | 5.2 | 100 |
| Bark | 647 | 0.6 | 94 |
| Waste wood | 9,680 | 8.8 | 100 |
| Waste paper (final consumers) | 12,330 | 11.2 | 82 |
| Paper sludge | 580 | 0.5 | 100 |
| Residual wood from forestry, miscellaneous smallwood | 16,600 | 15.1 | 75 |
| Total waste from forestry, wood and paper industries | 45,598 | 41.5 | 92 |
| Waste from agriculture | | | |
| Cereal straw | 30,970 | 28.2 | 12 |
| Rape straw and beet/potato foliage | 14,720 | 13.4 | 42 |
| Other harvest residues | 890 | 0.8 | no data |
| Slurry | 20,143 | 18.4 | 91 |
| Total waste from agriculture | 66,723 | 60.8 | 49 |
| Biotope and landscape maintenance | | | |

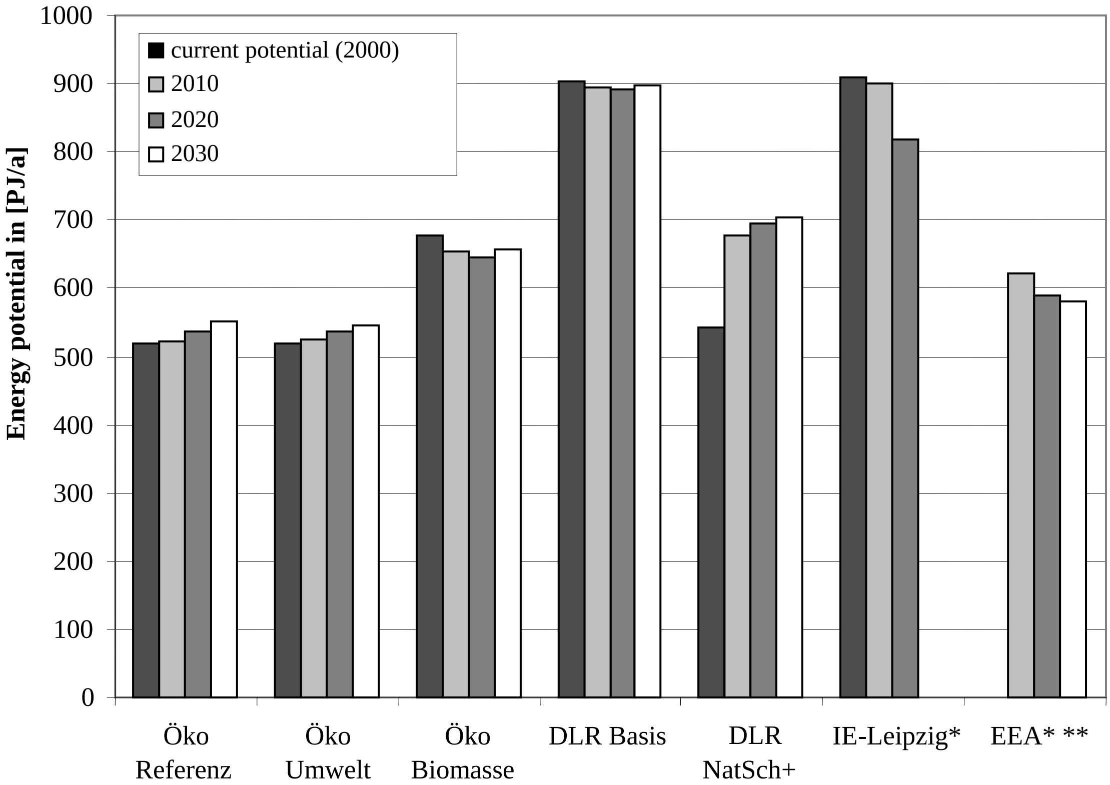
| | | | |
|---|---|---|---|
| Roadside pasture (maximum) | 778 | 0.7 | 56 |
| Private and public pasture (excluding wood) | 638 | 0.6 | 73 |
| Biotope maintenance (maximum) | 1,913 | 1.7 | 50 |
| Total biotope and landscape maintenance | 3,329 | 3.0 | 60 |
| Animal carcass disposal | | | |
| Slaughter waste | 59 | 0.1 | |
| Bone meal | 189 | 0.2 | |
| Animal fats | 284 | 0.3 | |
| Animal meal | 388 | 0.4 | |
| Total animal carcass disposal | 920 | 0.8 | 95 |
| Food and popular stimulants industry | | | |
| Potato slops | 43 | 0.04 | |
| Marc | 63 | 0.1 | |
| Brewer's grains | 700 | 0.6 | |
| Molasses | 720 | 0.7 | |
| Total waste from food and popular stimulants industries | 1,526 | 1.4 | 95 |
| Waste management | | | |
| Waste textiles (quantity collected) | 716 | 0.7 | |
| Food waste | 43 | 0.04 | |
| Household biowaste | 2,400 | 2.2 | |
| Biogenic component of residual waste | 2,844 | 2.6 | |
| Total waste management industry | 6,003 | 5.5 | 95 |
| Wastewater management | | | |
| Grease trap contents | 67 | 0.1 | |
| Sewage sludge | 2,195 | 2.0 | |
| Total wastewater management | 2,262 | 2.1 | 95 |
| Total | 109,761 | 100 | 65 |
| *percentages for technical potential refer to absolute figures for theoretical potential | | | |
| Source: KNAPPE et al. 2007 and own estimates | | | |

**11.** When determining the energy use potential of biomass from waste it is necessary to take account of how this – existing – biomass is already being used. Competing uses, for example material-oriented uses as wood material in the particle board or paper industries or for soil improvement (organic fertiliser, mulching material), reduce the potential for use as energy, but are frequently desirable and environmentally appropriate uses. For example, it is necessary to leave up to 80 % of straw on the fields in the interests of soil conservation (FRITSCHE et al. 2004).

**12.** Figure 2-10 shows the biogenic waste potentials revealed by the various studies and scenarios. The highest figures were determined in the Basic scenario of the DLR study and in the CP scenario of the IE-Leipzig study. For the base year 2000 the technical potential for biogenic waste is given as 523 to 908 PJ/a, or 3.7 % to 6.4 % of present primary energy consumption. From 2000 to 2030, all scenarios describe only minor changes in potential. Depending on the scenario there is an increase or even a slight decrease in potential. In almost all scenarios, an increase in technical potential is assumed in the fields of residual wood, separately collected organic household waste, landscape maintenance material and sewage sludge. The increase in organic household waste is based on the assumption that, in the interests of climate change mitigation, fermentation is regarded as more useful than composting, and priority is therefore given to fermentation of organic household waste (cf. FRITSCHE et al. 2004; NITSCH et al. 2004; THRÄN et al. 2005).

Figure 2-10

**Overview of biogenic waste potentials in potential studies**




*No breakdown into scenarios in the IE-Leipzig and EEA studies.

**No figures for 2000 in the EEA study.

Source: FRITSCHE et al. 2004; NITSCH et al. 2004; THRÄN et al. 2005; EEA 2006

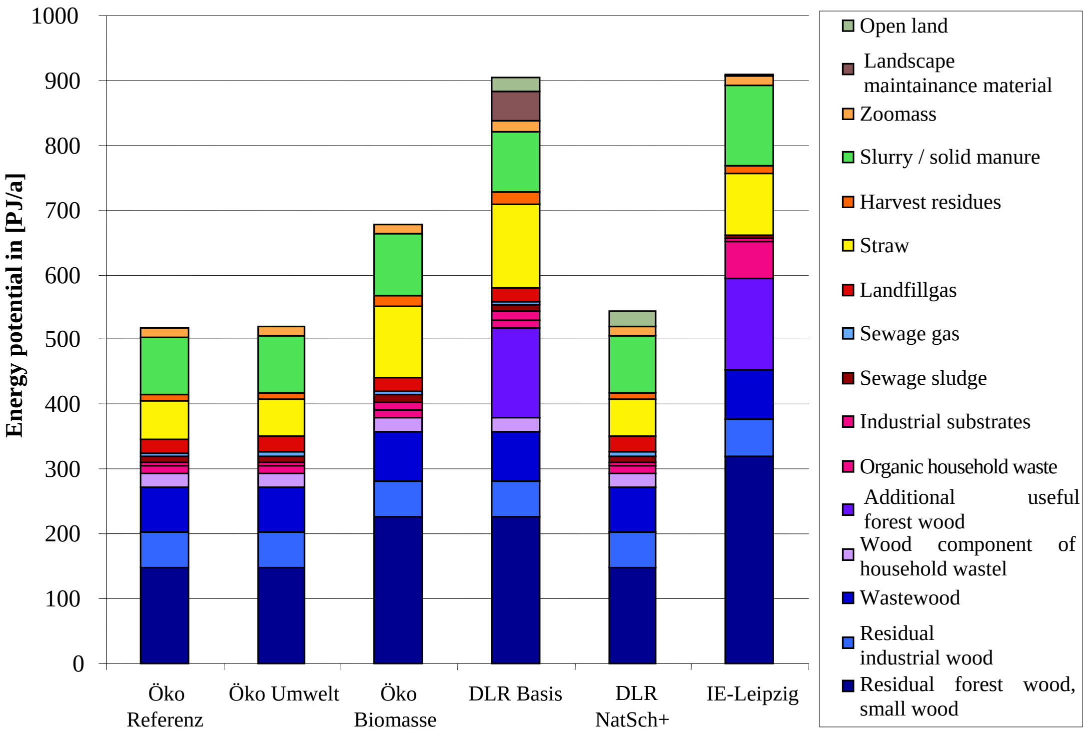
**13.** In Figure 2-11 the biogenic waste potentials are broken down by individual fractions for the year 2000 (except for the potential from the EEA study (2006), where no breakdown was available). The largest share of biogenic waste potential is accounted for by woody waste. This totals at least half, and in the Basic and CP scenarios it comes to over 60 %. In terms of mass, however, the biogenic waste figures in KNAPPE et al. (2007) show greater potential in the field of agricultural biogenic waste. The greater energy potential of woody waste is due to the higher calorific value than agricultural waste, so the data can be taken to agree.

The biggest differences between the studies are to be found in the assumed wood potential. For example, the CP (IE-Leipzig) and Basic (DLR) scenarios, unlike the other scenarios, assume 100 % mobilisation of the residual wood from forestry plus additional usable forestry wood, since these scenarios did not have an exclusive focus on use as material. However, the assumption of 100 % mobilisation seems very questionable, and these higher figures must be looked at in a critical light. Another major difference between the scenarios exists regarding the assumed straw potential. Here too, the CP scenario of the IE-Leipzig study assumes that 100 % of the straw can be made available for use as energy, which seems very dubious for soil conservation reasons. The marked rise between 2000 and 2010 in the Naturschutz-Plus scenario (DLR) is due to landscape maintenance material, where use for energy is not assumed until 2010. As shown in Figure 2-11, the difference between the Reference and Environment scenarios and the Naturschutz-Plus scenario is also due to the use of landscape maintenance material and open land.

However, in view of the lack of adequate information about the framework conditions assumed in the studies, it is hardly possible to discuss the results in more detail. On the whole, the potential figures in the Reference (Öko-Institut), Environment (Öko-Institut) and Naturschutz-Plus (DLR) scenarios and the EEA study appear to be the most realistic, since these scenarios take account of basic environmental and nature conservation requirements and thus indicate the ecological potential for biogenic waste.

Figure 2-11

**Overview of biogenic waste potentials in the potential studies for the year 2000, broken down by individual biogenic waste fractions***




*No breakdown of data from EEA study.

Source: FRITSCHE et al. 2004; NITSCH et al. 2004; THRÄN et al. 2005; EEA 2006

### 2.3.2 Renewable raw materials

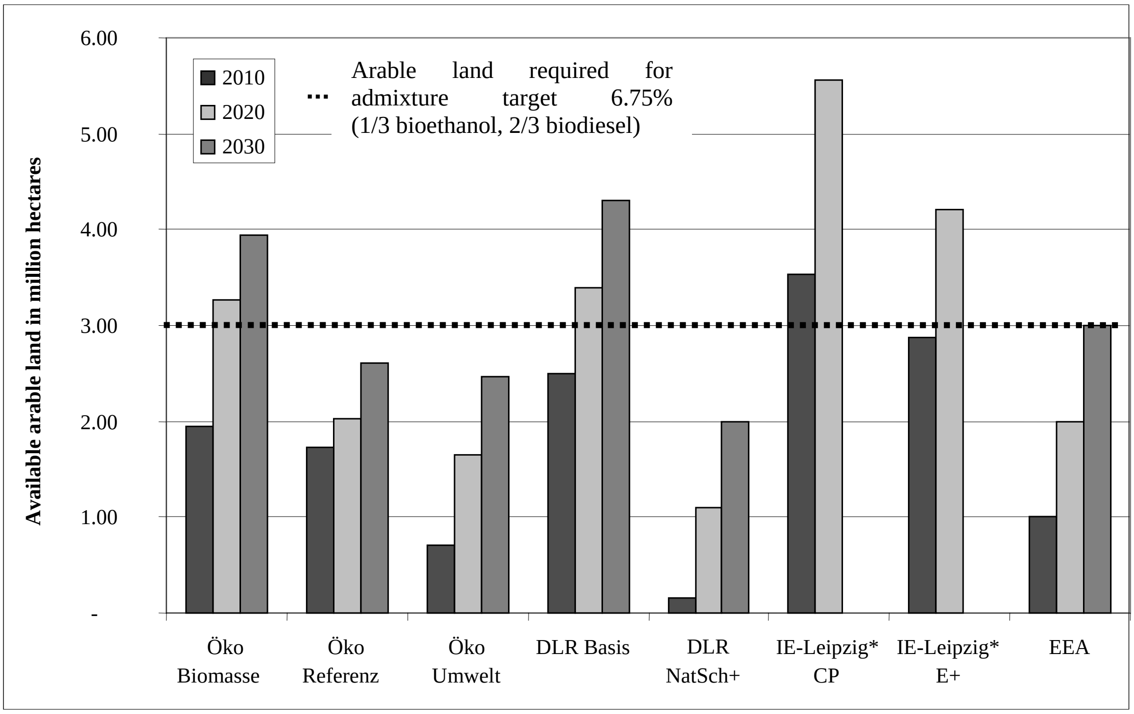
**14.** The key parameters for renewable raw materials potential are the available crop area and the energy crop yields per unit area. The total land area of the Federal Republic of Germany is approximately 35.7 million hectares. Of this, 11.9 million ha (33.3 %) was used as arable land in 2005. In 2006 some 1.6 million ha was used for growing renewable raw materials (approx. 13 % of the arable land). The oil-bearing crop rape, which is used primarily for the production of biodiesel, accounts for the largest share of the crop area, with approx. 1.1 million ha. Far behind, with less than 0.3 million ha crop area, come energy crops such as maize, grain or grasses. The remaining area (approx. 0.2 million ha) was used for growing plants for use as material (FNR 2006b).

Thus before calculating an energy potential for renewable raw materials, it is first necessary to determine the available area potential. A subsequent step involves making assumptions about the crops grown, their yields per unit area, and the conversion technologies employed, in order to determine the energy potential.

**15.** Figure 2-12 shows the crop area potentials for renewable raw materials, as determined in the various studies and scenarios for the years 2010, 2020 and 2030 (cf. Item 9). All studies and scenarios forecast an increase in the potential crop area for renewable raw materials, but there are considerable differences between the studies and also between the scenarios. The IE-Leipzig study arrives at the highest crop area potentials for 2020, with 4.2 million ha arable land plus 1 million ha pasture for the Environment+ scenario and 5.6 million ha arable land plus 1.8 million ha pasture for the CP scenario. The crop area potential of the CP scenario, at 7.3 million ha, corresponds to 43 % of the present area in agricultural use, and thus appears to be very high.

Figure 2-12

**Overview of crop area potentials in Germany for renewable raw materials, as shown by various studies for the period 2010 to 2030 (excluding pasture)**




*IE-Leipzig study: no data for 2030

Source: FRITSCHE et al. 2004; NITSCH et al. 2004; THRÄN et al. 2005; EEA 2006

Among other things, the biggest differences result from different assumptions about productivity trends, the degree of food self-sufficiency, population development, attention to nature conservation aspects, the shares due to fallow land and organic farming, and land take. This is illustrated by the following examples. For instance, the high potential estimates in the IE-Leipzig study are partly due to the fact that no account was taken of protected areas. The IE-Leipzig proceeds on the assumption of 17.02 million ha of farmland, whereas the other two studies work on the basis of 15.78 million ha. Moreover IE-Leipzig, and also DLR, lay down in their basic scenarios a self-sufficiency level of 100 % for milk and meat production, whereas the other scenarios assume a self-sufficiency of 102 %. Both studies assume a substantial decline in self-sufficiency levels. At present, for example, the figure for beef is as high as 124 % (BMELV 2007). This reduction is intended to reflect the deregulation of the market. A resulting drop in prices leads to additional release of arable land currently used for food production. The release of pasture gives rise to the problem of ploughing up pasture, but this is only taken up by the IE-Leipzig in its CP scenario. The EEA (2006) also assumes deregulation of the market for animal products by 2025. All other studies assume a constant increase in plant production in line with the trends of recent years.

Another reason for the differences in crop area potential is the different extents to which the scenarios take account of nature conservation interests. As already mentioned, the Biomass (Öko-

Institut), Basic (DLR) and CP (IE-Leipzig) scenarios do not take account of nature conservation interests to the same extent as the conservation-oriented scenarios Environment, Naturschutz-Plus and Environment+ and the EEA study (see also Table 2-4). These latter scenarios also differ in the way they take account of nature conservation interests. Depending on the study, for example, the NATURA 2000 conservation areas, which currently account for 13.5 % of Germany's land area, 21.4 % being used for agricultural purposes and 17.8 % as pasture (BfN 2006; RATHS et al. 2006), are not or not fully included in the Biomass (Öko-Institut), Basic (DLR) and CP (IE-Leipzig) scenarios. The statutory biotope network area requirement of 10 % of the total area of Germany (Section 3 Federal Nature Conservation Act) is taken into account differently in the different studies. Fritsche et al. (2004, Öko-Institut) work on the basis that as well as the existing biotope areas it is necessary to place an additional 7 % each of the arable and pasture areas under conservation for biotope network purposes in order to satisfy the statutory requirements. As basic data for these assumptions they cite a short report by Köppel et al. (2004) which was prepared as part of this project. There is also a difference between the Reference and Environment scenarios as to when this 7 % has to be completely achieved. In the Reference scenario the requirement is not met until 2020, in the Environment scenario it is met completely by 2010. In 2030 there is little difference between the Reference and Environment scenarios in line with the varying areas devoted to organic farming. Nitsch et al. (2004, DLR) reduce the additional biotope network component to 6 %, but apply this percentage not only to arable land, but also to pasture and forest areas. Corresponding figures are also taken from Köppel et al. (2004). This additional nature conservation land is taken into account in the Naturschutz-Plus scenario only, and not in the Basic scenario. Thrän et al. (2005, IE-Leipzig) integrate conservation areas in the Environment+ scenario only. They put the percentage of arable land at 2.5 % in 2010 and 5 % in 2020. 'The idea that by 2010 up to 10 % of arable land will appropriated for nature conservation and conversion to more extensive farming,' is described as an 'assumption going beyond the realm of reality' (THRÄN et al. 2005, p. 105). The EEA study proceeds on the assumption that by 2030 some 3 % of intensively farmed arable land will be available for nature conservation. It should however be noted that this study relates to 15, and the IE-Leipzig study to 22 states of the EU. Whereas the basic data (KÖPPEL et al. 2004) for the Environment and Naturschutz-Plus scenarios can be regarded as adequate for taking account of the current environmental and nature conservation regulations, this seems questionable in the case of the biomass-related scenarios, and also in the Environment+ scenario. The assumptions about nature conservation areas in the EEA study must also be regarded as low for the situation in Germany. A more individual consideration of the individual EU member states would have been desirable in both the EEA study and the IE-Leipzig study.

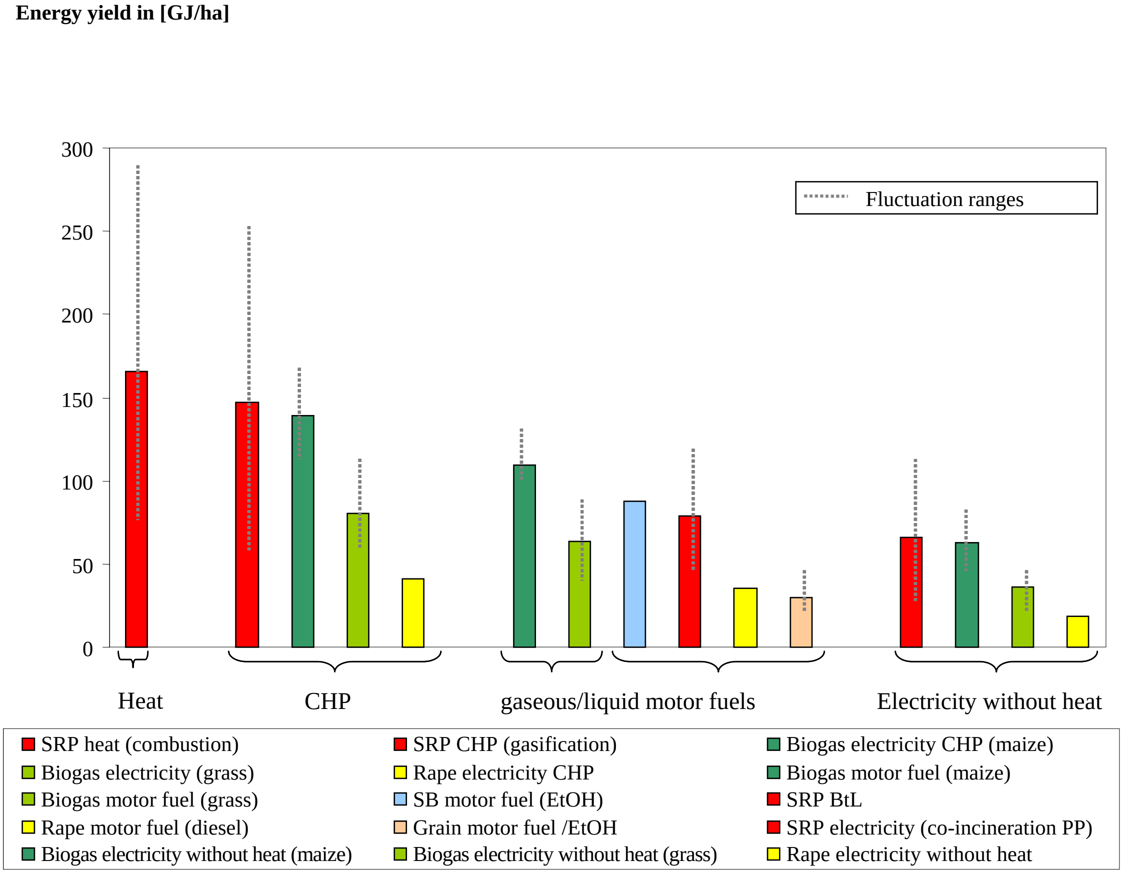
Which crops are used on this potential area, and in what proportions, is another nature conservation aspect which does not affect the potential area, but does affect the potential yield of the land. However, only the EEA study considers this aspect in relation to nature conservation and the environmental assets water and soil.

In general, the boundary conditions, as mentioned above, are not described sufficiently clearly in the studies, making it difficult to compare the results and virtually impossible to attempt a detailed discussion of the differences in potential. It is however clear that the Biomass (Öko-Institut), Basic (DLR) and CP (IE-Leipzig) scenarios do not appear realistic in the light of the present environmental and nature conservation framework, and these results should therefore not be taken as basic data for political decisions. Although the other scenarios take account of this framework at least to some extent, none of the scenarios caters adequately for nature conservation interests. For example, no scenario describes more far-reaching nature conservation requirements, e.g. the recommendation by the German Advisory Council on the Environment (SRU) that 5 % of Germany's forests be designated as total reserves, and that in the medium term up to 15 % of the total area of Germany be set aside for nature conservation purposes (SRU 2002, p. 41).

**16.** In order to derive an energy potential from the area potential, it is necessary to make assumptions about crop species used, including any prescribed crop rotation, and about possible production increases and the various use options with different technologies. Since these assumptions vary greatly between the different studies and are not adequately explained, the energy potentials described in the individual studies for renewable raw materials are not set out here. Instead, Figure 2-13 provides an overview of possible energy yields of renewable raw materials per hectare to show the differences between various use options, and an estimate of energy potentials of the various usage paths is given in Figure 2-14. The overview in Figure 2-13 shows clearly that using solid fuels such as wood from short rotation plantations to produce heat or combined heat and power, or using biogas and vegetable oil to produce combined heat and power, results in much higher energy yields per hectare than using energy crops to produce motor fuels or to generate electricity only. As far as motor fuels are concerned, using biogas results in even higher energy yields than using liquid biofuels such as ethanol, BtL or biodiesel. If the entire plant is used by means of enzymatic digestion of lignocellulose in the fermentation process for the production of bioethanol, it is possible to increase bioethanol energy yields still further. However, this use option is still at the development stage.

Figure 2-13

**Overview of current energy yields (net) of renewable raw materials for different usage paths in GJ/ha**




Notes:

Using Miscanthus (zebra grass) results in yields that are about 20% higher than SRP, but this possibility is not considered here because the technology is not yet commercially viable

In the case of heat, CHP, and power (without heat), the utilisation efficiencies are included; in the case of motor fuels only the production losses, but not utilisation losses, are included. Thus the data can only be compared to a limited extent; use of the fuels in motor vehicles will reduce the energy yield still further

SRP = short-rotation plantation, BtL = biomass-to-liquid, PP = power plant, CHP = combined heat and power, EtOH = ethanol, SB = sugar beet

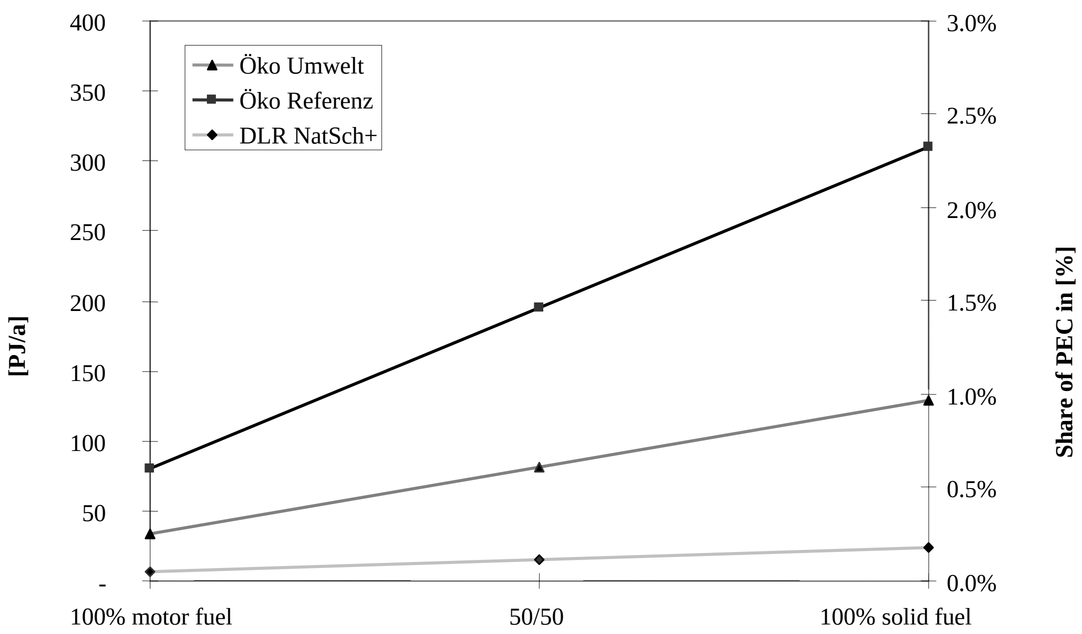
SRU/SG 2007-2/Fig. 2-13; data source: LfU 2004; ARNOLD et al. 2006; DENA 2006; FNR 2005b; 2005a; 2006a; KEYMER & REINHOLD 2006; SCHINDLER & WEINDORF 2006

With regard to the energy potential from renewable raw materials which is under discussion here, it is clear that CHP generally results in higher energy potentials than motor fuel. This is also illustrated in Figure 2-14. This diagram shows the possible energy yields of the various area potentials of the Environment and Reference scenarios of the Öko study and the Naturschutz-Plus scenario of the DLR study for the year 2010, for the options motor fuel only, solid fuel only, and 50/50 motor fuel and solid fuel. As one might expect, the energy potential is lowest for motor fuel only. However, only bioethanol and biodiesel are considered in this estimate, since only these first-generation fuels are available in the near future. But even when using BtL fuels (second-generation fuels), the energy yields per hectare are expected to be only 20 to 25 % higher. This increase in yield is due to the fact that these fuels, unlike present-day biofuels, use the entire plant. Thus even with the second generation, there will still be significant differences in energy potentials between CHP and motor fuels (DENA 2006). Large-scale production of this synthetic fuel is not expected before 2010, however (SCHÜTTE 2006). It is difficult to predict the timing of large-scale production, but conservative forecasts expect it to start around 2020 (REINHARDT et al. 2006). In view of the uncertainty about the availability of this technology, it should not be taken into account at all for the period up to 2010; for the period up to 2020, only realistic percentages should be included.

As well as the energy potential, Figure 2-14 also shows its percentage share of primary energy consumption in Germany. Until 2010 this ranges from 0.05 to 2.3 %, depending on the scenario and use path. By 2030 this potential could increase to nearly 5 % on the basis of the Reference scenario of the Öko-Institut study. Thus together with the biogenic waste potential it would be possible in 2030 to supply a maximum of 10 % of primary energy requirements (based on a PEC of approx. 12,000 PJ/a according to EWI and Prognos 2006). This makes the expansion targets described in NITSCH (2007) and BMU (2007c) (17 % biofuel share, 27 % renewable energy share of electricity generation, and 14 % renewable energy share of heat production by 2020) look very ambitious, and means that they cannot be achieved with biomass of German origin.

Figure 2-14

**Energy potentials in PJ/a and share of primary energy consumption* for the year 2010 for the Environment (Umwelt) and Reference scenarios of the Öko-Institut study and the Naturschutz-Plus scenario of the DLR study, assuming use of land for 100% motor fuels**, 100% solid fuels***, and 50% motor fuels** plus 50% solid fuels*****




*PEC (2010) = 14 080 PJ/a

** 1/3 bioethanol component with 50 % grain ethanol and 50 % sugar-beet ethanol with an average energy yield of 59 GJ/ha; 2/3 biodiesel component with an energy yield of 35 GJ/ha

*** Energy yield as average of wood from short-rotation plantations 166 GJ/ha

SRU/SG 2007-2/Fig. 2-14; data source: FRITSCHE et al. 2004; NITSCH et al. 2004; EWI and Prognos 2006

If one considers the political target of the Motor Fuel Quotas Act, which requires that alternative motor fuels account for 6.75 % of total motor fuel consumption in Germany from 2010 onward, it is clear that if one third of the quota consists of bioethanol and two thirds of biodiesel, an area of nearly 3 million ha will be needed for growing renewable raw materials for such uses. This land requirement is marked in Figure 2-12. It is clear that according to the results of the scenarios described here as acceptable (Environment and Reference of Öko-Institut study, Naturschutz-Plus of DLR study, and EEA study), this target cannot be achieved with Germany's national raw materials production. It must also be borne in mind that this estimate of areas for biofuel crops does not consider any other energy uses of the renewable raw materials.

Reinhardt and Gärtner (2005) also come to the conclusion that, after allowing for other land-depleting uses (such as sustainability criteria with regard to erosion control, Section 3 Federal Nature Conservation Act and organic farming, surface sealing and compensatory areas) and assuming 100 % self-sufficiency in the food sector, there will not be sufficient national area available for the production of biofuels – quite apart from the area requirements of other forms of bioenergy.

This shows that the targets for the use of biomass can only be met by importing considerable quantities of biomass or bioenergy sources, unless there is a reduction in food self-sufficiency, which would create a need for increased food imports. In view of the European target of 10 % biofuel component by 2020 and the German political target of 17 % biofuel component by 2020 (BMU 2007c), the import requirements will probably rise, even with increased yields in crop production and the prospect of large-scale use of second-generation biofuels such as BtL and ethanol from lignocellulose. Thus the ambitious political targets for biofuel use will encourage imports of biomass and/or bioenergy sources, and the consequences of this have not yet been taken into account (cf. Chapters 3 and 4).

Biomass can also be imported from other European countries. Increased growing of biomass is expected in Eastern Europe in particular. According to DAM et al. (2007), it will be possible by 2030 for biomass from Central and East European countries to meet up to 10 % of European energy requirements (approx. 108 EJ). This presupposes that the agricultural sector adapts to West European standards and uses 'high-input' cropping methods. On the other hand, if one assumes 20 to 30 % organic farming and other less intensive cropping methods, the potential is only around 5 % of European energy requirements (DAM et al. 2007). Moreover, the forecast does not take any account of the downward trend in summer rainfall that is predicted for Eastern Europe as a result of climate change (IPCC 2007). This, like less intensive cropping methods, can also result in a drop in potential. Thus imports from non-European states will be necessary if the European expansion targets for bioenergy by 2020 are to be met.

## 2.4 Summary

**17.** Biomass occurs in the form of biogenic waste and is also produced through growing of renewable raw materials by the agricultural and forestry sectors. This biomass can be used in many different ways to produce material and energy. Use as energy takes the form of electricity, heat and motor fuels. On the materials front, biomass can be used to replace almost the entire spectrum of fossil raw materials, as it is possible to produce numerous basic substances and chemical products for various branches of industry (e.g. cosmetics, soaps, paints/inks, hydraulic fluids, waxes, plastics, textiles, building materials). In view of its great political relevance, however, the main focus of this special report will be on the use of biomass for energy. Nevertheless, it is important not to forget that use as energy competes with use as material, and that this competition is intensified by strong promotion of use for energy.

In Germany the annual primary energy requirement is around 14,000 PJ/a. By contrast, final energy consumption is around 9,200 PJ/a. Conversion losses thus total some 36 %. Reducing primary energy consumption and reducing the losses from conversion into final energy therefore offer great potential savings. Renewable energy sources currently cover 5.3 % of primary energy requirements or 7.4 % of final energy consumption. Forecasts indicate that the proportion of primary energy requirements accounted for by renewable energy sources can increase to between 11 and 25 % by 2030, depending on the scenario. Within the renewable energy sector, the share due to biomass is currently around 70 %. This relative contribution of biomass is to be maintained in the future, with biomass aimed to cover a targeted 8 to 18 % of primary energy consumption.

The available supply of biomass is linked to numerous framework conditions. The technical potential of biogenic waste from the forestry and timber industry, agriculture, carcass disposal, the food industry and the waste and wastewater industries is in the region of 70 million Mg per annum, a large part of which is not yet used for energy purposes. For environmental and economic reasons it will not be possible to make full use of the biogenic waste potential (e.g. in the case of straw and residual wood from forestry). Studies to date appear to indicate that by 2030 some 4 to 5 % of current primary energy consumption will be available from biogenic waste. This potential should be fully used before there is any expansion of biomass production, though it should be noted that environmental limits must be placed on the use of biogenic waste from agriculture and forestry (straw and residual wood from forestry).

The supply of renewable raw materials has also been investigated in numerous studies. There are substantial differences between the scenarios described. The crucial parameters for such scenarios are the crop area available and the energy yields per unit area. Realistic estimates expect that an increase from the present 1.6 million hectares of farmland to around 3 to 4 million ha is possible by the year 2030. This increase depends to a large extent on how much land is needed for food production and what standards are laid down for the protection of soils, water bodies and biodiversity. The crop structure also has a great influence on the renewable raw materials potential because of the differences in yields and potential increases in yield. Different crops and conversion paths result in different energy potentials in the production of renewable raw materials. Much higher energy potentials can be achieved by using the crops for CHP generation in the stationary sector than if the same area is used for producing biofuels. Depending on the conversion path, for example, between 0.05 and 2.3 % of primary energy requirements can be met with renewable raw materials by 2010. Expansion to up to 5 % of primary energy requirements seems conceivable by 2030. Together with the biogenic waste potential, this results in a maximum combined bioenergy contribution to primary energy consumption of 10 % by 2030. Thus the targeted expansion to up to 18 % of primary energy requirements (see Item 6) and the current political target of 17 % biofuel share by 2020 would not seem to be possible with biomass of national origin. Assuming the present use of first-generation biofuels, the entire theoretically available area potential would be necessary merely to achieve the existing biofuel quota of 6.75 % by 2010.

It is clear from the above that ambitious targets for the production of electricity, heat and motor fuels from biogenic raw materials and biogenic waste cannot be achieved with biomass of national origin. Further expansion targets of the kind planned by the EU for the motor fuel sector (10 % admixture by 2020) will further increase this pressure to import, even given increased yields in crop production or more efficient technologies. Thus the ambitious bioenergy expansion targets will boost imports of biomass and bioenergy sources without taking any account of possible adverse consequences of such imports.

# 3 Impacts on environment and society

**18.** The following section provides a brief overview of the present state of knowledge regarding the impacts on the environment and society of growing and using renewable raw materials. It looks at the growing of biomass and its production and use for energy in both a national and an international context.

## 3.1. Environmental impacts

### 3.1.1 Life cycle analysis of bioenergy

**19.** A satisfactory comprehensive environmental ‘balance sheet’ (life cycle assessment – LCA) of the kind necessary for sound forecasting of the environmental impacts of biomass has yet to be achieved. This is due to the fact that life cycle assessments are sometimes extremely complex (REINHARDT et al. 2006) and that research is not keeping up with developments in practice (cf. HERRMANN and TAUBE 2006; RODE et al. 2005).

A life cycle assessment is a statement of the environmental impacts of a product, production process or other process, service, or production location. It is usual to prepare comparative life cycle assessments with the aim of comparing the environmental impacts of products, processes or services that have the same purpose or function. The methods used for life cycle assessment (LCA) are as laid down in the international standards ISO 14040 and ISO 14044 (cf. also UBA 2000).

As far as the use of biomass is concerned, the main focus is on the potential climate change mitigation effect. To make it possible to compare the climate protection effects of the usage paths ‘heat’, ‘electricity’ and ‘mobility’ and the different application options within these paths, it is necessary to have comparable life cycle assessments. One precondition for such life cycle assessments is that they consider the entire life cycle from growing the renewable energy crops to use of the crops to obtain energy. Co-products also play a crucial role.

Life cycle assessments performed to date suffer from a lack of comparability because of the choice of different accounting frameworks (system boundaries). In particular, many studies concerned with the greenhouse effect disregard emissions arising from the growing of biomass crops. It has to be remembered that in Europe the agricultural sector is the biggest emitter of nitrous oxide ($N_2O$) and methane ($CH_4$). In Germany it accounted for about 13 % of total greenhouse gas emissions (BMELV 2006b). Table 3-1 shows the parameters examined in three studies selected by way of example. However, a conclusive assessment of the climate change mitigation potential is only possible if the LCA also takes account of the production processes involved (cf. Items 20, 35).

The comparison of the three selected studies shown in Table 3-1 illustrates the differences in accounting framework, in other words the system boundaries that define which processes are attributed to the resulting product (in this case biomass). In view of these differences in basic framework and basic data between different studies of the ecological impacts of biomass use, it is difficult to arrive at a clear assessment. This means, for example, that it is currently impossible to produce a conclusive greenhouse gas statement and to assess the potential that biomass use offers for climate change mitigation. For this reason there is an urgent need for life cycle analyses to take account of all production processes and the associated emissions (‘from well to wheel’ or ‘from cradle to grave’).

Table 3-1

**Factors considered in life cycle analyses of the production and use of biomass**

| | Examples of different environmental studies | | |
|---|---|---|---|
| Life cycle factors | KLOBASA and RAGWITZ 2005 | CONCAWE et al. 2006 | REINHARDT et al. 2006 |
| Land use changes | | | |
| Acidification ($SO_2$ equivalent) | | | X |
| Nutrient input ($PO_4$ equivalent) | | | X |
| Photochemical smog ($C_2H_4$ equivalent) | | | X |
| Ozone depletion | | | X |
| Toxicity to humans ($PM_{10}$ equivalent) | | | X |
| Greenhouse gas emissions due to production of | | | X |

| | | | |
|---|---|---|---|
| fertilisers and pesticides | | | |
| Carbon loss due to cultivation (as a result of erosion, fertiliser, acidification, use of pesticides, changes in water regime) | | | |
| $N_2O$ emissions due to fertiliser use | | X | X |
| Greenhouse gas emissions due to energy consumption for irrigation | | | |
| Fuel consumed by agricultural vehicles | | | |
| Greenhouse gas emissions due to energy consumption for further processing | | | X |
| Greenhouse gas emissions due to energy consumption for transport | | | X |
| $CO_2$ equivalent emissions due to combustion of motor fuel ($CO_2$, $CH_4$, $N_2O$) | | | X |
| $CO_2$ emissions due to combustion of motor fuels | X | X | X |
| X = taken into account in calculation method | | | |
| SRU/SG 2007-2/Table 3-1/ data source: KLOBASA and RAGWITZ 2005; CONCAWE et al. 2006; REINHARDT et al. 2006 | | | |

One example of major uncertainties that exist regarding the inclusion of all climate-relevant processes is the production of biodiesel from rape. Recent research findings indicate that the greenhouse gas savings compared with fossil fuels are largely offset by the $N_2O$ emissions due to rape (FEEHAN und PETERSEN 2004) or may even result in additional greenhouse gas emissions. The effective contribution of certain biomass usage paths to climate change mitigation will remain questionable until greater reliability becomes possible in life cycle assessments.

### 3.1.2 Production of biomass

**Overall environmental impact assessment**

**20.** The production of biogenic raw materials and biogenic waste is not in itself sustainable. For sustainable management purposes, removal of biogenic waste such as straw and residual wood from forestry must take account of nutrient cycles. Recovery of other waste from the waste management sector is unproblematic as far as production is concerned. By contrast, however, changes in land use in connection with the expansion of renewable raw materials production have complex repercussions on nature and the environment. The share of crops accounted for by renewable raw materials shows a more than fivefold increase since the beginning of the 1990s and currently stands at 13 % of arable land (press release by Fachagentur Nachwachsende Rohstoffe e. V. (FNR) No. 449 of 17 January 2006). At present it is not possible to make any sound overall forecast of the environmental consequences in relation to the biomass expansion targets. Such a forecast would however provide an indispensable basis of information for the development of supporting environmental measures. The agricultural sector in Germany is essentially one of the main sources of harm to soil, water, species and biotopes, which means there is in any case an urgent need for action to reduce agricultural impacts on the environment (SRU 2004, Item 225). At present, however, the rapid increase in the growing of energy crops shows signs of having opposite effects: the risks to the natural regime are only partly due to aspects of new forms of cultivation that are particularly harmful to the environment. A much more serious factor is the widespread expansion of risk-prone, i.e. environmentally hazardous, crops such as rape or maize (which are also grown as food/animal feed crops), at the expense of more environmentally friendly crops, and the changed or excessive use of vegetation forms such as forest or pasture that store $CO_2$. Pasture runs an acute risk of being converted to arable land for the purpose of biomass utilisation. The main impacts of the growing of renewable raw materials are outlined below.

**Avoidance of greenhouse gas emissions**

**21.** The fixation of $CO_2$ during crop growth can make an important contribution to climate change mitigation. In order to avoid greenhouse gas emissions, however, it is essential that the production and use of biomass give rise to less $CO_2$ than the use of fossil fuels. In particular, the way the biomass is grown and the way it is converted into energy can result in marked differences in energy efficiency and in the greenhouse gas savings potential of the individual production-and-use systems. For a conclusive assessment, it is necessary to take account of the production and application of fertilisers and pesticides, and also of the environmental impacts of the field cultivation and treatment processes required, which themselves involve energy consumption and greenhouse gas emissions. When fertiliser is applied, for example, 1.25 % of the nitrogen it contains is released directly in the form of nitrous oxide ($N_2O$), and during further conversion of the fertiliser about 10 % of the nitrogen is released via nitrous oxide, ammonia and other oxides of nitrogen (FEEHAN and PETERSEN 2004). Life cycle assessment also has to take account of transport routes and the chosen means of transport (agricultural vehicles or trucks) between the growing site and the place of use (cf. RODE et al. 2005, p. 33; RAMESOHL et al. 2006; K.E.R.N. e. V. 2006, p. 33). Allowance must also be made for any additional energy required for storage or drying. Such additional energy should however be kept to a minimum in the interests of minimising energy input and maximising energy efficiency (SPLECHTNA and GLATZEL 2005, p. 31; WOLTERS 1999, p. 11).

The carbon balance is also of importance in the case of land use changes, which can potentially release additional greenhouse gas emissions. According to JANSSENS et al. (2005), for example, pasture in Central Europe acts as a carbon sink with an average annual fixation of 60 g C per $m^2$. Arable land, by contrast, releases an annual average of 70 g C per $m^2$, which means that ploughing up pasture to create new arable land results in a net increase of 130 g C per $m^2$ per annum. However, if new pasture is sown at the same time, fresh carbon fixation can take place. Thus if the total area of pasture remains constant, the carbon balance need not necessarily be negative (IBS and ILB, no year stated).

If, for example, boggy soils are drained or pasture ploughed up to grow energy crops, this can have considerable adverse impacts on the $CO_2$ balance. According to a rough calculation of the net carbon balance for arable, forest, bog and pasture areas for 34 European states, Germany currently comes fifth in Europe with a net annual carbon fixation of + 43.3 g C per $m^2$ of land (JANSSENS et al. 2005). A reduction of only 5 % in the existing sinks would release as much carbon as is currently emitted every year due to the combustion of fossil fuels on the entire continent of Europe (JANSSENS et al. 2005).

**22.** There have already been functional losses on the forest front. Forest vegetation, and in particular natural forest, serves worldwide as a storage reservoir for 75 % of the carbon currently fixed in biotic systems (UNFCCC, Secretariat 2006). In Germany the forests have hitherto performed an accumulating sink function, which results primarily from the low felling rates in the past and the corresponding increase in timber stocks. However, both the storage function and the sink function will be put at risk if timber stocks do not remain constant or show no further increase. The increasing utilisation of recent years, including the removal of wood for biomass, is already making itself felt in a downward trend in the sink effect. From 1993 to 2004 the additional carbon fixation fell by a good third (Statistisches Bundesamt/Federal Statistical Office 2006). Increasing the felling rate has an impact on forest age structure and has direct repercussions on the carbon sink potential. In 2004, for example, the quantity felled, at around 54.5 million $m^3$, was a quarter higher than the average for the previous ten years (BMELV 2006a). In view of the way crude oil and energy prices are currently developing, there seems unlikely to be any reversal of this trend.

**Impacts of biomass production on soil and water**

**23.** Existing approaches to life cycle assessment have revealed negative environmental impacts, in some cases substantial, for various energy crop growing methods. These have for example involved nutrient inputs or soil acidification (REINHARDT et al. 2006). The approximately 60 energy crop species in question display many differences, including aspects such as one-year or multi-year cultivation, yield, sensitivity to pathogens, fertiliser and pesticide requirements (BASSAM 1998). In general it can be said that multi-year cropping methods (e.g. short-rotation plantations (SRP) for the production of wood and green prunings) have less negative environmental impacts than one-year methods, since they cause less soil erosion due to cultivation and treatment and have lower nutrient and pesticide requirements (EEA 2006; WINKELMANN 2006; SPLECHTNA and GLATZEL 2005, p. 8).

The cultivation of annual crops gives rise to environmental impacts of varying extent. The impacts on the natural regime also depend on the prevailing climate and soil conditions. In view of this it is essential, when comparing life cycle assessments of biomass and food crop cultivation, or for different biomass crops, always to base them on a clearly defined (location-specific) reference system to ensure that the results are comparable. In dry locations, for example, the environmental impacts of water-intensive crops have to be weighted differently than in high-rainfall regions. Table 3-2 shows the environmental impacts of different growing methods or crop groups for selected parameters in the European region, sorted by their impact on nutrient leaching and pesticide inputs.

Table 3-2

**Environmental impacts of selected crops in Europe**

| Crop | Nutrient leaching | Pesti-cide inputs | Erosion | Soil com-paction | Water con-sumption | Impact on bio-diversity | Impact on agro-diversity |
|---|---|---|---|---|---|---|---|
| Permanent pasture | A | A | A | A | A | A | A |
| Winter grain | A | A | A | A | A | B | B |
| Short-rotation planta-tions (poplar, willow) | A | A | A | A | B | A/B | A |
| Hemp | A | A | A/B | A | B | B | A |
| Linseed | A | B | A/B | A | A | A/B | A |
| Grass seeding | B | A | A | A/B | A | B/C | A |
| Alfalfa | B | A | A | A/B | A/B | A/B | A |
| Wheat | A | B | A | A | B | B/C | C |
| Switch-grass | ? | ? | A | A | A | B | A |
| Millet | A | B/C | A | A | A/C | B | B |
| Mustard | A/B | B | A/B | A | B | B | A |
| Sunflower | A/B | B | B/C | A | B | A/B | B |
| Sugar beet | B/C | B | C | C | A/C | B | B |
| Potatoes | B/C | B | C | C | C | B/C | B |
| Rape | B/C | C | B | A | – | B/C | A/B |
| Maize | C | C | C | B | A/B | C | B/C |

A = low risk, B = medium risk, C = high risk, – = criterion not applicable,
? = inadequate data

SRU/SG 2007-2/Table 3-2; data source: EEA 2006, Annex 4

**24.** It should be noted that assessments of the impacts of the individual crops still involve uncertainties, even in the case of plants currently grown as food or fodder crops. Certain growing restrictions relating to the quality of the final product that have to be observed when producing food crops may not apply when growing energy crops, for example quality fertilising of grain for bread, or fertiliser restrictions in the case of sugar beet. In the first case one can expect a slight reduction in the environmental burden; in the second case there may be a risk of increased fertiliser use to boost yields, with consequent negative impacts on water and soil.

Impacts on soil and water are basically reduced whenever selection of the crops to be grown takes account of the varying sensitivity of sites to erosion, soil compaction and other harmful effects on the soil. As far as soil protection in particular is concerned, a change in crop sequence for the production of biomass may, by ensuring longer soil cover, make a positive contribution to reducing erosion. This is the case if short-cover crops such as sugar beet or maize are replaced by crop sequences involving long-cover crops such as winter grain, clover, grass and – especially – tree plantations.

The high water requirements of some crops – for example intensive short-rotation plantations of poplar or willow – may, where these cover large areas, give rise to considerable problems for the district water supply and associated functions such as drinking water abstraction, threats to soil fauna, or biotope conservation (cf. EEA 2006; WINKELMANN 2006). Acute water shortages are in any case predicted for certain regions of Germany – for example the catchment area of the River Spree – as a result of climate change (GRÜNEWALD 2005; BECKER 2005). This can be expected to bring about changes in the framework conditions for agricultural use in these areas.

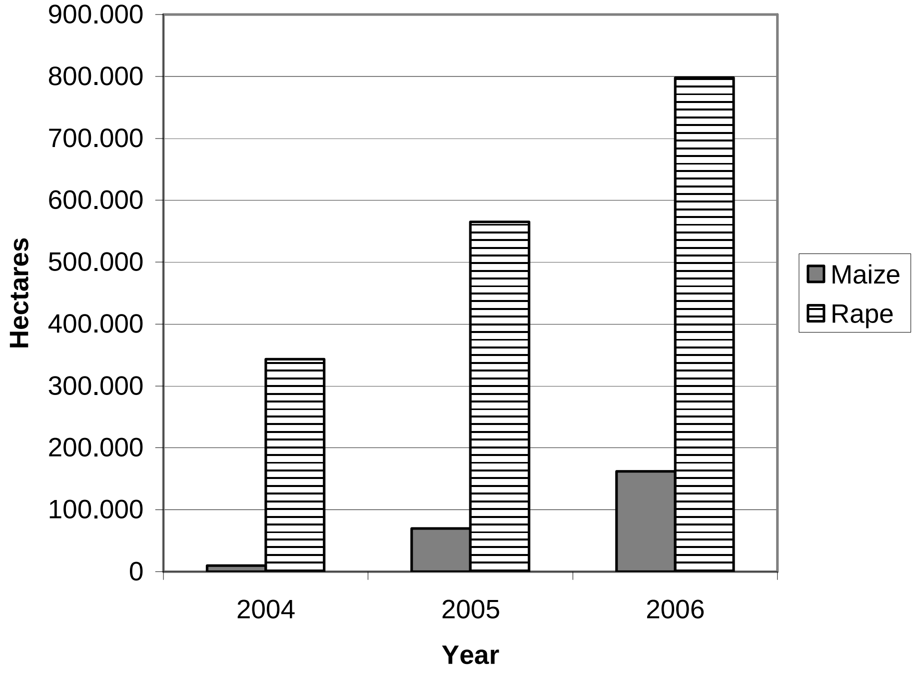
**25.** At present it is not yet possible to make any conclusive assessment of the effects that biomass growing in mixed crops has on the natural regime (e.g. due to different harvest times) (GRAß and SCHEFFER 2003). As well as the growing of energy crops, intensive use of agricultural and forestry residues (residual forestry wood, straw) can also result in serious threats to the environment. Utilisation of whole plants and utilisation of agricultural residues such as straw involve a risk of negative humus balances, since straw plays an important role in humus formation (VETTER 2001). Increased removal of wood from forests can have an adverse impact on forest soils. The lack of nutrient supplies from weathering of old wood, bark and twigs results in acidification of the soil (RODE et al. 2005).

**Environmental impacts of intensively farmed renewable raw materials**

**26.** Although there are a large number of energy sources that can be used for biomass production, there is currently a preference for mainly large-scale monocultures of rape for biofuel production and maize for biogas production: the area under rape in Germany comes to about 1.7 million ha in 2007, following only 1.08 million ha in 2000 (UFOP 2006). The area under maize for biogas production more than doubled from 2005 (approx. 70,000 ha) to 2006 (approx. 162,000 ha); this was at the expense of silage maize, however, since the total maize crop area of around 1.7 million ha has remained relatively constant for some years now (Deutsches Maiskomitee 2007). With a share of around 90 %, maize is the most frequently used co-substrate in biogas systems (loc.cit.).

Figure 3-1

**Development of crop areas of rape and maize for energy and biomass**



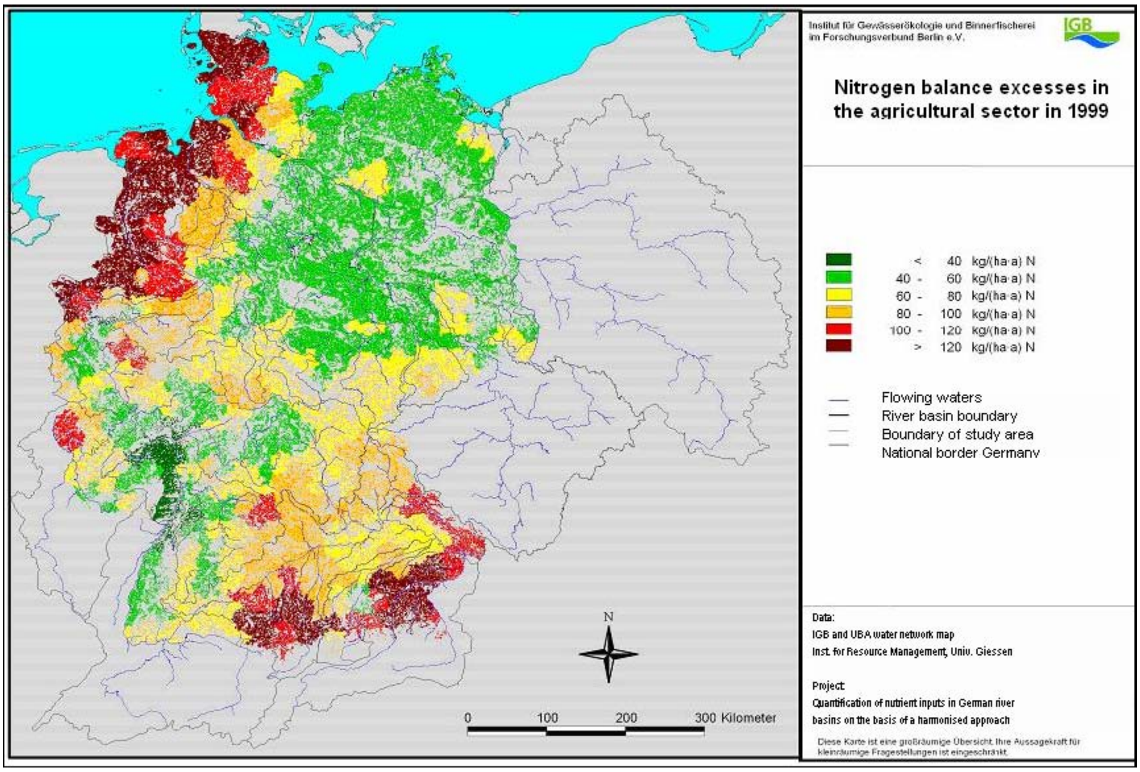

SRU/SG 2007-2/Table 3-1; data source: Deutsches Maiskomitee 2007; UFOP 2006

**27.** Monocultures covering large areas, especially in cases where no further cultivation measures such as undersowing or catch cropping are taken, frequently lead to soil erosion, soil compaction due to use of heavy equipment, and increased use of fertilisers and pesticides with corresponding repercussions on soil and water. When farming on permeable soils there is a corresponding increase in the risk of environmental impacts (RODE et al. 2005; KAINZ 2006; LVLF 2004).

Increased growing of rape and maize may have substantial effects on nitrogen balances. In order to achieve optimum crop yields, the maximum uptake of N may be between 280 and 300 kg N/ha. However, since the maximum removed during harvesting is 140 kg N/ha, up to 160 kg N/ha may enter the soil as crop residues, with an attendant risk of leaching (Landwirtschaftskammer Niedersachsen 2007). A further rise in nitrogen inputs into groundwater and surface water would increase the environmental burdens in an area where further loads cannot be tolerated: in many parts of Germany, nitrogen excess figures are still at a relatively high level (cf. Fig. 3-2) and the agricultural sector is one of the main originators of the nitrogen and phosphate loads in surface waters (SRU 2004). In Germany the basic indicator of water quality, measured as nitrogen excess, is 105 kg/ha, nearly twice the average for the EU 15 countries, which is around 55 kg/ha (BMELV 2006b). Roughly one sixth of the measuring stations monitored throughout Germany continue to exceed the maximum concentration of 50 mg/l which is permitted in the groundwater under the EU Nitrate Directive (BMU 2004).

Figure 3-2

**Nitrogen balance excesses in the agricultural sector 1999**




Source: BMELV 2006b, p. 16

**28.** One aspect that is hardly taken into account at present is the fact that the practice of returning biogas fermentation residues to the fields could cause considerable nutrient enrichment there and lead to conflicts with the Fertilisers Ordinance. The Fertilisers Ordinance limits the application of organic manure and secondary raw material fertilisers to a maximum of 170 kg N per hectare per year. This quantity of nitrogen would be reached with the fermentation residues from a maize yield (dry matter) of 16.2 Mg/ha (HERRMANN and TAUBE 2006). However, hopes of yields of 30 Mg/ha are being held out for high-yield varieties of energy maize. This would result in a situation where on the one hand mineral fertiliser would be required to achieve the expected yields, but at the same time a substantial nitrogen excess would be produced which could no longer be accommodated on the fields given a high energy maize share in the crop sequence (loc.cit.).

Large-area monocultures also involve an increased risk of pest infestation and consequent crop failures, as illustrated by the flower-beetle plague in Schleswig-Holstein, Mecklenburg-Western Pomerania and Brandenburg in the summer of 2006. Although the Mecklenburg-Western Pomerania Ministry of Agriculture had drawn attention in 2004 to the fact that the expansion of rape cropping had already reached its limits (MELFF 2004), the crop area showed a further increase of 18,000 ha in 2006 to reach 250,000 ha (Union zur Förderung von Oel- und Proteinpflanzen e. V., press release of 14 November 2006).

Intensive crop farming also requires the use of crop protection agents such as herbicides, insecticides or fungicides. The data situation regarding precise application quantities of such agents in Germany is currently unsatisfactory. There is a need for further research on this point. It is therefore difficult to assess the risk potential of individual crops. Furthermore, each crop displays specific sensitivities to pests, and these have to be dealt with accordingly. That is why, for example, the insecticide treatment index for rape as determined in the 'Neptun 2000' project is relatively high compared with the other crops (ROßBERG et al. 2002), and this, in combination with the large and increasing crop area, may present soil and water pollution risks.

Even if energy crops are grown in accordance with the current rules for good professional practice and the EU cross-compliance requirements, further expansion of intensively farmed monocultures of rape and maize holds considerable potential for pollution of the natural regime. This calls for prior risk assessment to prevent any further increase in fertiliser and pesticide inputs into the soil and water.

## Impacts on biodiversity and the countryside

**29.** An increase in intensive growing of energy crops has considerable impacts on biodiversity and the countryside. In particular, this is influenced by the consequences of intensive conventional farming, which leads to a reduction in perceived recreational value. In a study on the development of agricultural landscapes in Southern Bavaria, for example, respondents cited pesticide and fertiliser application, monocultures, cleared landscapes etc. as the main disturbing factors (LINDENAU 2002). Future use of new varieties for biomass production (e.g. maize growing up to 6 metres high) will have further adverse effects on the aesthetic qualities and hence the recreational suitability of the countryside (RODE et al. 2005).

Even without farming of new varieties, a further reduction in both natural species diversity and location-specific agro-biodiversity can be expected where additional monocultures replace former more varied farming practices. The impacts already created by the agricultural sector (cf. SRU 2004, Item 225) could be further exacerbated by a continuing increase in large-scale crop growing. In these fields, conflicts arise between nature conservation and biomass production, especially if biomass farming results in ploughing of pasture, drainage of boggy soils, renewed farming of set-asides, or abandonment of extensive farming practices required in the context of agro-environmental measures. According to a documentation complied by NABU (2007), ploughing of pasture is already taking place. In Rhineland-Palatinate, for example, pasture has been ploughed up at two locations situated in Habitat-Directive areas in order to grow maize for biogas or animal feed production. This threat exists even in protected areas: in past years the protection ordinances for many nature conservation areas have imposed no more than basic protection. All extensification or maintenance measures of a more far-reaching nature have for preference been implemented via limited-term agro-environmental measures or contract-based nature conservation. Where competition exists between contract-based nature conservation and biomass production, there is now a risk that, even within protected areas, the decision will go in favour of the more profitable biomass production and the intensification of use, or that contract-based nature conservation will have to offer considerably larger financial incentives. However, since in most Laender the budget allocations for agro-environmental programmes show a decrease for the assistance period starting in 2007 (DVL and NABU 2007), there is no reason to expect that additional funds will be made available.

Where residual wood from forests is used, biomass utilisation will in future provide an incentive to make greater use of fallen or standing dead wood. In view of the important role of dead wood for many endangered species in the forest ecosystem, e.g. as nesting and hollow trees, such a development would not be desirable (RODE et al. 2005). In general, foliage should not be collected, since it contains about 20 % of the nutrients. If it is left on site it protects the roots from soil erosion (EEA 2006).

### Agro-biodiversity

**30.** Agro-biodiversity means that part of biological diversity which is used by human activities, for example crop plants and farm animals (BMELV 2005). Use for energy is to some extent less demanding with regard to the quality of the harvested products than is the case with food plants. When selecting varieties, therefore, phytosanitary aspects may play a more important role or may be achieved by using mixtures of varieties. Farming and preservation of ‘old’ varieties is also possible.

By contrast, large-scale monocultures have a negative impact on agro-biodiversity. Instead, diversity should be achieved using a mix of varieties. This may, for example, be done by including different energy sources, breaking up arable land by means of adjacent short-rotation plantations etc. Since banks grant loans for biogas systems on the basis of maximum energy yield (currently maize) and there is also a lack of incentive systems that would encourage experimentation with a mix of varieties, this currently presents obstacles to diversity of varieties.

To date, no genetically modified plants are used in biomass farming in Germany. Their introduction would involve risks, particularly from the long-term and unpredictable consequences of such plants interbreeding or running wild. Changes in environmental conditions, for example due to climate change, could also give rise to unexpected impacts as a result of epigenetic effects (influence on expression of the genotype in the phenotype due to environmental conditions).

### Sustainable cropping systems

**31.** Given an appropriate cropping system, however, synergies may arise between the production of biomass and the conservation of the functional capacity of the natural regime and of biodiversity. This is particularly true in cases where intensive arable farming (reference system) is replaced by a diversified crop system. In certain areas and situations, this may make biomass production particularly desirable (e.g. continued use of pasture in areas with declining milk production and lamb or beef production, use of material resulting from landscape maintenance, extensification of use in environmentally sensitive areas by means of suitable cropping methods that are not profitable in food production).

Alternative cropping systems such as limited-area and limited-term mixed crops (crop rotation) (GRAß and SCHEFFER 2005), mulching and low-input-low-output crops, for example, offer possibilities for the development of a typical arable associate flora combined with extensive farming. In cleared landscapes, planting extensive short-rotation plantations of fast-growing trees can make a contribution to improving the functional capacity of the natural regime including improvements in biodiversity, flood retention or soil conservation (DLG and Umweltstiftung WWF Deutschland 2006; SPLECHTNA and GLATZEL 2005; RODE et al. 2005). There is also the possibility of practising extensive use to enhance boundary biotopes at the transition from forest to open land from the point of view of species and biotope protection. Finally, if it were made appreciably more attractive to use the prunings from landscape maintenance as biomass, this would create greater economic incentives for maintenance of open land, forest fringe development, coppice and composite forest maintenance, and the development of riparian strips or erosion control strips (RODE et al. 2005).

**32.** Corresponding changes in cropping methods have not yet become established on a relevant scale, whereas the growing of rape and energy maize is expanding rapidly. This may be due partly to the present lack of infrastructure for the utilisation (especially combustion) of the prunings, and partly to the fact that operators of biogas systems exclusively use maize because of its high methane yields and better profitability. The biogas and methane yields per unit area of landscape maintenance prunings are relatively low compared with other plant substrates (PROCHNOW et al. 2007, p. 22), whereas combustion could be a profitable use. There is no doubt that the greater economic attractiveness of rape in particular as a result of the compulsory admixture to motor fuels which came into force on 1 January 2007 plays an important role.

**Impacts of biomass production on protected assets of the natural regime**

**33.** Table 3-3 summarises the possible impacts of biomass production on protected assets of the natural regime and describes the principal causes and originators.

Table 3-3

**Environmental burdens associated with certain forms of biomass production (cf. Table 3-2), and impacts on protected assets of the natural regime**

| **Environmental burdens** (especially due to expansion of crop areas for rape, maize, sugar beet, potatoes) | Affected protected assets of natural regime |
|---|---|
| Increased use of fertilisers | Input of nutrients into soils, groundwater, surface waters and air leading to eutrophication of biotopes, soil acidification; increased emissions of nitrous oxide and methane. |
| Increased use of pesticides and/or expansion of pesticide-intensive crop growing | Inputs of active substances and metabolites into soil, water and air leading to increased impairment of sensitive communities and of usability of groundwater and surface waters. |
| Land use changes and/or conversion (e.g. ploughing of pasture due to increased demand for arable land) | Loss and destruction of greenhouse gas sinks, e.g. through ploughing of pasture or cropping on sensitive soils; loss of functions of natural regime through increased erosion and rapid runoff; loss of habitats and hence threats to species and communities; changes in countryside with restriction of recreation function; growing in sensitive area (NATURA 2000, nature conservation/landscape protection areas, water conservation areas); loss of fringe biotopes and structural elements, increases in field size. |
| Limited or standardised crop sequences | Reduction in diversity of varieties and traditional varieties; trend towards monocultures; changes in countryside; loss of habitats. |

| | |
|---|---|
| **Growing of water-intensive crops in dry locations** (e.g. intensive operation of short-rotation plantations) | Reduction in availability of water; change in water table; reduction in groundwater regeneration rate; need for irrigation (especially on permeable soils). |
| Removal of organic material including residual material (straw, leaves, dead wood) | Humus depletion and negative humus balance; acidification; rapid water runoff; loss of habitats (especially due to removal of dead wood and residual wood from forests); impairment of greenhouse gas sinks. |
| Use of genetically modified organisms | Currently on trial plots only; danger of spread of genetically modified material in soils, organisms and plant populations. |
| | SRU/SG 2007-2/Table 3-3 |

### 3.1.3 Biomass use

#### 3.1.3.1 Environmental impacts of biomass use

**34.** The use of biomass for energy results on the one hand in environmental relief due to reduced use of fossil energy resources, and possibly in reduced greenhouse gas emissions. On the other hand it also gives rise, as with any technological use, and especially thermochemical conversion, to environmental burdens such as emissions with acidifying and eutrophicating impacts (sulphur dioxides and nitrogen oxides) and emissions of particulates (especially fine particulates) and other pollutants.

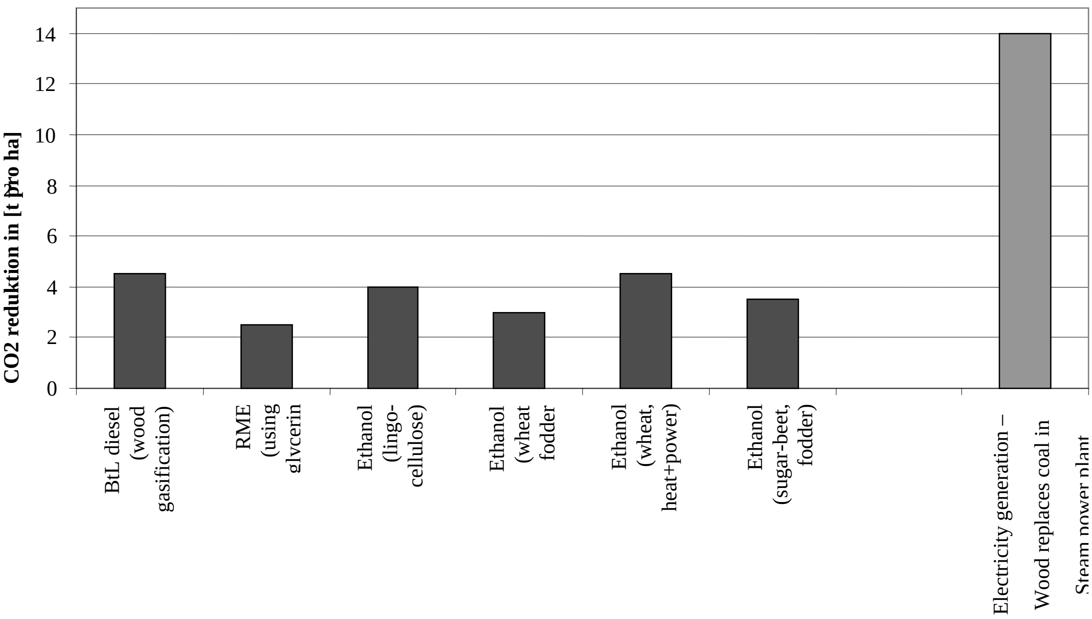
**Greenhouse gas emissions**

**35.** As far as any increase in the $CO_2$ content of the air is concerned, use of biomass for energy is generally regarded as having a neutral impact on climate, since it only releases to the environment the $CO_2$ that was previously absorbed by the plants during their growth. Climate-relevant emissions are however produced because fossil energy is used in the production of fertilisers and pesticides, during farming processes, in the process of supplying biomass and in the operation of bioenergy systems. Moreover, the greenhouse gas balance is also dependent on the efficiency of the entire chain of use and on the reference fossil technology that is replaced in each case, and hence varies depending on the usage path (technology), which means that the claim to 'greenhouse gas neutrality' is only of limited validity (cf. KALTSCHMITT and HARTMANN 2002; NITSCH et al. 2004; ARNOLD et al. 2006; RAMESOHL et al. 2006).

As shown in Figure 2-13, combustion of biogenic solid fuels for heat purposes and combined heat and power generation from solid fuels and biogas in particular provide the highest energy yields per hectare. Accordingly, Nussbaumer (2006) has shown that the use of wood as a motor fuel has only 50 to 75 % of the substitution effect of a wood-fired heating system. It has also been shown by a comparison of the greenhouse gas balances of various biomass usage paths that the use of biomass for heat and power generation offers the greatest greenhouse gas avoidance potential (ARNOLD et al. 2006; RAMESOHL et al. 2006; CONCAWE et al. 2006; NITSCH 2007). It should however be noted that there is not always a correlation between greenhouse gas savings and energy content. When considering greenhouse gas savings potential, it is also important to consider the reference system in question. The saving is most effective when substituting for $CO_2$-intensive technologies such as coal (FRITSCHE 2003). Accordingly, calculations by Concawe et al. (2004; 2006) show that the greenhouse gas savings offered by the biofuels currently available are no more than one third of the reduction potential offered by substitution of biomass for coal in the generation of electricity (see Fig. 3-3). The EU Commission also comes to the conclusion that the greenhouse gas savings possible with biofuels are considerably less than can be achieved by stationary use of biomass to generate power and/or heat (EU Commission 2005, p. 32).

Figure 3-3

**Greenhouse gas emission reduction potential of various biofuels compared with electricity generation from biomass**




Source: CONCAWE et al. 2004; 2006

Calculations by RAMESOHL et al. (2006) and ARNOLD et al. (2006) show that electricity generation using biogas from slurry and also from renewable raw materials is always advantageous with regard to greenhouse gas savings. Slurry fermentation in particular has a positive impact on greenhouse gas emissions. For example, fermentation reduces emissions of methane ($CH_4$) by about 90 %, substantially reduces emissions of nitrous oxide ($N_2O$), and also permits reductions in emissions of ammonia ($NH_3$) (FAL 2004). There is however a need for optimisation of the storage and application of the fermentation residues (WILFERT et al. 2004). The use of biogas as a motor fuel displays only a slightly lower greenhouse gas saving potential than the use of biogas in the stationary sector. In particular, the high energy yield per hectare is stressed as an advantage of biogas use (see also Item 16 and Fig. 2-13). The possibility of using grass silage through biogas technology also offers great advantages in terms of preventing greenhouse gases, since it avoids ploughing up pasture, which would result in additional greenhouse gas emissions due to this change of land use (cf. Item 21). The greatest greenhouse gas savings can be achieved by generating electricity plus heat from wood in CHP plants (20 $MW_{el}$), according to RAMESOHL et al. (2006) and ARNOLD et al. (2006). Basically, heat utilisation always has a beneficial effect on direct greenhouse gas savings potentials. There are however structural limits to waste heat recovery (RAMESOHL et al. 2006).

There are great variations in the greenhouse gas savings potential of motor fuels. According to QUIRIN et al. (2004), the greenhouse gas savings per hectare of crop area are greatest for ethanol from sugar cane and sugar beet, followed by biogas. The lowest savings are achieved with biodiesel. According to Concawe et al. (2006), the highest greenhouse gas savings per hectare are obtained by using bioethanol from wheat (when the by-products are used for heat and power generation) and by using BtL fuels (BtL – biomass-to-liquid) (see Fig. 3-3). Arnold et al. (2006) come to the conclusion that the greatest greenhouse gas savings in relation to the energy yield in kWh are obtained with BtL fuels and biodiesel. By contrast, biogas and ethanol from wheat or sugar beet offer lower greenhouse gas savings. A particularly important aspect in these studies is the use of residual substances or secondary products. For example, the greenhouse gas savings potential of ethanol is considerably higher if additional energy is produced from the residual material, for example by fermenting it to output biogas instead of producing animal feeds. In the case of ethanol, moreover, utilisation of whole plants offers advantages in terms of the greenhouse gas balance thanks to the breakdown of cellulose, with the result that the use of bioethanol displays similarly high greenhouse gas savings potential to whole-plant utilisation via BtL. However, such whole-plant utilisation is not yet state of the art for the production of either bioethanol or BtL (see box in Item 3, Chapter 2). As also shown by CONCAWE et al. (2006), the low greenhouse gas savings potential may show a positive change if the by-products or residual material are used to generate heat and power.

The varying results of the greenhouse gas balances make it difficult to arrive at a clear assessment of the different usage paths. One thing that is clear, however, is that using motor fuels has marked climate change disadvantages compared with stationary heat and power generation. Biogas utilisation, by contrast, especially where slurry and grass silage are used, can always be rated positive from a climate protection point of view, as can the replacement of coal. Since the greenhouse gas savings of biogas as a motor fuel are only slightly smaller than the savings achieved when it is used for heat and power generation, using biogas as a motor fuel makes sense and can be recommended as a means of replacing fossil motor fuels (NITSCH et al. 2004; RAMESOHL et al. 2006; ARNOLD et al. 2006; FVS 2007).

**Acidifying and eutrophicating emissions**

**36.** Apart from greenhouse gas emission savings, using biomass as a heating fuel gives rise to emissions of gases relevant to acidification and eutrophication ($SO_2$, $NO_x$ etc.) that are higher than with comparable fossil technologies (NITSCH et al. 2004). According to Nitsch et al. (2004), the eutrophicating effects are greatest for biogas, short-rotation plantations, and rape. Also, in connection with biogas technology, emissions of oxides of nitrogen and ammonia take place during application of the fermentation residues to the fields (WILFERT et al. 2004). These emissions can be reduced by using new application technologies.

**Particulate emissions**

**37.** Particulate emissions during the combustion of solid biomass are higher than for fossil fuels because of the higher ash content of biogenic fuels. As a result, the increase in small combustion plants brought a rise in particulate emissions from small wood-burning systems in the household and small business sectors from 22.7 kt in 2002 to 24.0 kt in 2003. These particulates now exceed particulate emissions from motor vehicles (see Table 3-4; though local levels along routes with heavy traffic can be higher). In the case of small wood-burning combustion plants, fine particles ($PM_{10}$) account for more than 90 % of total particulate emissions. However, the quantity of fine particulates actually emitted depends on the type and age of the system, its state of repair, the firing method, and the fuel wood used (see Table 3-5). Wood pellet firing systems, for example, are advantageous. Some of these firing systems have such low emissions that they have been awarded an environmental mark (‘Blue Angel’). Thanks to better flue-gas cleaning, emissions from large plants are considerably lower than from small combustion systems (NUSSBAUMER 2006). The German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) is planning to revise the requirements for small combustion plants that are laid down in the First Ordinance for the Implementation of the Federal Immission Control Act (1. BImSchV) (UBA 2006). Unlike combustion, gasification does not give rise to any particulate emissions.

Table 3-4

**Annual emissions $PM_{10}$ in kilotonnes (1 kt = 1,000 t)**

| $PM_{10}$ emissions in kt | 2002 | 2003 |
|---|---|---|
| Small wood-burning combustion plants in households and small business | 22.7 | 24.0 |
| Road traffic (combustion only) | 25.4 | 22.7 |
| Source: UBA 2006 | | |

Table 3-5

**Specific $PM_{10}$ emissions of certain small wood-burning combustion plants (average figures for plants in the household sector)**

| Firing system | Nominal heat output [kW] | $PM_{10}$ [kg/TJ fuel energy] |
|---|---|---|
| Slow-combustion stoves | < 15 | 71 |
| Tile stoves | < 15 | 111 |
| Fireplaces | < 15 | 158 |
| Hearth ovens | < 15 | 113 |
| Heating boilers | 4 - 25 | 22 |
| Source: UBA 2006 | | |

In straw and other stalk material, the levels of sulphur, nitrogen, chlorine and ash in particular are much higher than in untreated wood. Its combustion can therefore release correspondingly higher emissions of $SO_2$, $NO_x$, HCl (PCDD/F) and (fine) particulates. In view of the high chlorine content and low ash fusion point of stalk material, its combustion can give rise to corrosion and slag build-up problems (WEISS 2001). Data cited by HERING (2006) reveals great differences in emissions by various plant types and makes. There are also differences in the way the material is prepared. Where cereal grain is burned on its own, emissions tend to be higher than for combustion of straw or mixtures. There are also differences between the individual types of grain. With modern systems, however, it is possible to achieve particulate and $CO_2$ emission levels similar to those for wood (FNR press release No. 449 of 17 January 2006). There are nevertheless problems with using mowings from extensive pasture or landscape maintenance areas (heath, bogland etc.). In view of the emission situation improvements achieved to date, there is reason to expect further technological optimisation.

### 3.1.3.2 Thermodynamic technical optimisation of biomass use

**38.** The following information is concerned with optimising biomass use from an energy and thermodynamic point of view. The result of such optimisation need not necessarily be identical with the most efficient solution from an economic point of view. In view of the existence of external environmental effects, the result of such optimisation also need not necessarily be identical with the most efficient solution from a business point of view. In the interests of climate change mitigation, promotion of specific usage paths should not increase such inefficiencies.

In principle, the energy conversion step should minimise the losses of the entire process or usage chain. It may prove efficient to use energy sources in the state (solid, liquid, gaseous) in which they occur or are produced. This avoids conversion losses and improves the energy efficiency of their use.

It is therefore efficient to use wood primarily for heat generation, though there are structural limits to waste heat recovery (RAMESOHL et al. 2006). By contrast, crude oil and its (petroleum) products and also natural gas should be used primarily for mobility purposes. Thus before converting wood into motor fuels, therefore, it makes more sense in terms of energy efficiency to use it for replacing oil and gas in the heating sector. In general, assistance for biomass use for energy purposes should not run contrary to these efficiency criteria.

The efficiency figures for central and distributed heat generation are more or less the same. However, the efficiency of distributed power generation with capacities of a few hundred kW is significantly lower (max. 25 %) than for central power generation (up to 50 %). Distributed processes are thus more suitable for heat than for power generation. Biomass utilisation in distributed plants with comparatively low power generation efficiency levels should therefore take the form of combined heat and power generation.

Since raw materials can only be made from raw materials, whereas electricity (including for mobility) can also be obtained from other renewable energy sources (sun, wind, water), the long-term preference will be to use fossil and biogenic resources to supply materials.

From a climate protection point of view as well, it would make sense as far as use for energy is concerned if renewable raw materials of which only limited supplies are available (cf. Chapter 2.3.2) were only used to a modest extent in the motor fuel sector. Instead, preference should be given to combined heat and power generation. By contrast, biogas produced from residual materials offers, with its lower energy losses, a motor fuel option that should be promoted in the interests of climate change mitigation.

### 3.1.4 Environmental impacts of biomass production and use at international level

**39.** Since imports are necessary to meet biomass requirements in Germany and in Europe (cf. Item 16), it is important that the impacts of biomass farming at the relevant locations be included in these deliberations. For this international frame of reference there is a need for in-depth studies, but these do not fall within the purview of the German Advisory Council on the Environment (SRU). In the context of this special report, the SRU can only point out a few examples of the environmental aspects that are of relevance to biomass production in third countries. Further examination of such issues should be made by the Federal Government's Scientific Advisory Council on Global Environmental Change (WBGU).

A particularly problematic aspect is the growing of biomass under conditions that are not compatible with nature conservation. In many cases it is difficult for users in Europe to appreciate the conditions under which biomass is grown. The processes in the producing countries are often not documented sufficiently to permit their inclusion in life cycle assessments. One example of this is palm oil, which is widely grown in southeast Asia as a feedstock for producing biofuels. In particular, the clearing of primary rainforests to create oil-palm plantations must basically be regarded as problematical, and may cancel out or more than offset the greenhouse gas savings effect of the biofuel. The same applies to the pollutant emissions arising from further processing, which may be harmful to air and water. Furthermore, the additional clearance of primary forests means a further decline in biological diversity. Even positive greenhouse gas or energy balances do not justify the destruction of valuable ecosystems. Although first studies and findings are available on the environmental impacts of palm oil production (cf. REINHARDT et al. 2007; GLASTRA et al. 2002; FRITSCHE et al. 2006), further development of the life cycle assessment approach is needed in these cases to permit an assessment of the greenhouse gas savings potential and the environmental impacts. Existing potential for ecological optimisation of production should also be exploited here, especially since forecasts indicate a doubling of global demand for palm oil by 2030 (REINHARDT et al. 2007).

## 3.2 Impacts on society

### 3.2.1 National frame of reference

**Socio-economic effects in the agricultural sector**

**40.** At national level the expansion of biomass production and use could have effects on the labour market. Net employment effects are expected in the plant engineering sector, above all in view of Germany's technological leadership and the associated trend in exports (BMU 2006). In the agricultural sector the net impact on employment is likely to be slight. ISERMEYER and ZIMMER (2006) expect positive effects mainly in the case of bioenergy lines which are keyed to exploiting hitherto unused energy sources and which do not compete with food production uses (ISERMEYER and ZIMMER 2006, p. 13). Increased growing of biomass can basically have positive effects on the agricultural income of at least certain types of operation; it may result in improved prospects of keeping value added within the region (FNR press release No. 449 of 17 January 2006). In regions such as the central uplands of Germany, where discontinuation of agricultural use would have undesirable consequences for the quality of biotopes and recreation, this could indirectly have positive effects on the environment as well. On the other hand this does not justify the expansion of biomass as a structural policy measure to strengthen rural areas. Biomass utilisation with this object in view would have to compete with other assistance measures pursuing the same objective.

The extent to which any advantages may be cancelled out by countervailing effects is uncertain. The demand for production areas for biomass creates competing pressure on other types of crop. This leads to a rise in land prices, rents and prices in the production of food and animal feeds. In a number of biomass farming strongholds – for example in the Rotenburg, Grafschaft Bentheim or Soltau-Fallingbostel districts of Lower Saxony – a strong upward trend in rents can currently be observed. In some cases the figures for 2006 were nearly three times as high as for 2003 (from € 250/ha to over € 700/ha), and in isolated cases even higher. Whereas rents can be expected to come into line with market levels in the long term, there is a possibility of short and medium-term distortion to the disadvantage of farmers or of displacement effects at the expense of food production (BAHRS and HELD 2007). Grain prices – partly due to worldwide crop failures – increased in 2006, e.g. in the case of wheat by more than 30 % (LfL 2007). Whereas cash crop farms profit considerably from this, fattening and fodder-growing farms are confronted with disadvantages if they have to rely on purchases of animal feeds and bear the burden of a large proportion of rented land.

### 3.2.2 International frame of reference: biomass imports

**Land availability and land use conflicts**

**41.** It is an undisputed fact that ambitious national and EU quantity targets can only be achieved by importing biomass. For this reason we cannot ignore the impacts that biomass production has in the individual producing countries. At the present time only rough estimates are possible of the economic and social effects that could be triggered by an international bioenergy boom (BERGSMA et al. 2007; Project Group Sustainable Production of Biomass 2006). In view of alternative use options and largely identical production factors respectively, the growing of energy crops is in direct worldwide competition with the production of food and animal feeds. Owing to the increasing population and economic growth, the present boom in demand for farm-produced energy sources is accompanied by increased demand for food and a trend towards land use intensive animal feed production for increasing meat production (OECD and FAO 2006). There is a clear correlation between the trends in energy crop prices and the prices of food and animal feed crops. Assuming there is no change in demand for food, a rise in demand for energy crops tends to increase the profitability of growing energy crops compared with alternative agricultural products. There is an increase in demand for agricultural land and other production factors for the production of energy crops. This results in price increases for land and other production factors. Moreover, the usual expectation that energy crops will always be grown on hitherto unused inferior land is not generally true. Indeed, the competition between uses depends on the relative profitability of the alternative land use options. If large profits on energy crops compensate producers for the higher cost of acquiring better land, food production is displaced in the direction of inferior soils (AZAR and LARSON 2000). For certain social classes this can result in adverse changes in the security of food supplies or their land rights (cf. Chapter 4).

**42.** Furthermore, if Germany or Europe becomes more self-sufficient in energy crops, this can have an adverse impact on the production of food and animal feeds in developing countries. The EU is currently a net exporter of agricultural produce. The increased use of agricultural land within the EU for growing energy crops could change this situation and make Europe's food supplies increasingly dependent on imports. This automatically increases demand for agricultural products on the world market, with the result that food will be exported to countries with relatively high purchasing power.

**43.** The increasing demand for additional land use for biomass production in other countries that arises from the necessity for imports could result in land use conflicts between the requirements of industrialised land use geared to global agricultural markets and those of a small-scale agricultural system that produces largely for the people's own needs (subsistence) and for local markets. This conflict potential exists in many developing countries. In such countries there is also the possibility of impacts on land prices or lease (FRITSCHE et al. 2006, p. 13). Such price increases would mostly benefit those groups who own large areas of land and who are in a position to sell or lease parts of it, whereas they would have an adverse impact on the poorer sections of the population who own little or no land. Special attention must also be paid to the issue of long-term supplies for the poorer social strata in the big cities of these developing countries.

**Food supply and food security**

**44.** At the present time it is possible to produce enough food worldwide to feed the entire population. Where people are suffering from food shortages or malnutrition, this is largely due to the fact that owing to lack of purchasing power they have no secure access to available food. 'Food security is currently a distribution problem not a production problem' (WBGU 2005, p. 49). Although biomass production is not the central cause of lack of security of food supplies (FRITSCHE et al. 2006, p. 13; cf. FAO 2006), it can contribute to aggravating existing food problems by giving rise to price increases for agricultural products in response to growing demand created by profitable biomass utilisation processes (cf. ISERMEYER and ZIMMER 2006, p. 3). On the other hand, biomass production may also help to generate income and thereby improve food supplies (FRITSCHE et al. 2006, p. 13).

**Other impacts**

**45.** Depending on the framework conditions, the expansion of biomass production can have varying effects on working conditions (safety precautions, wages, illegal overtime, child labour, quasi-slavery etc.). In particular, the use of pesticides or the air pollution caused by burning off fields can have harmful effects on the health of the persons employed in production (FRITSCHE et al. 2006, p. 21).

Impacts of biomass production on the natural environment can have indirect effects on the living conditions of the local population. For example, water pollution can manifest itself in contamination of drinking water. Soil erosion can result in land no longer being available for farming. However, since these effects are linked to direct environmental impacts of biomass production, the starting point for preventing them consists in the development of environmental standards in the exporting countries (Chapter 4).

## 3.3 Summary

**Life cycle assessment**

**46.** An overall picture of all advantages and disadvantages of the increased expansion of biomass production and use in Germany requires a comprehensive analysis of various production and usage paths. Particularly from the point of view of climate change mitigation, it is necessary to make a sound analysis of the greenhouse gas avoidance potential, taking account of the production paths and processes from start to finish. The greenhouse gas emissions arising especially from land use impacts such as fertiliser usage and land use changes involving carbon losses are frequently overlooked. In principle, life cycle assessment is a suitable tool for assessing greenhouse gas avoidance potential. When defining the assessment framework, however, it is important to ensure that it includes all relevant processes and leads to comparable results.

**Production of biomass**

**47.** The production of biomass is not in itself sustainable. Excessive use of agricultural and forestry residues can result in problems with nutrient cycles. Above all, however, the present rapid expansion of renewable raw materials at both national and international level has impacts on the environment. In particular, intensive farming of such crops often conflicts with nature conservation objectives, especially since conventional farming is already causing serious negative impacts on the natural regime – notably soil and water. However, expanding intensive farming of renewable raw materials onto less productive land that has hitherto been used on an extensive basis aggravates the conflicts with nature conservation objectives. On the other hand, sustainable production methods and the use of a broad spectrum of possible energy crops in an extended crop rotation system can result in synergies with nature conservation.

The large amount of land needed for biomass production runs into problems with the limited availability of suitable land, which is already claimed by competing uses (mainly food and animal feed production). The risks to the natural regime are not so much due to aspects of new forms of cultivation that are particularly harmful to the environment. A much more important aspect is the large-scale increase in the area under crops that have strong adverse effects on the environment. Examples include the growing of rape and maize at the expense of crops posing less of a threat to the environment, and the changed or excessive use of vegetation forms such as forest or pasture that store $CO_2$. Intensive use of land hitherto used on an extensive basis also involves adverse impacts on the environment. Thus there is a general increase in pressure on sensitive regions and biotopes.

It is basically possible to grow renewable raw materials in a sustainable manner. As well as the testing and use of alternative growing methods and traditional varieties, this includes the development of varieties with minimal pesticide and fertiliser requirements. In addition to protecting soil and water, sustainable crops and methods – especially where they replace intensive crops – have positive impacts on biodiversity. To date, however, they have not succeeded in becoming established. Neither is the spectrum of crops usable for energy purposes being fully exploited. There is thus a need to step up promotion of these methods and crops to permit their integration in land use.

Form a geographical point of view there is therefore an increased need for coordination in order to prevent further harm to the environment and define ‘priority areas’ for biomass utilisation. This will make it possible to take better advantage of the synergies mentioned.

**Biomass use**

**48.** In view of life cycle assessment deficits, for example with regard to the climate impacts of land use changes, there is a tendency to overestimate the greenhouse gas reductions resulting from the use of biomass for energy. Particularly because of failure to include the greenhouse gas emissions arising during the production of biomass, it is currently impossible to arrive at any conclusive assessment. A soundly based assessment of technologies is only possible to a limited extent with regard to greenhouse gas savings potential, since the life cycle assessments available to date are based on different accounting frameworks. Nonetheless, the findings arrived at so far lead to the conclusion that stationary use of biomass for electricity and heat production is more advantageous than its use as a motor fuel. Furthermore biogas has advantages, regardless of whether it is used in stationary applications or for mobility purposes. Although BtL fuels have advantages over first-generation biofuels, even this technology, which will only become available for large-scale production in the medium term, appears to have disadvantages compared with stationary use as things stand at present. For this reason, only moderate expansion in the use of biofuels for transportation should be targeted. Stationary use harbours great potential for greenhouse gas savings, especially in heat supply and in combined heat and power generation. Promoting combined use of biomass in this way should thus be pursued further. In general, the physical state of the individual energy source should not undergo multiple changes (e.g. biogas as a substitute for natural gas, wood to heat instead of BtL), in order to keep conversion losses to a minimum. Even if these general energy principles are not always in line with market practice, they should always be observed in promotion policy.

Combustion of biomass continues to pose environmental problems with regard to particulate emissions, especially in the case of small systems. Ambitious emission limits must be laid down to bring about reductions. Using solid fuels by means of gasification and subsequent gas combustion can make a contribution to solving the problem.

**Impacts on society**

**49.** On a national scale the socio-economic impacts can be classified as relatively minor. Nevertheless, the fact that imports of biomass are needed to achieve the energy policy targets for Germany and the EU means that the international level is affected as well. Here it is important to comply with high social and environmental standards. The basic criterion should be that imported biomass is grown under similar environmental and social conditions to those prevailing in Germany. Biomass utilisation is neither sustainable, nor does it serve the interests of climate change mitigation, if the production conditions abroad fail to satisfy certain minimum requirements. In the producing countries, production of biomass for export can lead to food shortages, land use conflicts or even the destruction of primary rainforest in favour of crop-growing land. With respect to sustainability, any national biomass strategy should take global impacts into account to prevent such adverse effects.

# 4 Guard rails and fields of action for supporting standards for the sustainable production and use of biomass

## 4.1 Introduction

**50.** In general, the introduction of new technologies calls for a political approach that either reduces or precludes their foreseeable undesirable consequences and side-effects. Substantive principles, analytical schemes and suggested methods have been drawn up in the context of a theory of technology assessment (OTT 2005; ROPOHL 1996; HASTEDT 1991). It has become clear from the preceding chapters that biomass utilisation is a complex field of activities which requires a particularly high degree of political and legal organisation because of its connections with agriculture and with energy policy (see also DRL 2006). Especially where new technologies receive substantial assistance from government, it is important to ensure that no serious adverse effects arise from their use – and hence from the assistance provided.

**51.** The German Advisory Council on the Environment (SRU) regards biomass utilisation as an opportunity to promote sustainable, environmentally sound and socially acceptable development. Nevertheless, people have come to realise that sustainable, environmentally sound and socially acceptable production of biomass needs to be ensured by means of 'guard rails' and standards. For example, the EU Commission sets out the following conditions for biomass production in its Biomass Action Plan (EU Commission 2005):

- no effect on domestic food production for domestic use;
- no increase in pressure on farmland and forest biodiversity;
- no increase in environmental pressure on soil and water resources;
- no ploughing of previously unploughed permanent grassland.

According to the action plan, these conditions are to be satisfied by means of

- a shift towards more environmentally friendly farming, with some areas set aside as ecological stepping stones, and
- ensuring that the rate of biomass extraction from forests is adapted to local soil nutrient balance and erosion risks.

Thus the European Commission is working on the basis that production of renewable raw materials should only take place within certain 'guard rails'. By proposing especially environment-friendly farming methods for the growing of renewable raw materials, the EU action plan recommends efforts for biomass that go beyond current land use practices. On the other hand the conditions mentioned by the Commission are only initial starting points that need to be amplified, systematised and given more concrete shape. In April 2007 the EU Commission therefore initiated a public consultation procedure for discussing in particular the necessary elements of a biomass regime aimed at reducing greenhouse gas emissions and minimising environmental risks (EU Commission 2007b). At national level, an environmental framework for the cultivation of renewable raw materials can be laid down on the basis of Section 37 d paragraphs 3 and 4 of the Federal Immission Control Act (BImSchG) in particular. Under these provisions, the federal government may prescribe by statutory ordinance that biofuels may only be counted towards the biofuels target quota if the production of the biomass used demonstrably satisfies certain requirements for the sustainable management of farmland or for the conservation of natural habitats, or if biofuels possess a certain $CO_2$ reduction potential. The federal government may also lay down requirements for more precise definition of these criteria.

**52.** This chapter is intended to provide general guidance on the necessary organisation, definition of guard rails and standards, and examination of regulation options. As regards contents, the German Advisory Council on the Environment bases its approach on the concept of 'strong' sustainability which it advocates (cf. SRU 2002b, Chapter 1; OTT and DÖRING 2004). The management rules involved in this concept (SRU 2002b, Item 29) call for replacement of non-renewable by renewable energy sources, which means that biomass utilisation is basically to be welcomed. On the other hand, the same understanding of sustainability also gives rise to environmental objectives for land use systems that can conflict with certain biomass production variants. The SRU therefore takes an extremely critical view of the unmistakable tendencies, due partly to biomass utilisation, towards pressure to intensify land use, especially in the forestry sector.

**53.** In previous reports, the German Advisory Council on the Environment has operationalised a number of guard rails and standards for the agricultural sector (SRU 2002b; 2004, with further references). These do not apply exclusively to the use of biomass, but are aimed at agricultural production as a whole. These general guard rails and standards are described below with special reference to the production of renewable raw materials and, where necessary, specified. Since the increasing demand for renewable raw materials can only be met through imports (cf. Section 2.3), it is also necessary to lay down guard rails and standards in the potential exporting countries. This calls for cooperation and contractual arrangements between importing and exporting countries (cf. Item 91 ff.). Ultimately, certification systems are also based on such standards.

**54.** Of the technology assessment criteria, only the criteria of social acceptability and environmental soundness, and especially nature conservation interests, are discussed below. In view of the distinction between the national and the global level, this results in four fields of action.

For these fields of action the following sections set up normative 'guard rails' which will as far as possible be given concrete shape in standards and examined with regard to the legal regulation options for the implementation of these standards. The standards are intended to define specific levels of protection for certain protected assets. In principle, the German Advisory Council on the Environment proceeds on the assumption that the production of renewable raw materials should be subject to the same standards as the production of other agricultural produce, especially food. This does not exclude the possibility that there may in individual cases be reasons why biomass-specific rules might prove sensible or indispensable (Items 55, 58).

## 4.2 National challenges

### 4.2.1 Environmental aspects

**55.** The following remarks focus on agricultural production of renewable raw materials. The various impacts of the expansion of such production are based on complex interactions (cf. Table 3-3). A distinction can be made between impacts that generally occur wherever intensive farming is practised, and impacts that are specific to the growing of renewable raw materials. Regarding those impacts that occur in connection with any type of intensive farming, it is important to note the increasing geographical expansion of renewable raw materials production, which results in a general pressure to intensify. This applies not only to individual areas of farmland, but also to the expansion of the total area. The increase in demand for agricultural produce which is triggered by the use of biomass can be met either by increasing crop yields or by using additional land which has hitherto been farmed extensively or not at all. This pressure to intensify justifies the need for new standards, farming practices and framework management.

#### 4.2.1.1 Nature conservation standards for minimising the environmental impacts of the production of renewable raw materials

**Standards for non-biomass-specific impacts**

**56.** Approaches to regulating the adverse impacts of agriculture due to farming of food and animal feeds and also of renewable raw materials are offered by the rules for "Gute fachliche Praxis" (good professional practice, cf. Table 4-1) and the cross-compliance rules (cf. Table 4-1). The German Advisory Council on the Environment states a considerable need for improvement with regard not only to the specification and binding character of the requirements of "Gute fachliche Praxis" (good professional practice), but also to monitoring of compliance with them (cf. SRU 2002a, Item 359). Production of renewable raw materials should not lead to any dilution of standards, but to rigorous design and implementation of the criteria of "Gute fachliche Praxis" (good professional practice). In particular, the growing of renewable raw materials should not present a threat to the multi-functionality of agricultural land.

**57.** Since the production of renewable raw materials leads to increased production pressure on land already used for intensive farming, and to an increased tendency towards intensive farming of land that is only farmed extensively or not at all, rigorous enforcement of the standards of good professional practice is essential. Additionally, the SRU advocates a partial tightening of standards for the following points:

- Use of fertilisers: Eutrophication of the landscape is one of the main reasons for loss of biological diversity (REID et al. 2005; EEA 2006; HÄRDTLEIN 2000). Discharges of nitrogen place heavy burdens on the environmental media 'soil' and 'water'. In its Environmental Report 2004, the SRU proposed the introduction of a nitrogen excess charge tied to a basic allowance of 40 kg N/ha (SRU 2004, Item 324 ff.). In view of the continuing high level of nitrogen excesses, there would seem to be a need for the introduction of such a charge to accompany the legal provisions and support their enforcement.
- Use of pesticides: Integrated crop protection is based on minimising the use of pesticides, especially through cultivation of resistant and site-appropriate varieties, giving priority to the use of beneficial organisms and plant fortifiers, and tying the use of pesticides to damage thresholds. In order to reduce the adverse impacts of pesticide use, the SRU suggests

compulsory application of the principles of integrated crop protection in farm management (BMVEL 2005).

- Tightening of crop rotation: Maintenance of at least a threefold crop rotation with no exceptions would seem to be an appropriate minimum requirement, in order to counteract the further expansion of certain crops which are already reaching their limits (e.g. rape).
- Ban on ploughing up permanent grassland: Neither the cross-compliance rules nor the rules of “Gute fachliche Praxis” (good professional practice) applied to specific sites in the Federal Nature Conservation Act (BNatSchG) offer adequate protection against ploughing of pasture. There is therefore a need for a general ban on ploughing up pasture.
- Protection of fringe elements and structural elements: To supplement the protection of fringe elements and structural elements that is laid down in the Federal Nature Conservation Act (BNatSchG) and in the cross-compliance rules, one might consider a compensation system (similar to the “Eingriffs-Regelung” (interference rules) under nature conservation law) which did not completely prevent changes in farm field layout, but did not alter the overall values and elements for landscape elements.

In the case of land subject to statutory protection, a need is seen for conservation area ordinances to specify greater detail with regard to the growing of renewable raw materials. Any growing of genetically modified plants for biomass production must not worsen the prospects of ensuring the permanent coexistence of GM- and non-GM-crops.

**Specific standards for the production of renewable raw materials**

**58.** Specific standards for the production of renewable raw materials are only needed in the case of impacts that do not occur when growing food and animal feeds. The SRU takes the view that in the light of current findings the following impacts of biomass production expansion create a need for specific regulations:

- Removal of organic material, especially residual material (straw, leaves, dead wood): biomass utilisation opens up hitherto non-existent opportunities for using such residual material. Simply for reasons connected with greenhouse gas optimisation of biomass production and use processes, the removal of such material must not lead to a decline in the organic content of the soil. With regard to the removal of organic material, there would seem to be a need for evidence of a good humus balance.
- Growing of new species or varieties of renewable raw materials: For nature conservation reasons, the growing of new or genetically modified species and varieties of renewable raw materials may require special species-specific regulations.

Against the background of the increased demand for agricultural produce caused by the expansion of renewable raw materials production, it is important to review the need for a set-aside bonus designed to reduce agricultural surpluses. The resources thereby liberated could be used via agro-environmental programmes to serve the interests of nature conservation. Since there is still a lack of adequate research into the overall impacts of increased production and use of biomass, the standards listed by the SRU cannot be seen as more than initial steps towards long-term environmentally sound regulation of the growing of renewable raw materials. Additional findings about environmental impacts may make it necessary to define further standards in the future.

**Objectives for site-specific and location-specific impacts of biomass use**

**59.** For comprehensive regulation of site-specific and location-specific impacts of renewable raw materials production there is a need for a range of spatial instruments, because many purposes or limits of the growing of renewable raw materials can only be defined in relation to specific location types or regions, as it is only then that their characteristic sensitivities can be taken into account (cf. Item 69 ff.). This approach is efficient, since it avoids imposing unnecessarily high restrictions on less sensitive land. A summary of the nature conservation standards mentioned can be found in Table 4-1.

### 4.2.1.2 Synergies with nature conservation

**60.** In view of a number of pronounced environmental problems affecting German agriculture compared with the EU average, for example the relatively high nitrogen excesses of 105 kg N per hectare per year (BMELV 2006b; see also REID et al. 2005; EEA 2006; HÄRDTLEIN 2000 for the environmental impacts), it would seem particularly desirable not merely to maintain the status quo of environmental quality, but actually to take advantage of the shift of some agricultural production to the growing of renewable raw materials as an opportunity to reduce environmental burdens. Since special assistance is given to the production of renewable raw materials and the use of biomass in the interests of environmental objectives, it is particularly desirable and necessary that this sector should play a pioneering role.

**61.** Bioenergy potentials that give reason to expect synergies with the requirements of nature, soil and water conservation are therefore especially eligible for assistance (REINHARDT et al. 2005, cf. Chapter 3). Other synergies can be achieved (see also CHOUDHURY et al. 2004, p. 53) if biomass production

- prefers native to non-native species;
- minimises the use of pesticides;
- minimises the use of fertilisers;
- ensures soil protection and/or erosion control;
- satisfies water conservation requirements;
- promotes the restoration of native ecosystems and biotope network formation.

**62.** According to present knowledge, the following cropping methods appear to be particularly consistent with nature conservation (similar findings in DRL 2006, p. 40):

- coppice forest and composite forest (hazel, birch, hornbeam, aspen etc.),
- short-rotation plantations,
- use of grassland mowings and woody prunings, especially from landscape maintenance, for energy purposes,
- low-input-low-output crops,
- mixed crops and two-crop systems (the latter only in high-rainfall areas).

Such cropping methods should be promoted via agro-environmental measures. The resulting beneficial impacts on protection of the ecosystems would then be a ‘spin-off’ of the production of renewable raw materials. The use of landscape maintenance prunings as biomass is also conceivable in this context and should be targeted. Climate-optimised use of such ‘co-products’ is particularly worth promoting.

### 4.2.2 Socio-economic effects

**63.** The consequences listed in Item 41 suggest that price increases for agricultural produce are probable. Working on the basis of average yields per hectare, future increases in the price of primary products are likely to be spread over the entire processing and allocation chain, with the result that there will probably be no substantial increase in end product prices. Thus biomass production is unlikely to have any appreciable impact on the food situation of the German population (see also DRL 2006).

**64.** There is some doubt as to how a moderate increase in food prices should be viewed. A slight increase in the share of household income spent on food seems reasonable. In view of the overall problem of industrial meat production (STEINFELD et al. 2006), a possible increase in meat product prices as a result of competition between biomass utilisation and animal feed production should on balance be regarded in a positive light. A realisation of the limited availability of arable land in view of a large number of competing use options (food, alcoholic drinks, animal feeds, biomass for the various usage paths) could lead to a welcome new awareness of agricultural policy issues among the general public and could contribute to a change in consumer habits that would be desirable from an environmental point of view.

**65.** On the whole, the social impacts of biomass production at national level are not serious either for consumers or for producers. On the other hand, one should take a sceptical view of excessive hopes regarding the development of rural areas. Unlike the socio-economic impacts of imports of renewable raw materials in the producing countries, the German Advisory Council on the Environment does not see any special need for regulation with regard to the socio-economic impacts within Germany. However, the SRU is assuming here that average yields per hectare in the food production sector in the Central European production areas remain at least constant (IPCC 2007). If this assumption had to be reviewed as a result of climate change, food production would obviously take priority over biomass. This priority would be even more true on an international scale.

## 4.3 Instruments for environmentally sound support for renewable raw materials production at national level

**66.** Existing research findings on the production of renewable raw materials do not yet make it possible to establish a comprehensive ‘grid’ of standards of sufficiently ambitious scope and goals to guarantee the elimination of environmental threats. Indeed, it has to be said that research in this field is hardly keeping pace with the rapid expansion of renewable raw materials production. This expansion is a consequence of the extremely dynamic design of the state funding for production and supply (Section 5.1.2 and Section 5.2). For reasons of damage limitation and precautionary environmental protection, there is thus an urgent need to decelerate the promotion of renewable raw materials. Without such action, there is a risk that to ensure attainment of (dynamically increasing) renewable energy targets, environment-related requirements will be formulated in such a way that they provide less than adequate protection.

**Minimum requirements for modification of nature conservation and agricultural law**

**67.** On the basis of the existing findings (Item 57 ff.), it emerges that at least the following modifications to nature conservation and agricultural legislation are necessary to ensure environmentally sound support for the production of renewable raw materials:

- A revision of the Fertilisers Act to introduce a regionally differentiated nitrogen excess charge (SRU 2004, Item 324 ff.; for the legal admissibility of fertiliser charges, see: MÖCKEL 2007).

  Partial tightening of the good professional practice requirements under fertiliser legislation as a result of the 2006 revision of the Fertilisers Ordinance (DüngeV) (including further restrictions on the use of organic manure of animal origin, specific minimum distance rules, the prohibition of certain application techniques, and specifications for the fertilisation of arable land having a pronounced slope towards bodies of water) are not sufficient to ensure environmentally sound use of fertiliser.

- More precise specifications for integrated crop protection with simultaneous enhancement of its legal status.

  Integrated crop protection as an element of good professional practice pursuant to Section 2 a para. 1, third sentence, of the Crop Protection Act (PflSchG) assigns essentially secondary importance to the use of pesticides compared with other pest control measures (cf. Section 2 No. 2 PflSchG). With its model character, however, it is too unspecific to be capable of performing a control function (cf. Section 2 a para. 1, third sentence, of the Crop Protection Act (PflSchG): 'to take account of the principles of integrated crop protection [...]'; SRU 2004, Item 359). Even the principles of good professional practice published by the Federal Ministry of Food, Agriculture and Consumer Protection on the basis of Section 2 para. 2 of the Crop Protection Act do not include very precise action requirements (BMVEL 2005). More detailed minimum requirements should be developed, especially with reference to the guidelines for integrated protection of arable crops published by the Federal Biological Institute for Agriculture and Forestry (BBA 2004) and the requirements imposed by certain federal states under their agro-environmental programmes. A glance at relevant specification measures in other European countries would also be useful (overview in OPPERMANN et al. 2005). There would also seem to be a case for enhancement of the legal status of integrated crop protection on the lines of a duty of compliance in the context of good professional practice (at present: duty to take into account, Section 2 a para. 1, second sentence, Crop Protection Act). Furthermore, the competent authorities should be obliged to offer advisory services to farmers in the interests of proper implementation of integrated crop protection.

- Tightening of crop rotation regulations

  Giving more concrete shape to the obligation to maintain all agricultural land in good agricultural and environmental condition in accordance with Art. 5 para. 1 and Art. 3 para. 1 of Council Regulation No. 1782/2003 of 29 September 2003 establishing common rules for direct support schemes under the common agricultural policy and establishing certain support schemes for farmers, German national law (Direct Payment Obligations Ordinance (DirektZahlVerpflV)) requires the following alternatives from all direct payment recipients:

  - growing of at least three crops a year with a minimum area of 15 % per crop (Section 3 para. 1 DirektZahlVerpflV),
  - growing of one or two crops a year, provided a different crop is grown on each of the areas in three successive subsequent years (Section 3 para. 3); supplementary rules exist for cases of area switching; or
  - the preparation of an annual humus balance subject to detailed specifications (Section 3 para. 4 and 5).

  With its specifically soil-oriented protective purpose, the provision is not suitable for taking proper account of biodiversity protection aspects. It should therefore dispense with the existing options and be transformed into an obligation to maintain a threefold crop rotation. This obligation should be combined with a requirement that makes it possible to specify that a certain minimum number of crops per year is to be grown on certain percentages of the farmland.

  Above and beyond the Direct Payment Obligations Ordinance, which only applies to farms that receive direct payments under the EU agricultural assistance, such an obligation should be embodied in the good professional practice requirements of nature conservation law. If decoupled from direct payments, these obligations would not only be legally upgraded, but would also move compliance control within the competence of the nature conservation authorities. By contrast, the on-site cross-compliance checks, which are in any case only carried out in a small number of cases (4.92 %

of direct payment recipients in 2006 (EU Commission 2007a)), fall within the competence of the agricultural authorities, who are not primarily charged with safeguarding nature conservation interests. On the other hand the resources of the nature conservation authorities in many places are so limited that no increase in compliance checks can be expected, at least in the near future (SRU 2007, Item 102 ff.; BENZ et al. 2007). Additional instruments are therefore needed to ensure implementation of the crop rotation regulations. The certification system currently under discussion for renewable raw materials could be used for this purpose (Items 51, 68).

- Increased legal protection for permanent pasture

  Current legislation does not contain any comprehensive ban on ploughing up permanent pasture. Section 5 para. 4, fifth indent, of the Federal Nature Conservation Act prohibits ploughing of pasture only on certain areas that are particularly sensitive from an environmental point of view. This provision should be extended by a general ban on ploughing of permanent pasture, such as already exists in Spain, Italy and Greece and applies on a location-specific in basis in Austria. There is no rigorous protection of permanent pasture in European legislation either. The cross-compliance regulations provide only for quantity-based protection of permanent pasture in the form of a requirement to maintain the net area under pasture. Although Art. 5 para. 2 sub-para. 1 of Regulation 1782/2003 contains a general obligation to maintain permanent pasture, exceptions to this obligation may, under para. 2 sub-para. 2, be made in ‘duly justified circumstances’ provided measures are taken to prevent any significant decrease in the total permanent pasture area. Neither Regulation 1782/2003 nor the relevant implementation regulation 795/2004 defines what qualifies as duly justified circumstances. The latter merely lays down that ploughing of permanent pasture is to require an official permit if there is a decrease in the total area. Moreover, a loss of more than 10 % permanent pasture in relation to the base year 2003 is to be prevented by official orders to sow new pasture (Art. 4 para. 1 and 2 of the implementation regulation). Increased protection for permanent pasture could be provided relatively quickly by defining a strict interpretation of the unspecific legal concept of ‘duly justified circumstances’ in a revised version of the implementation regulation. A comprehensive ban on ploughing at European level would however require modifications to the Cross-Compliance Regulation itself. At national level a revision of the Federal Nature Conservation Act would be needed to introduce a ban on ploughing of permanent pasture. For direct support recipients such a standard could be applied in the short term by means of stringently worded Land legislation on the basis of Section 5 para. 3 No. 1 of the Act regulating compliance by farmers with other obligations under Community law provisions on direct payments (Direct Payment Obligations Act – DirektZahlVerpflG).

  In practice, however, a ban on ploughing permanent pasture can only perform a steering function if it is not undermined by economic incentives. The promotion of renewable raw materials (Sections 5.1.2 and 5.2), in combination with other elements of agricultural assistance policy, reinforces the incentives for increased ploughing of permanent pasture (cf. BMELV 2006a, Annex 15; SRU 2004, Item 262). From 2005 to 2006 alone, 47,000 hectares of pasture were lost in Germany as a whole (press release of 9 July 2007 by Cornelia Behm, member of the Bundestag). This is due to

  - the withdrawal of agricultural support for livestock farming with grazing systems qualifying for nature conservation oriented assistance, and
  - the cuts in financial resources for agro-environmental measures in accordance with the second pillar of rewards for the conservation or appropriate use of permanent pasture.

  Against this background there is an urgent need for a critical overall review of the individual components of current agricultural assistance policy with the aim of their consistent orientation to environmental criteria.

- Safeguarding nature conservation and landscape maintenance in protected areas

  Another indispensable measure is a review of the existing conservation area ordinances and other protection concepts, especially for NATURA 2000 areas, which in many cases have only rudimentary requirements with regard to co-financing. In some cases protected areas are only safeguarded as a whole (BENZ et al. 2007). Where appropriate, the basic protection needs to be supplemented to reduce the extent to which the success of the protective efforts depends on voluntary agro-environmental programmes which are increasingly finding themselves on the defensive.

**68.** In view of the severely restricted capacity of the authorities, monitoring of the requirements described above can only be ensured to a limited extent via the control mechanisms of cross-compliance or the monitoring powers of the environmental authorities. In the interests of effective environment protection, monitoring of compliance with the regulations should therefore be incorporated in the certification that is being established for biofuels from environmentally sound production pursuant to Section 37 d of the Federal Immission Control Act. Under this provision, assignment of fuels to the biofuels quota (Items 51, 128) may be made conditional upon evidence of compliance with specified sustainability standards. Consideration is also being given to the possibility of stipulating that assistance for electricity generation under the Act giving priority to renewable energy sources (Renewable Energy Sources Act – EEG) will depend on certification of the material used (KOTYNEK 2007). Certification systems provide an opportunity to shift the onus of proof of compliance with standards onto the producer of the renewable raw materials and thus place the burden of the monitoring costs on the party giving rise to them. It is nevertheless important to ensure the necessary modifications to the relevant environmental and agricultural legislation. It would not be sufficient to identify environmental standards as the sole criteria for the promotion of renewable raw materials. In the first place, such an approach would not do justice to the fact that the great majority of environmental problems are not due solely to the expansion of renewable raw materials (Chapter 3.1). Moreover, laying down specific standards for the promotion of renewable raw materials would in practice lead to substantial demarcation problems and would open up opportunities for circumvention at the expense of effective environmental protection.

**In particular: Planned geographical control of growing of renewable raw materials**

**69.** As a result of the growing production of renewable raw materials, it is foreseeable that there will be an increase in competition for land use within the agricultural sector, and also between agriculture and other forms of land use. To resolve such competition for space, there is a need for better coordination of the various usage interests and, where appropriate, for resolution of such competing interests in the context of planning-oriented conflict management. From an environmental standpoint, the primary objective of such planning must be to ensure differentiated utilisation of space on the basis of environmental criteria, with guard rails for the use of specific areas (SRU 2002a, Item 417). This also means, however, that planning-oriented control segmented on the basis of the individual agricultural production sectors in the form of food, animal feeds or renewable raw materials production can essentially only be considered to the extent that these sectors involve different environmental hazard potentials. Above and beyond geographical allocation of locations (‘where’), it would also be possible in principle to prescribe the overall scale of such use (‘how much’) in the planning process (for the admissibility of such quantity-related allocations, see KOCH and HENDLER 2004, p. 49). At present, however, modifying the promotion of renewable raw materials offers a more direct, though less easily differentiated means of controlling production land.

**70.** Limits to the expansion of farmland in environmentally sensitive areas should be set in the context of regional policy, and especially at the regional planning level. This is also the place for environmentally necessary restrictions on agricultural usage types. Subsequent designation of protected areas under nature conservation, water resources management or soil protection law is as far as possible to be guaranteed by area-specific representations in the form of priority or reserved areas (e.g. in particular for areas for nature and landscape conservation, see SRU 2002a, Item 262, with further references). Particularly as binding objectives of regional policy, this would safeguard such environmental planning declarations against later conflicts. Such stipulations would prevent the lower planning authorities from permitting conflicting uses in the relevant areas (cf. Section 4 para. 1 Federal Regional Policy Act – ROG)). Where there are loopholes in the protection afforded by existing conservation area ordinances (Items 29, 67), it is not possible to use regional planning measures to take corrective action (Federal Administrative Court (BVerwG), judgement of 30 January 2003, Ref. 4 CN 14.01, NuR 2003, p. 489 ff.). It should nevertheless be permissible to use regional planning designations to exert influence on the protection goals and the minimum protection of future protected areas. The possibility of using regional planning to protect natural resources is however being increasingly undermined directly or indirectly, for example by the abolition, under the revision of Schleswig-Holstein’s nature conservation legislation, of the arrangement for designating priority nature conservation areas (Schleswig-Holstein parliament 2007) or by general tendencies to relativise landscape planning as nature conservation related sectoral planning (SRU 2007, Item 234 ff.).

**71.** The control effects of regional planning in the agricultural sector are however limited by the fact that relevant determinations, even as binding objectives of regional policy, do not have any direct binding force in relation to the individual citizen. Basically they only target public agencies, and to acquire binding external force they need to be implemented under a further, usually administrative, sovereign act (Section 4 para. 1 Federal Regional Policy Act – ROG). Only new construction of or significant constructional changes to farms are subject to official approval, but not changes in the use of existing agricultural land. Construction planning law as a form of local overall planning which is to be adapted to the objectives of regional policy (Section 1 para. 4 Federal Building Code – BauGB) is not an instrument with a comprehensive development and regulation mandate (existing fundamental decision: Federal Constitutional Court (BVerfG), judgement of 16 June 1965, Ref. 1 PBvB 2/52, BVerfGE 3, p. 407 ff.). Only where the construction is associated with land take is it subject, as a ‘miscellaneous use’, to local physical development planning. In principle such a connection, which is receiving increasingly wide interpretation (SÖFKER, in: ERNST et al. 2007, Section 1 marginal number 12), also exists between agricultural construction work and agricultural land use. Nevertheless, it will only be possible to a very limited extent to use construction legislation to influence agricultural production methods, which are furthermore not necessarily designed to be permanent. This is because the Federal Building Code is based on the title to competence provided by land law (Art. 74 No. 18 Basic Law – GG). Other fields of regulation, for example the law of landscape maintenance in particular, are only dealt with in certain areas as an annex (HENDRISCHKE 2002, p. 153 ff.). It would at any rate be permissible, when designating agricultural land pursuant to Section 9 para. 1 No. 18 a Federal Building Code (BauGB), to differentiate between the branches of agriculture listed in Section 201 Federal Building Code. Thus it would be possible to differentiate between arable farming and meadow or pasture farming (e.g. Baden-Württemberg Higher Administrative Court, judgement of 7 December 1995, Ref.: 5 S 3168/94 – juris, concerning the restriction of land for agriculture as meadow land). The instrument of physical development planning could thus be used to maintain pasture land, since such determinations would render other forms of agricultural use inadmissible. As a ‘planning offering’, however, physical development planning can in principle only decide on the admissibility of certain land uses. It cannot establish an active duty to actually implement the designated use, for example in the form of management of permanent pasture or even the sowing of new pasture. The approach suggested here of a statutory ban on ploughing of permanent pasture would, by contrast, not require extensive designations of an urban development nature in view of the lack of need for *planning-oriented* conflict management (Section 1 para. 3 Federal Building Code – BauGB).

Even beyond this, however, construction planning law offers certain – though not extensive – possibilities of influencing agricultural land use. Greater consideration should be given to these in future. On the basis of Section 9 para. 1 No. 20 Federal Building Code (BauGB), for example, restrictions on agricultural land use are possible, especially for the purpose of nature conservation, even if the land is farmed in accordance with good professional practice. It is even possible on water conservation grounds to make extensification of farming in a particular area the subject of local authority physical development planning (HENDRISCHKE 2002, p. 186 f. with reference to Federal Administrative Court (BVerwG), decision of 3 December 1998, NVwZ-RR 1999, p. 423, and Munich Higher Administrative Court, judgement of 3 March 1998, NuR 1998, p. 375 f.). Moreover, changes in cropping methods that represent a change in the traditional function of the farm can also be relevant from a construction law point of view (e.g. large-scale use of new crops such as *Miscanthus* or other significant changes in the function of the farm that mark a shift from ‘agriculture to energy’).

**72.** Basically the growing of renewable raw materials should only be promoted where it does not run counter to the binding objectives of regional policy and, where appropriate, the determinations of physical development planning. This should be ensured by a suitably worded condition for assistance.

**73.** Table 4-1 contains a summary of the minimum nature conservation standards with which compliance is required to prevent environmental hazards, the relevant legal regulations, and the foreseeable need for regulation on the basis of existing findings:

Table 4-1

**Biomass production: Nature conservation requirements and need for regulation**

| Processes | Nature conservation standards | Main legal provisions | Need for regulation |
|---|---|---|---|
| Increased use of fertilisers | Rigorous application of good professional practice; reduction of nitrogen excesses by introducing a nitrogen excess charge for excesses greater than 40 kg N/ha/a | Fertilisers Act (DüngMG) (esp. Section 1 a), Fertilisers Ordinance (DüngeV) | - Revision of Fertilisers Act and Fertilisers Ordinance to introduce a compulsory charge |
| Increased use of pesticids | Rigorous application of good professional practice; upgrading of integrated crop protection | Section 2a Crop Protection Act (PflSchG) | - Specification of integrated crop protection pursuant to Section 2 a para. 1, third sentence, Crop Protection Act (PflSchG)<br>- Obligation to provide guidance for farmers |
| Land use changes or area conversions | - Ban on ploughing of permanent pasture at all locations<br>- Review and if necessary modification of conservation area ordinances with (if necessary) cultivation restrictions in NATURA 2000, nature conservation and landscape protection areas; if necessary, restrictions in water conservation areas;<br>- Need to examine further standards for protection of fringe elements and structural elements | **Regarding pasture:** Section 5 para. 4, 5th indent, Federal Nature Conservation Act (BNatSchG), Art. 5 para. 2 Reg. 1782/2003 in conjunction with Art. 3 Reg. 794/2004,<br>Section 3 Direct Payment Obligations Act (DirektZahlVerpflG)<br>in conjunction with Land legislation<br>Regarding conservation areas:<br>Sections 22 ff. and 8, Federal Nature Conservation Act (BNatSchG) in conjunction with Land legislation (conservation area ordinances, contract-based nature conservation) | Regarding pasture:<br>- Inclusion of a basic ban on ploughing<br>- Short term: Tightening of Reg. 794/2004, medium term: inclusion of a basic ban on ploughing in Reg. 1782/2003<br>- Short term: Ban on ploughing through provisions under Land legislation<br>**Regarding conservation areas:** Where appropriate, revision of ordinances, adjustment of contracts |
| Limited or standardised crop sequences | Rigorous application of good professional practice; compliance with at least threefold crop rotation; development of parameters for avoiding dominance of individual varieties<br>Promotion of especially conservation-friendly | Section 5 para. 4, 1st indent, Federal Nature Conservation Act (BNatSchG),<br>Sect. 17 para. 2 no. 6, Federal Soil Protection Act<br>Art. 5 para. 1 Reg. 1782/2004 in conjunction with Section 5 | - Inclusion of a separate obligation to maintain threefold crop rotation with the possibility of reducing percentages of farm area for crops in Section 5 para. 4 Federal Nature Conservation Act (BNatSchG)<br>- Binding specification of threefold crop rotation |

| Processes | Nature conservation standards | Main legal provisions | Need for regulation |
|---|---|---|---|
| | production methods | para. 1 No. 2 Direct Payment Obligations Act (DirektZahlVerpflG) and Section 3 Direct Payment Obligations Ordinance (DirektZahlVerpflV)<br>- (legally non-binding) agro-environmental programmes | with annual crop ratio requirements through revision of Direct Payment Obligations Ordinance (DirektZahlVerpflV)<br>- Modification/ upgrading of agro-environmental programmes for promoting especially conservation-friendly production methods |
| Growing of water-intensive crops in dry locations | Rigorous application of good professional standards; site-appropriate varieties and production methods | Section 5 para. 4, 5th indent, Federal Nature Conservation Act (BNatSchG);<br>(legally non-binding) agro-environmental programmes<br>where appropriate, programmes of measures under Section 36 Federal Water Act (WHG) in conjunction with land legislation | - Modification/ upgrading of agro-environmental programmes for promoting especially conservation-friendly production methods |
| Removal of organic material including residual material | Maintenance of good humus balance | Sect. 17 para. 2 no. 7, Federal Soil Protection Act (BBodSchG) | Currently no need for regulation |
| Use of genetically modified organisms | Ensuring permanent coexistence of different types of production | Genetic Engineering Act (Gesetz zur Regelung der Gentechnik) | Currently no need for regulation |
| | | | SRU/SG 2007-2/Table 4-1 |

## 4.4 International challenges and perspectives for setting standards

**74.** This section looks at the social and environmental conflict potential that could arise in the producing countries as a result of increased imports of biomass into Germany. The subsequent remarks on perspectives for the development of standards and legal framework conditions focus on the question of environmentally sound growing of renewable raw materials.

### 4.4.1 Social conflict potential

**75.** Chapter 3 described the negative social impacts that unregulated expansion of biomass utilisation could have, especially in developing countries (Item 41 ff.). The socio-economic changes brought about by expansion of biomass utilisation should not lead to any deterioration in the social situation of population groups in the producing countries who are already disadvantaged. However, it cannot be concluded from this minimum criterion that the existing socio-economic situation in developing countries meets ethical standards of equitable distribution. It would therefore be desirable if the expansion of biomass utilisation brought socio-economic changes that benefited particularly disadvantaged sections of the population. The following aspects are of relevance to both these criteria:

- security of food supply,
- working conditions,
- land rights.

**76.** Changes in relative prices pose a considerable threat to poorer sections of the population. If biomass production leads to price increases for agricultural produce, it may aggravate existing food problems (ISERMEYER and ZIMMER 2006, p. 3). Whereas such price increases may generate additional income for producers of agricultural produce, they can have a negative impact on poorer sections of the population in both rural and urban areas (UN-ENERGY 2007, p. 31). The 'Tortilla Crisis' in Mexico in January 2007 (e.g. Süddeutsche Zeitung of 15 January 2007) could be an indication that such conflicts are already making themselves felt.

**77.** The concept of food security provides a general normative criterion here. It is based not so much on the quantity of existing food supplies, but rather on continuous access by various social strata to an adequate and sufficiently varied diet. For many population groups this standard is currently not satisfied. It is therefore necessary to take a critical view of both biomass production and animal feed production for the European and US markets in regions where the population's food security is already low. Further deterioration as a result of export-oriented biomass production is not morally justified. The concept of food security and the ban on making the situation worse can be described in more detail on the basis of the following parameters (cf. for example FAO 2001; WBGU 2005):

- continuity of supplies,
- adequate quantity,
- nutritionally balanced diet,
- safety to health, and
- share of income spent on food.

**78.** The expansion of biomass production can have both positive and negative effects on working conditions (safety precautions, pay, deductions, unpaid overtime, child labour etc., cf. FRITSCHE et al. 2006, p. 20). Biomass production should be organised such that the working conditions in this sector can be described as humane. The International Labour Organisation (ILO) has drawn up appropriate social and labour standards. However, the ILO standards are only binding in those states which have ratified the relevant ILO conventions. Examples include the Convention concerning Freedom of Association and Protection of the Right to Organise, 1948 (No. 87) or the Convention concerning Minimum Age for Admission to Employment, 1973 (No. 138). Germany should require that biomass production and biomass imports into the EU comply with the ILO standards ratified by Germany. It does not fall within the purview of the German Advisory Council on the Environment to specify this standard in greater detail.

**79.** It is also important to take account of impacts on the health of employees, for example due to use of pesticides or to air pollution arising from burning off fields. Water pollution may also be reflected in contamination of drinking water, soil erosion can result in land no longer being available for farming. Such impacts are not included in the following discussion of standards, as they are essentially covered by the standards for environmental impacts of biomass imports (cf. Item 81 ff.).

**80.** In many countries the security of property rights to land is comparatively poor. In many cases the established rights of the indigenous people to possess, use and manage land are not legally defined. As a result, internationally operating consortiums can acquire land rights from public authorities and use the land. Existing forms of use are then classified as 'illegal'. According to the Indonesian Legal Aid Foundation (YLBH), in 1998 alone there were 553 cases in Indonesia in which 214,365 households lost 827,351 ha of common land to private companies. In some cases the people are forced off the land by police or troops using armed force (WAKKER 2005, p. 29, with further references). This often results in the displaced farmers being forced to retreat into areas that are not particularly suitable for arable farming, but of great importance for nature conservation. Such displacement is unacceptable from a social and environmental point of view. The introduction of large-scale biomass production should therefore be tied to the condition that the ownership situation is clearly defined and rights of use are determined by law. In particular, traditional land use rights should be respected (FRITSCHE et al. 2006, p. 13). Existing land use conflicts must not be aggravated by the expansion of biomass production. Compliance with elementary legal standards in the assignment of land rights is a condition for the legitimacy of biomass imports. One example of how this demand can be operationalised is provided by the second principle of the Forest Stewardship Council (FSC) entitled 'tenure and use rights and responsibilities', which requires the following evidence (FSC 2004):

- long-term use rights,
- control retained by local communities to the extent necessary to protect their rights or resources, and
- functioning mechanisms to resolve disputes over land use conflicts.

### 4.4.2 Areas of environmental conflict and perspectives for developing standards

**81.** The ambitious bioenergy expansion targets of the EU and Germany will lead to future substantial growth in imports of biomass products. Against the background of the expected increase in demand, Brazil, Malaysia, Indonesia and Thailand, and also several African states are seeking to make a considerable increase in their biomass production (EU Commission 2006, p. 7; Die Zeit, 28 December 2006, 'Der Boom der Biokraftstoffe kommt den Agrarländern zugute – vielleicht' (Biofuel boom benefits agricultural countries – maybe)). In general, an increased opening of European markets for agricultural produce from the Third World and newly industrialising countries is sought through the removal of technical, tariff and other barriers to trade. In principle, this opening must include the production of biomass, since the developing countries have considerable comparative cost advantages here (e.g Brazil). One can however expect substantial direct and indirect changes in land use in the producing countries, which will be accompanied by the risk of over-exploitation of valuable natural assets (cf. Items 39, 80).

**82.** The Intergovernmental Panel on Climate Change (IPCC) cites the principal causes of climate change as 'fossil fuel use, land use change and agriculture' (IPCC 2007). If biomass utilisation is to make a contribution to the goal of limiting and managing climate change, it must not only have a positive impact on reducing the consumption of fossil fuels, but must at the same time not have any negative impacts on land use systems and nature conservation areas. Land use changes may be negative from a climate change and nature conservation point of view. This applies in particular to the conversion of forests, bogs and wetlands in tropical and sub-tropical regions, which can be a major source of greenhouse gas emissions (cf. on palm oil, for example HOOIJER et al. 2006, p. 30; REINHARDT et al. 2007, p. 27 f.; in general UN-ENERGY 2007, p. 43).

There is no reason to expect that the growing of biomass intended for export will be confined to the land currently used for agricultural purposes. Expansion of biomass production could have substantial negative impacts on biodiversity, soils and water if hitherto unused land is brought into use (FRITSCHE et al. 2006, p. 11). In all probability there will be an increase in conversion of the remaining tropical rainforests into secondary and plantation forests. Southeast Asia in particular is an especially problematical region in this respect. In many cases it makes economic sense for the parties concerned to clear-cut primary forests, make a profit on the sale of the timber, and then reforest the land with palm oil plantations (e.g. in Indonesia). From a climate and nature conservation point of view, however, it would be completely absurd to direct biomass produced in this way into the motor fuel sector of the industrialised countries. The SRU regards the expansion plans of the Southeast Asian states (cf. for example MAIER 2006) with great concern.

**83.** Furthermore, biomass production should not take place on land which enjoys legal protection under international standards (for example as national parks), or which is classified as being of national or international importance (e.g. as 'bio-diversity hot spots'). The social impacts described (cf. Items 75, 80, 103) can also result in increasing pressure to use hitherto unused land, with the possible consequence of land conversion at the expense of ecosystems and biotopes. Land that was hitherto less suitable for agricultural purposes would be transformed for agricultural use and would only be able to achieve the expected yields with the aid of heavy inputs of fertiliser and artificial irrigation. Such coupling of socio-economic factors with conversion of ecologically undisturbed areas is one of the driving forces behind the loss of biological diversity (for details see HENRICH 2003). The expression 'poverty-induced environmental destruction' is not entirely appropriate as a description of these processes, since it only touches the level of the superficial factors and not that of the underlying causes.

As shown by the example of the national impacts of renewable raw materials production in Section 3.1.2, environmental impacts differ in particular depending on the climatic and soil conditions, the crops grown, and the production methods. Setting standards is therefore a very complex undertaking. Local actors should also be involved in the process of setting standards, partly because they are the ones who will subsequently have to comply with the standards, and partly in order to take advantage of local knowledge about environmental impacts and alternative production options.

The following conceptual approaches under which specific standards could be developed and established are currently under discussion and are assessed in more detail below:

- setting standards in the context of voluntary certification systems,
- multilateral conventions, and
- unilateral restrictions.

#### 4.4.2.1 Possibilities and limitations of certification systems

**84.** Certification is a procedure in which compliance with defined standards is checked by private individuals or companies and a certificate is awarded if the result is positive. It is intended to ensure monitoring of compliance with standards in the individual case. In the field of private certification systems, the task of drawing up standards is part of the certification system and is performed by the actors who take part in the system. There are already numerous private certification systems that have developed standards which are also of relevance to the production of renewable raw materials (DAM et al. 2006; FRITSCHE et al. 2006). One example of such a private initiative is the Roundtable on Sustainable Palm Oil (RSPO), which is concerned with elaborating sustainability standards for palm oil production (cf. also Table 4-2). Also well known are the standards for organic farming and for sustainable forestry. In particular, the certification system run by the FSC enjoys international diffusion and recognition.

A distinction must be made between the certification of voluntary compliance with privately set standards and certification of compliance with legally binding standards under international conventions, and especially under unilaterally formulated exclusion criteria for biomass qualifying for assistance. In such cases certification is an aid to enforcement in the implementation of legally binding standards and criteria. Relevant activities for drawing up legally binding standards are currently in progress as part of the work on Section 37 d Federal Immission Control Act (BImSchG) in Germany and by the EU (EU Council 2007, Annex I, IV. 7; similar to European Parliament 2006, Nos. 44, 46) and individual EU member states, especially the United Kingdom and the Netherlands. At international level work is being carried on by the International Energy Agency (‘Bioenergy – Task 40’), the FAO (‘International Bioenergy Platform – Task Sustainability’), UNCTAD and the G8 countries (G8-Global Bioenergy Partnership).

**85.** These many and various initiatives differ in the quality and scope of the standards, the size of the range of agricultural products certified (Table 4-2), the targeted level and degree of specificity of the criteria, and the indicators used. There are also considerable organisational differences with regard to a) participation by the actors in the development of the systems, b) ways of involving the public in the task of identifying and specifying the environmental criteria, and c) the evaluation and monitoring process (cf. FRITSCHE et al. 2006). There are also differences in the quality assurance mechanisms or the density and quality of the inspections. Thus the picture presented by certification systems is quite heterogeneous (Table 4-2).

Table 4-2

**Environmental criteria covered by voluntary international certification systems**

| | Biodiversity | Soil | Agro-chemicals | Water | Genetic engineering | Air pollution | Greenhouse gases |
|---|---|---|---|---|---|---|---|
| Roundtable Sustainable Palmoil (RSPO)<br>(www.rspo.org):<br>Palm oil | X | X | X | X | | planned | planned |
| Basel Criteria for Responsible Soy Production<br>(http://assets.panda.org/downloads/05_02_16_basel_criteria_engl.pdf):<br>Soybeans | X | X | X | | X | X | |
| Green Gold Label<br>(http://www.controlunion.com/certification/program/Program.aspx?Program_ID=19):<br>Sustainable biomass | X | X | X | X | | | |
| Forest Stewardship Council (FSC)<br>(www.fsc.org): Wood | X | X | X | X | X | | |
| Pan-European Forest Council (PEFC) | X | X | X | X | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| (www.pefc.org ):<br>Wood | | | | | | | |
| Protocol for Fresh Fruit and Vegetables (EUREPGAP)<br>(www.eurepgap.org):<br>Sustainable agriculture | X | X | X | X | | | |
| Sustainable Agricultural Network<br>(http://www.rainforest-alliance.org/programs/agriculture/certified-crops/documents/standards_indicators_2005.pdf):<br>Sustainable agriculture | X | X | X | X | X | | |
| International Federation of Organic Agriculture Movement (IFOAM)<br>(www.ifoam.org): Organic farming | X | X | X | X | X | | |
| Fairtrade Labelling Organisations International (FLO)<br>(www.fairtrade.net): Bananas, cocoa, coffee, dried fruit, fresh fruit and vegetables, herbs, species, honey, nuts, oilseeds, qinoa, rice, tea, sugar-cane sugar, grapes, non-edible flowers and plants, cottonseed | X | X | X | X | | X | |
| Flower Label Programm (FLP)<br>(www.fairflowers.de): Cut flowers | X | X | X | X | | X | |
| Utz Kapeh - Codes of Conduct<br>(www.utzkapeh.org): Coffee | X | X | X | X | | X | |
| USA only: | | | | | | | |
| Sustainable Forestry Initiative Standard (SFIS)<br>(http://www.sfiprogram.org/): Wood as PEFC | X | X | X | X | | | |
| American Tree Farm System<br>(www.treefarmsystem.org): Wood | X | X | X | | | X | |
| SRU/SG 2007-2/Table 4-2; data source: FRITSCHE et al. 2006 | | | | | | | |

**86.** As can be seen from Table 4-2, none of the existing systems covers all the relevant environmental aspects of the use of biomass for energy. The climate protection aspects of importance for its use as energy are not adequately elaborated in the certification systems. Moreover, the systems do not include any specifications for weighting aspects in the event of conflicts of objectives between different environmental assets. A synoptic analysis and assessment of the existing standards does not exist at present, but is currently being prepared. Mention must be made here of the preparations for drawing up sustainability criteria for biofuels or for biomass as a whole by the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) and the Federal Ministry of Food, Agriculture and Consumer Protection (BMELV) (UBA and IFEU 2007; Meó Consulting 2007).

**87.** Certification systems require reliable verification of compliance with prescribed standards. Effective inspection and verification mechanisms of the kind required for organic farming or by the Forest Stewardship Council have tended to be the exception (cf. FRITSCHE et al. 2006, p. 40 f.). In many cases compliance with the criteria, which to some extent only have the character of a declaration, is merely confirmed by signed voluntary undertakings.

**88.** This brief overview makes it clear that certification of renewable raw materials is still in its infancy. In the short term one cannot expect a uniform private system that could simply be recognised by international environmental policy makers. Neither does a reliable system exist that could ensure appropriate verification of legally binding standards. It is clear from the many questions of design and organisation that speedy solutions are unrealistic. The establishment of an effective certification system can be expected to take in the region of a decade.

**89.** Finally, it is important to bear in mind the effectiveness limits that are inherent in certification. Certifiable standards have to address the operational business management level and cannot therefore take account of indirect effects which arise elsewhere as a result of increased biomass production. Certificates are fundamentally unable to cover the entire economic, environmental and social interactions that can be triggered by an international bioenergy boom (BERGSMA et al. 2007; Project Group Sustainable Production of Biomass 2006).

**90.** Voluntary systems will therefore be unable to achieve comprehensive regulation of the biomass production that is currently being vigorously promoted. In view of the competitive disadvantages of the production systems that comply with the certification standards, it will not be possible to establish high standards unless they are legally binding. To this extent, hopes that private certification might be able to render government-imposed unilateral standards or internationally agreed standards superfluous are unrealistic. The relevant state responsibilities cannot be delegated to private parties. Efforts should nevertheless be made to benefit from existing experience with regard to drafting, practicability and verification, and to identify exemplary standards and verification procedures (‘best practice’).

#### 4.4.2.2 Legal framework conditions for environmentally sound biomass production

**91.** Through their ambitious quantity targets for the share of energy accounted for by biomass, both the EU and Germany are creating incentives to increase imports of biomass and biomass products from non-EU countries. For the economies of these countries, mostly Third World and newly industrialising countries, this expansion of biomass demand creates urgently needed sources of income, but it also presents a threat of considerable damage to the environment (see Item 81 f.). One central element of a biomass policy that cannot be implemented without imports must therefore be to avoid creating incentives to generate income by over-exploiting natural resources, and this should be done by seeking to achieve sustainable biomass production outside the EU as well. Only if the expansion of biomass production in the producing countries takes place in line with certain environmental standards can the states in question make appropriate sustainable use of the competitive advantages that they have over European countries thanks to their more favourable climatic conditions. The opening of EU markets to biomass produced outside the EU must therefore be subject to the proviso that the imported products are produced in compliance with such standards. Thus effectively it is a matter of ensuring that imports into the EU of biomass produced using methods characterised by specific environmental standards are privileged compared with non-sustainable production methods.

Such preferential treatment could take various forms: for example, the biomass imports allowed into the EU could be made conditional upon sustainable production, and import bans could be imposed upon biomass and biomass products that were not produced in compliance with the requirements. It is also possible, however, to base the funding policy for biomass use for energy on the environmental requirements, and to count towards the funding quota only the use of biomass products produced in line with the specified production standards. Regardless of the detailed approach adopted, the privileges associated with easier market access for the producing states would be tied to the condition of compliance with certain environmental standards. This approach of conditional market access is not a new instrument for the EU. Particularly under the common trade policy, for example, a wide variety of arrangements facilitating market access for a number of developing and newly industrialising countries are made conditional upon compliance with certain social and/or environmental standards (KOCH 2004).

The binding character of the relevant sustainability standards for biomass production can be achieved in two different ways: for example, an agreement under international law on the necessary production requirements could be reached under an international convention. The parties to such a convention would have to be importing countries, especially the EU, and the relevant producing countries. As an alternative to such a multilateral approach, one could also consider a unilateral arrangement. In that case the EU would, without any international law consensus on environmental production methods, make such imports conditional on compliance with the specified sustainability criteria. Since both approaches aim to restrict international trade in biomass produced by non-sustainable methods, questions arise as to their compatibility with the rules of the World Trade Organisation (WTO), which are keyed to extensive deregulation of world trade. However, the WTO rules do not fundamentally preclude either a multilateral convention or a unilateral enforcement of the standards, though the latter should only be regarded as a second choice – a last resort.

**Multilateral standards for environmentally sound biomass production**

**92.** International conventions are the central element of international environmental law, and have been agreed by a large number of states to protect a wide variety of environmental assets. In many cases they make provision for restrictions on international trade as instruments for enforcing certain environmental protection objectives, for example the CITES convention (Convention on International Trade in Endangered Species of Wild Fauna and Flora) or the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes. Many of these conventions have been established and internationally recognised for many years. In spite of their restrictive effects on trade, measures taken under these conventions have never been the subject of disputes under WTO rules (SAMPSON 2005, p. 128). In the 'Shrimps' case, which set the precedent for the relationship between environmental protection and WTO rules, the Appellate Body based its decision partly on the content of multilateral environmental protection conventions as a crucial argument justifying the unilateral import bans imposed by the USA (United States – Import Prohibition of Certain Shrimp and Shrimp Products, Report of the Appellate Body, 12 October 1998, WT/DS58/AB/R, Items 130, 132; referred to below as: Shrimps). Against this background one can basically assume acceptance of multilateral measures agreed in the interests of transboundary environmental protection, even – or especially – in connection with the free trade regulations of the WTO (KLUTTIG 2003, p. 32 ff.). In view of the expected increase in international trade in biomass and biomass products, there is an urgent need to work towards the signing of a convention under international law that lays down standards for environmentally sound production of biomass plants.

**93.** The following elements constitute the necessary contents of such a convention:

- The scope of application of the convention must be sufficiently broad to cover all plant species and methods of cultivation that are relevant to biomass production and use.
- The core of the biomass convention should be the environmental standards already described (see especially Items 39, 80, 82, 83), which are to be implemented in legally binding standards. At global level, however, the criteria that sustainable biomass production has to satisfy can only be defined with a certain degree of abstractness. A global convention cannot provide the specificity that is necessary to take account of individual local natural conditions. The convention must therefore lay down mechanisms which ensure that the standards are indeed defined more specifically and complied with at the local production level (Item 83).
- As a supporting measure, the convention should also lay down that biomass and biomass products are only marketable in international trade if they are grown and produced in compliance with binding sustainability standards. To provide evidence of environmentally sound production the convention could introduce a certification system or make reference to existing certification systems or specific elements of such systems.
- From an institutional point of view there is a need for preparations for the implementation of the biomass convention, for example the establishment of a separate secretariat or attachment to an existing institution such as the United Nations Environment Programme (UNEP) or the United Nations Conference on Trade and Development (UNCTAD). The central functions of this secretariat must include correspondence with the WTO on the trade impacts of the biomass convention.
- Finally, there is a need to set up an arbitration mechanism for resolving disputes about the implementation of the biomass convention. This instrument is necessary not only for effective implementation of the convention, but also to forestall the referral of a potential implementation dispute to the WTO bodies (for the importance of arbitration mechanisms in international environmental conventions, cf. SAMPSON 2005, p. 129).
- Owing to institutional and financial capacity shortages, developing countries are unable to ensure adequate enforcement of specific standards. The biomass convention must therefore lay down mechanisms that support the producing states in their efforts to implement the required sustainability standards. Such mechanisms may range from training of the relevant actors in the producing states to kick-off finance for production projects that comply with the required standards. If such support measures are ensured on a multilateral basis as a fundamental prerequisite for compliance with the required standards, a certification system can be used to counteract implementation deficits.
- The convention should also include measures designed to prevent the indirect effects of increased biomass production. For example,

they should in particular combat harmful effects arising from displacement of other agricultural sectors as a result of energy crop production. They could take the form of minimum standards for land use planning.

**94.** Negotiating a biomass convention with the content outlined above will involve dealing with challenges that, although demanding, do not appear to be insurmountable. In view of the considerable socio-economic differences between the potential signatory states – industrialised countries as importers, mainly developing and newly industrialising countries as exporters – one of the principal concerns will have to be achieving an appropriate reconciliation of interests.

### Unilateral standards for environmentally sound biomass production

**95.** In the event of failure of the negotiations on an international biomass convention, there is the possibility of unilateral enforcement of the necessary sustainability standards in relation to the producing countries. Priority must however be given to vigorous efforts to achieve a multilateral approach. On the one hand this guarantees greater acceptance and better enforcement of the standards. On the other hand, international cooperation on the implementation of sustainable biomass production standards is called for as a prerequisite for unilateral action, also in view of the requirements of world trade law.

In the context of unilateral enforcement of the environmental standards, the EU and Germany could, without an international consensus, restrict the marketability of foreign biomass or biomass products not produced in compliance with the required standards. This could be done either by means of a ban on imports of biomass or biomass products not produced in compliance with the specified requirements, or by refusing to count the use of such biomass products towards the funding quota (Item 91). The point of attack both for possible import restrictions and for a funding policy based on sustainability criteria is the production methods used for biomass crops in the producing states. Regarding the admissibility under world trade law of such production-specific barriers to market access, WTO arbitration practice has developed legality criteria which are now widely accepted. In particular, the much publicised ‘Shrimps’ decision by the Appellate Body (SRU 2000, Item 90; 2004, Item 1045 ff.) has encouraged a fundamental re-thinking with regard to the acceptance of environmental protection requirements – and especially extra-territorial requirements for environmental production methods – in the context of world trade law.

The rules of the World Trade Organisation are geared largely to increasing the welfare of its member states by establishing a free trade regime (KLUTTIG 2003, p. 5; KOCH 2004). Thus any move by a WTO state to restrict access by foreign products to its national market, or to put foreign products at a disadvantage on the market by comparison with domestic products, in principle conflicts with the free trade regulations of the WTO. The statutory core of these rules consists of the principles of national treatment, which takes the form of bans on direct and de facto discrimination (Art. III (4) General Agreement on Tariffs and Trade (GATT)), most-favoured nation status (Art. I GATT) and the general abolition of quantitative restrictions on imports and exports (Art. XI GATT). The starting point for application of these provisions is different treatment of a foreign product compared with a ‘like product’ of domestic origin on the market of a WTO member country. According to the bulk of opinion in the arbitration practice of GATT/WTO and in the literature, the distinction between like products – in other words, the judgement as to whether a foreign product is allowed to be treated differently from a domestic product with regard to market access or its treatment on the market – must not be made on the basis of criteria that relate to the manufacture of the product in the producing country and have no influence on the properties of the product (SCHMIDT and KAHL 2003, Item 95; KLUTTIG 2003, p. 13 f. with numerous references to arbitration practice and literature). In particular, environment-related import restrictions which are not reflected in the properties of the goods produced are thus regarded as an infringement of the requirement of national treatment laid down in Art. III (4) GATT. This principle lays down that the products of the territory of any contracting party imported into the territory of any other contracting party shall be accorded treatment no less favourable than that accorded to like products of national origin in respect of all laws, regulations and requirements affecting their internal sale, offering for sale, purchase, transportation, distribution or use.

However, a closer analysis of the debate about ‘like products’ reveals that when assessing the products it is necessary to take a critical view of the abstraction of production processes. The WTO’s stance on this problem can be characterised as follows: on the one hand the WTO aims to exclude the possibility of different production processes being used as an excuse for import restrictions. On the other hand it cites a number of reasons and examples which suggest that it is appropriate to broaden the consideration of a product to take in the production conditions involved in its manufacture. In some cases it is argued that the WTO does not possess either competence or responsibility in respect of the broad spectrum of value judgements involved in such broader consideration, and that value judgement issues relating to the similarity or dissimilarity of products must be left to the preferences of the consumer, i.e. the ‘market’. According to this argument, the assessment of similarity is crucially dependent on consumer perception. In recent WTO arbitration practice, the differentiation between like and unlike products is again based to some extent – albeit along with other criteria – on the consumer perception aspect (EC Measures Affecting Asbestos and Asbestos-Containing Products, Appellate Body Report of 12 March 2001, WT/DS135/AB/R, Item 101). In other recent decisions, however, the competitive relationship between products on the market as determined by consumer perception is not taken as an underlying criterion for distinguishing between like and unlike products, which thus means that there is no established arbitration practice in this respect (SCHMIDT and KAHL 2003, Item 93 ff. with extensive references to arbitration practice and literature).

Ultimately this method of distinguishing between like and unlike products is unsatisfactory, because it is based on the fiction of fully informed consumers who have a complete overview of all production conditions in the global market for goods and are able to make confident judgements on the basis of their preferences. Differentiation on the basis of consumer perception should therefore not be decisive. Even if one nevertheless regards the consumer perspective as crucial, consumers are currently not in a position to distinguish biomass products on the basis of production properties in view of the lack of appropriate standardisation and certification. This too argues against assessing the comparability of products on this market on the basis of consumer perception. If the consumer perspective is nevertheless taken as decisive, it has to be assumed that unilateral enforcement of the biomass production standards – whether in the form of a ban on imports or in the form of a corresponding funding policy – infringes in particular the requirement of national treatment laid down in Art. III (4) GATT.

**96.** However, infringements of the principles underlying the free trade rules of the WTO are not necessarily prohibited under GATT. Indeed, in special circumstances Art. XX GATT grants WTO states wishing to use trade-restricting measures to protect certain goods the right to deviate from the anti-discrimination rules. In the case of environmental protection is basically possible to justify such measures in accordance with Art. XX b) and g) GATT, under which measures to protect the life and health of people, animals and plants and to conserve finite natural resources may be permitted. Here the arbitration practice of the Appellate Body involves a two-stage investigation, the first step in which is to examine whether a trade-restricting measure corresponds to the requirements laid down in one of the clauses a) to j) of Art. XX GATT. The second step is to analyse whether the specific application of the measure is compatible with the introductory sentence of Art. XX GATT, the ‘chapeau’ (for this investigation structure and references to arbitration practice, see for example KLUTTIG 2003, p. 17 f.). Fundamental substantive criteria for the justification of environmentally motivated unilateral trade restrictions were developed in particular in the often quoted Shrimps decision of the WTO Appellate Body (see SRU 2004, Item 1045 ff., with further references). These criteria are also relevant for the justification of production-specific import prohibitions and other marketing restrictions.

From a thematic point of view, such trade restrictions designed to enforce appropriate environmental standards in the producing countries are covered by Art. XX b) and g) GATT with the above mentioned content. The trade restrictions are intended to ensure sustainable production of biomass products that is geared particularly to the conservation of tropical primary forests and also bogs and other wetlands (cf. Section 4.4.2). These areas are indispensable habitats of the flora and fauna to be preserved in the producing countries, which means that the protective measures fall directly under the protection of flora and fauna and hence within the scope of Art. XX b) GATT. Regarding the substantive applicability of Art. XX g) GATT, it is clear from the arbitration practice that exhaustible natural resources at any rate include environmental assets that are acknowledged by international environmental conventions or declarations to be seriously endangered (Shrimps, Item 130 ff.). Although there has so far been no success in negotiating an internationally binding instrument geared specifically to the conservation of forest ecosystems, numerous international declarations and initiatives by various actors bear witness to the fact that a consensus exists within the international community of states on the threat to the environmental assets that are to be protected by the trade restrictions (for details of this and the following, see KROHN 2002). The need for better protection of forest ecosystems is also expressed in various multilateral conventions, and in particular in the Convention on Biological Diversity’s forest work programme, though this has no binding legal force. Some of the species native to tropical forests are listed in the annexes to the CITES Convention. International activities to protect bogs and other wetlands and the species native to them are carried on under the Ramsar Convention on Wetlands.

As well as the protected asset 'exhaustible natural resources', unilateral protective measures pursuant to Art. XX g) GATT must be used in connection with comparable restrictions on domestic production or domestic consumption. This requires that the sustainability standards demanded of the exporting countries also have comparable binding force in the importing countries. However, since agricultural production in the EU and Germany is already subject to an extensive list of environmentally relevant regulations which require further modification with regard to biomass-specific threats (Item 67 ff.), there can be no question here of imposing one-sided obligations on the exporting countries. Thus the protective standards to be enforced unilaterally cannot be accused of 'green protectionism'. It is rather the case that they represent a counterpart, which is to be demanded of the producing states in the interests of effective global climate change mitigation, of the importing countries' own – and in significant respects even stricter – efforts to achieve sustainable biomass production.

According to the 'chapeau' of Art. XX GATT, trade-restricting measures must not result in arbitrary or unjustifiable discrimination between countries where the same conditions prevail, or in a disguised restriction on international trade. Thus the chapeau clause lays down criteria for the practical application of the protective measures, the general purpose of which is seen to lie in preventing abuse of the exception provision (United States – Standards for Reformulated and Conventional Gasoline, Appellate Body Report of 29 April 1996, WT/DS2/AB/R, p. 23; Shrimps, Item 151); it is intended to bring about a reconciliation of interests between the rights of a WTO member that invokes the exception provision, and other WTO members whose substantive rights guaranteed by the WTO rules are impaired. In the Shrimps decision, the Appellate Body saw an infringement of this reconciliation especially in view of the fact that the USA, before imposing unilateral standards, had not been active in the field of international negotiations for a multilateral protection regime for turtles and that the system finally chosen sought to enforce the USA's own protection standards in a rigid and inflexible form. It was regarded a serious infringement of the chapeau clause of Art. XX GATT that no provision was made for measures which ensured acceptance of foreign protective measures that guaranteed a level of protection comparable to that targeted by the USA, but did so by means other than the protective measures compulsorily imposed by the USA (Shrimps, Item 161 ff.).

The importance of the first of the aforementioned criteria – priority of multilateral negotiations over unilateral trade restrictions – for the GATT-conformity of a future ban on imports of biomass has already been stressed. Thus such measures may only be taken if they are preceded by a 'serious attempt' to reach agreement (Shrimps, Item 166 ff.). The international efforts already in progress (cf. for example UNEP Global BioEnergy Initiative http://www.uneptie.org/energy/act/bio/GBEP.htm, or the certification system development initiatives described in Item 84 ff.) could be used as a forum for international negotiation of production standards for renewable raw materials. Particularly where the protection of tropical rainforests is concerned, the time for imposing unilateral trade restrictions may already have come. These forests are increasingly suffering destruction as a result of the expansion of agricultural land. Regardless of the work of the Intergovernmental Panel on Forests, the Intergovernmental Forum on Forests, the United Nations Forum on Forests and numerous other institutions, forest clearance in tropical countries continues unabated (FAO 2007). This being so, one could well argue that the multilateral efforts of the past decade have not succeeded in ensuring an adequate level of protection and that it is now in principle appropriate to take unilateral measures to protect the forest ecosystems.

The flexible handling of the protection system that is called for in the WTO's arbitration practice prohibits in particular exclusive recognition of the environmental protection mechanisms established in the EU or in Germany. This requirement precludes the blanket application to non-European producing countries of production standards that are binding under EU or German law. However, flexible recognition of foreign protective measures is guaranteed if the definitions of the required production conditions are sufficiently open to permit situation-appropriate specification of the standards in the producing countries. The EU must give the countries technical assistance with the implementation of the required production standards. This also includes the establishment of relevant know-how in the producing countries. If a certification system is used to ensure compliance with the standards, all WTO states must be granted equal access to the system. Moreover, intensive cooperation on the establishment and running of the certification system is needed between the EU and the exporting countries, and this must cater for the specific needs of the countries affected and the conditions prevailing there. Finally, the design of the certification system must be fair and transparent. To this end it will be necessary to set up communication mechanisms between the EU and the producing countries to handle submission of applicants' statements about their certification applications, notification of reasons for rejection of certification applications, and legal rights in the case of rejected applications.

## 4.5 Summary

**97.** The German Advisory Council on the Environment (SRU) sees biomass utilisation as an opportunity to promote sustainable, environmentally sound and socially acceptable development. Nevertheless, people have come to realise that sustainable, environmentally sound and socially acceptable production of renewable raw materials needs to be regulated by means of 'guard rails' and standards. Since both the production of renewable raw materials and the utilisation of biomass receive substantial assistance from government, it is important to ensue that no serious adverse effects arise from the use of biomass – and hence from the funding provided. There is thus a need for 'guard rails' and specific standards at national and international level.

**98.** Some impacts of the production of renewable raw materials at national level are very similar to those of conventional food and animal feed production. However, the production of renewable raw materials also has environmental impacts that do not occur in this form in the production of food and animal feeds. The first group of impacts should be subject to the same standards as for food and animal feed production. The second group, by contrast, require biomass-specific standards.

**99.** In principle, the negative impacts that can be expected as a result of increased growing of renewable raw materials can be counteracted with the aid of the requirements of good professional practice and cross compliance. These should be implemented in a determined manner and advanced where appropriate. On the basis of present knowledge, the German Advisory Council on the Environment advocates a tightening of the standards in the following respects:

- regarding the use of fertilisers: the introduction of a nitrogen excess charge;
- regarding the use of pesticides: further specification, legal enhancement and forceful implementation of the requirements for integrated crop protection;
- regarding compliance with at least threefold crop rotation: without exception, and at the same time creating the possibility of regulating the number of crops grown annually and the maximum share of the farm's land that they may cover;
- a general ban on ploughing of permanent pasture.
- Furthermore, the present standard of protection afforded by conservation area ordinances should be reviewed to see if it is appropriate and raised where necessary. The Advisory Council also sees a need for further investigation of the question of providing greater protection for fringe and structural elements by means of an additional compensation system.

**100.** Specific standards for the production of renewable raw materials are needed in the case of impacts that do not occur when growing food and animal feeds. This applies in particular to the removal of organic material, for which evidence of a good humus balance is required, and specific rules for the growing of new or genetically modified species and varieties of renewable raw materials.

**101.** For comprehensive regulation of site-specific and location-specific impacts there is a need for a range of spatial instruments, because many objectives and limitations of renewable raw materials production can only be defined in relation to specific location types or regions. This is the only way to take account of the characteristic sensitivities of different locations.

**102.** In the foreseeable future, the social impacts of biomass production at national level will not be serious either for consumers or for producers. On the other hand, one should take a sceptical view of excessive hopes regarding the development of rural areas. Unlike the socio-economic impacts of imports of renewable raw materials on the producing countries, the German Advisory Council on the Environment does not see any special need for regulation with regard to the socio-economic impacts within Germany.

**103.** At international level, however, the expansion of biomass production gives considerable cause for concern about changes in the living conditions of the poorer sections of the population in exporting countries with regard to food security, working conditions and land rights. It would hardly be justifiable if biomass imports for the motor fuel sector resulted in a situation where the consequences of a misguided transport policy (SRU 2005) in the industrialised countries was borne by poorer sections of the population in the exporting countries in the form of reduced food security.

**104.** Intensification of biomass production in the producing countries goes hand in hand with a considerable risk of over-exploitation of the remaining natural resources, especially tropical rainforests, bogs and other wetlands. There is thus an urgent need for binding international standards designed to ensure environmentally sound biomass production. Private-sector certification systems are not a functional equivalent for binding standards for biomass production. For one thing, none of the existing certification systems covers all aspects of environmental relevance. For another, in view of its inherent limitations the instrument of voluntary certification cannot ensure effective enforcement of the necessary environmental standards. There is thus a need for binding standards and for making compliance with them a prerequisite for marketing imported biomass and biomass products in the EU and in Germany. To this end, priority should be given to pressing ahead with negotiations on an international biomass convention that lays down binding environmental standards and also provides mechanisms for enforcing the standards. An option of secondary importance, but also conceivable as a last resort, is unilateral enforcement of the standards in relation to the producing countries. Under the WTO rules it may be taken that such an approach is permissible provided the individual requirements listed are satisfied.

# 5 Current objectives and instruments for expansion of bioenergy

## 5.1 Funding objectives

### 5.1.1 Climate change mitigation and other strategic objectives of bioenergy funding

**105.** The fourth assessment report by the Intergovernmental Panel on Climate Change (IPCC 2007) provided impressive scientific confirmation of the urgent need for ambitious climate change mitigation. Without a radical reversal of the trend, it will no longer be possible to limit the global rise in mean annual temperature to 2°C above pre-industrial levels, which is widely accepted as the goal for preventing further serious harm. Given moderate climate sensitivity, this means that the minimum required is stabilisation of the greenhouse gas concentration at around 450 ppmv $CO_2$ equivalent, and hence a substantial reduction in global greenhouse gas emissions.

In the light of the urgent warnings by climatologists and the economic costs of the consequences, both the EU and the German government have set new climate change reduction targets for the period to 2020. The EU is seeking to achieve a unilateral greenhouse gas emission reduction of 20 % and an internationally coordinated reduction of 30 % compared with 1990, while the German government is targeting a reduction of 40 % (BMU 2007). And looking further ahead, there is a need to reduce $CO_2$ emissions in Germany and other industrialised countries by up to 80 % by the year 2050 (SRU 2002; 2004).

Rapid expansion of renewable energy sources and hence of bioenergy will play a very important role in achieving these climate targets (cf. Section 5.1.2). Particularly if the German government's climate protection target is to be achieved simultaneously with the phasing-out of nuclear power, it is indispensable that renewable energy from biomass make the maximum possible contribution to climate change mitigation (NITSCH 2007; BMU 2007; MATTHES et al. 2006; BARZANTNY et al. 2007; LECHTENBÖHMER et al. 2005; ERDMENGER et al. 2007). At the same time, however, it is important to maximise the potential climate protection contribution of energy from biomass in the light of other environmental framework constraints.

**106.** At present several objectives of using biomass are under discussion: apart from climate change mitigation, other aspects include the promotion of rural areas and fuel supply security through substitution of motor fuels (Deutscher Bundestag 2006b, p. 19; BMVEL 2005; EU Commission 2005b). Closer analysis reveals that the idea that all these objectives can be pursued without any conflicts is illusory. It is therefore essential to set priorities.

In view of the IPCC's warnings, and also in view of the limits to the expansion of renewable raw materials that are set by environmental 'guard rails' and standards (Chapter 4), it would be irresponsible not to make optimum use of the potential contribution of biomass to reducing greenhouse gases. There are better ways of pursuing the promotion of rural areas and of fuel supply security. For this reason the goal of reducing greenhouse gases should be given priority.

**107.** The German Advisory Council on the Environment therefore advocates biomass utilisation that is primarily climate-oriented within a nature-friendly and socially acceptable framework.

**108.** At the same time, a bioenergy funding strategy that is focused on climate change mitigation will undoubtedly have positive side-effects on rural areas and on supply security. Nevertheless, it is important to ensure an appropriate cost-benefit ratio and to bear in mind the non-negligible conflicts of objectives (ISERMEYER and ZIMMER 2006; HENKE 2005; HENKE and KLEPPER 2006).

**109.** Depending on the crop and the production method, and also on the conversion process and purpose, different types of bioenergy make very different contributions to climate change mitigation. Funding measures geared to energy content or volume cannot adequately reflect these substantial differences in performance, since there is no correlation between the energy yield and the climate protection contribution of bioenergy sources (Item 35). Empirical studies and the argumentation in Chapter 3 agree that there should be a clear and definite graduation of priorities with regard to climate-oriented optimisation of biomass use in the German energy mix today: its use for energy in the heating sector and the generation of electricity has significant advantages over its use for motor fuels in two ways. For one thing the savings potential per unit area is significantly higher, and for another, the $CO_2$ avoidance costs are substantially lower (cf. Chapter 3; HENKE and KLEPPER 2006; FRITSCHE and ZIMMER 2006; SRU 2005b; EU Commission 2005b, p. 6; NITSCH 2007).

According to estimates by the EU Commission, 1 Mt oil equivalents of biomass input results in 2,466 t $CO_2$e greenhouse gas emission reduction when used for heating, 2,167 to 2,560 t $CO_2$e when used for power generation, and only 1,688 t $CO_2$e when used as motor fuel (EU Commission 2005a, p. 32). The climate reduction potential per unit of biomass is, on average and in the theoretical reference case, at least 50 % higher if $CO_2$ optimisation of biomass use is ensured (NITSCH 2007, p. 17 f.; SRU 2005b, Item 355, with further references; CONCAWE et al. 2006, p. 85; RAGWITZ et al. 2006). In individual cases, the climate protection contribution of biomass substitution for coal can be as much as three times higher than for motor fuel substitution (cf. Fig. 3-3). Even within the individual usage sectors, there are very great variations in the possible climate protection contributions. For example, depending on crop and production methods, it is possible to save 15 to 45 million t $CO_2$ by achieving the EU's biofuel target for 2010 (EU Commission 2007b, p. 112).

The differences in the economic avoidance costs of the individual uses are just as significant. According to estimates by the European Commission, these costs are around 100 €/t $CO_2$e for biofuels – though the figures vary considerably depending on the crop and conversion technology. The avoidance costs for power generation are around € 22, whereas use for heating purposes actually yields a profit of nearly € 40 (own calculation based on EU Commission 2005a). Similar cost ratios are to be found in many other studies (SRU 2005b, Item 356; CONCAWE et al. 2006, p. 65 f; FRITSCHE and ZIMMER 2006, p. 16; RAGWITZ et al. 2006). Climate-optimised promotion of biomass use should reflect these technical and economic facts and set appropriate priorities. Any failure to do so is a waste of technically and economically mobilisable climate change mitigation potential. According to calculations for the European Environmental Agency, suboptimal biomass use in the EU would amount to foregoing up to 22 % of the domestically producible substitution potential, or a reduction of about 150 Mt $CO_2$e by 2030 (RESCH et al. 2007, p. 11).

**110.** Synergies between climate change mitigation and promotion of rural areas can be achieved if biomass funding is geared to maximising the climate protection contribution. For rural development, the impacts of such optimisation of climate change mitigation primarily relate to production structure and further processing. If the focus is on climate protection, the share of energy crops used for motor fuels will decline, while that used for stationary energy generation will increase. Bioenergy funding as a whole will create new markets and holds promise of price increases – in some cases substantial – for agricultural products (cf. Chapter 4.1; DUFEY 2006, p. 15; UNCTAD 2007, p. 46; EU Commission, DG Agriculture and Rural Development 2007; OECD and FAO 2007). A considerable boost to the labour market can be expected in the field of plant construction and also as a result of the probable very dynamic development of exports (BMU 2006).

However, ISERMEYER and ZIMMER (2006) point out that this funding effect will only create new jobs in rural areas if the prices of energy products and agricultural products are low. As oil prices rise, the market demand for biofuels will increase even without state funding, which will also bring about an increase in food prices. If this makes food production more profitable, funding of biomass will merely displace agricultural production that is taking place anyway, but without having direct employment effects on balance (ISERMEYER and ZIMMER 2006, p. 13).

**111.** However, employment effects alone can hardly justify priority funding of certain uses where these are suboptimal from a climate point of view. Since the 1990s the system of market intervention and of direct payments coupled to production has been reformed in various stages for budget and trade reasons, and for also consumer and environmental reasons (SRU 2004, p. 178 f.). The 2003 agricultural reform aims to decouple subsidies from production. In the debate about further reform of agricultural policy, concepts have therefore been developed for coupling subsidies to compliance with statutory environmental standards (cross compliance) or rewarding further environmental achievements under agro-environmental programmes. Thus a policy that derived its legitimacy solely from its sales-promoting and price-supporting effects in the agricultural sector would mean a relapse into the years before the reform of the Common Agricultural Policy. General funding measures can be justified better by general welfare impacts, such as climate change mitigation or conserving biodiversity or cultural landscapes. This being so, the goal of promoting rural areas is also secondary to the climate protection objective where biomass funding is concerned. It is pursued as a desirable side-effect of climate change mitigation.

**112.** Security of supply can be seen from a physical point of view, with regard to the national or international availability of certain resources, or from an economic point of view, as protection against excessive price fluctuations. Physical supply shortages will on the whole play a relatively minor role in the decades ahead. In the case of oil there is admittedly reason to expect a regional concentration of the producing countries, and there is a controversial debate about when oil production will pass its peak, but in the short to medium term this is on the whole more likely to involve price risks than the prospect of 'our running out of oil' (IEA 2006, p. 88 ff.; YERGIN 2005; BMWi and BMU 2006, p. 2; SCHINDLER and ZITTEL 2006). In view of the present dependence of gas imports on pipelines, physical supply problems are easier to imagine in this sector (KALICKI and ELKIND 2005; BMWi and BMU 2006, p. 2 ff.), but the situation will ease with the growing importance of gas liquefaction (MÜLLER-KRAENNER 2007, p. 22 ff.). On the coal front there is no prospect of physical supply problems in the foreseeable future. Thus the discussion about security of supply is primarily concerned with the economic question of how to reduce our vulnerability to large price fluctuations or price increases on the world energy markets. As far as reducing the medium-term economic risks is concerned, there are three basic strategic approaches that can be distinguished in the political discussion: increased use of domestic energy sources, diversification of imported energy sources, or reducing the energy intensity of the economy. With all these strategies, however, it must be borne in mind that it is unrealistic to expect any decoupling of the national or European energy markets from world energy markets (YERGIN 2005, p. 55). Regardless of this restriction, biomass promotion can aim either to replace imports with domestic energy sources or to diversify imports.

As a replacement for imports, bioenergy sources quickly reach their limits. As explained in Chapter 2, the potential of biogenic waste – assuming that the crop area is cultivated in accordance with nature conservation requirements – is in the region of 3.5 to 5 % of primary energy consumption, and that of the energy crops used for motor fuels is probably less than 5 % of motor fuel consumption (cf. Item 15 f.). Various studies show that the EU's biofuel target of 10 % for 2020 cannot be achieved without imports even if the entire potential area available is used for this purpose alone (CONCAWE et al. 2006; KAVALOV 2004; IEA 2006; EU Commission 2006a). Such small shares of potential domestic production will hardly be in a position to influence the world energy markets.

There are also fundamental objections to an import replacement policy: states that are integrated in the global economic system can only be isolated from the factor price effects of global energy price fluctuations by sacrificing beneficial international trade relations. In view of the small potential market shares of biofuels, there is no reason to expect the production of a significant supply to decouple motor fuel costs from world oil market prices, or even to slow down the rise in oil prices.

It is also worth noting the unfavourable cost-benefit ratio of an import replacement policy: if biofuel production costs are higher than conventional fuel prices, the difference has to be either subsidised or financed by the motorist. If they are lower than fuel prices, this will lead to an increase in the supply of biofuels accompanied by a possible build-up effect between agricultural and biofuel prices (ISERMEYER and ZIMMER 2006, p. 2 f.). However, in view of the relatively insignificant quantity of biofuel available in the medium term, this will not lead to any substantial reduction in fuel prices. Moreover, the greater the degree of self-sufficiency, the higher will be the associated costs. The EU Commission's optimistic assessment of the consequences for the target of 10 % biofuel by 2020 shows that given low oil prices the total annual cost of domestic production is around € 12.3 billion, or in the event of high imports only around € 5.2 billion (own calculations on the basis of EU Commission 2006a, p. 14). Thus in the event of an import replacement strategy based on domestic resources, motorists or the government will pay a high 'insurance premium' without being able to ensure effective protection from price risks. Empirical research into the factors determining oil price trends shows that the volatility of crude oil prices in the past three decades has been very largely due to the dynamic nature of demand, and has had comparatively little to do with fluctuations in supply. Thus attempts to smooth supply by increasing self-sufficiency in the energy sector are unlikely to do much to reduce the risk of energy price fluctuations (KILIAN 2007).

**113.** Comparing this approach with other strategies for reducing the transport sector's dependence on oil, e.g. a vigorous efficiency strategy for motor vehicles or transport switching and prevention measures (cf. SRU 2005b, as already mentioned), the European Commission came to the conclusion that a relatively cautious efficiency policy would yield more than twice the motor fuel savings compared with the biofuel strategy (EU Commission 2006a, p. 26; and, with the same basic tenor, ECMT 2007; GOODWIN 1998; FRONDEL and PETERS 2007, p. 1682). Motor fuel savings are thus the central contribution to reducing the economy's oil intensity and hence its vulnerability in the face of fluctuations (TOMAN 2002; YERGIN 2005; KILIAN 2007). It would be sensible if the opportunity costs of privileged funding of biofuels also included the unexploited benefits of climate-optimised use of biofuel for other purposes, for example heating and electricity generation.

**114.** Anyone who puts his faith in the very limited price-cushioning effect (see above) of biofuels in the context of a supply security strategy must, in view of the high costs of an import replacement policy, rigorously insist on opening markets and abolishing agricultural protectionism to make it possible to take advantage of the cost benefits of biofuels from these countries. The pressure to deregulate under the world trade regime is also moving in this direction (ISERMEYER and ZIMMER 2006; HENKE and KLEPPER 2006; COELHO 2005; DUFEY 2006). Not only are the tariff-related and non-tariff-related trade barriers to biofuels the subject of critical discussion today, but biofuels are also candidates for 'environmental products', which are to receive priority treatment under the Doha negotiations on further deregulation of world trade (Fourth Ministerial Conference of the WTO Member States in Doha/Qatar, 2001). However, such a strategy of diversification of imports must take a serious look at the environmental and social repercussions in the relevant exporting countries and minimise the associated risks (cf. Chapter 4.4). It is also important to note that far-reaching land-use changes in the exporting countries can also have considerable adverse effects on the climate balance of the imported biomass. On the other hand, ambitious and effectively applied criteria that seek to prevent such risks will in turn limit the potential of imported biomass. Thus although diversification of imports will not be impossible, its growth potential will be limited.

**Conclusion**

**115.** Achieving the national and European climate protection targets set in 2007 calls for ambitious expansion of renewable energy sources and hence of bioenergy as well. At the same time it is important to maximise the potential climate protection contribution of energy from biomass in the light of other environmental framework conditions. In view of the IPCC's warnings, and also in view of the limits to the expansion of biomass production that are set by environmental 'guard rails' and standards (Chapter 4), it would be irresponsible not to make optimum use of the potential contribution of biomass to reducing greenhouse gases. Since other goals of biomass promotion (promoting rural areas, improving security of supply) can be better pursued by other means, there are good grounds for giving priority to climate-relevant aspects. Thus the German Advisory Council on the Environment advocates climate change mitigation by means of biomass within a nature-friendly and socially acceptable framework.

**116.** Conflicts of objectives frequently exist between the agricultural, energy and environmental policy goals of bioenergy funding. For example, energy policy priorities in biomass funding do not necessarily match climate protection objectives. From an energy policy standpoint, the replacement of oil by biofuels in the motor fuel sector takes priority, whereas from a climate change point of view priority goes to replacing fossil fuels in the heating and power generation sectors. Replacing coal has the greatest climate change mitigation effect. Giving preference to domestically produced biofuels is such an expensive climate protection measure compared with others that from an economic point of view it should not be considered until the numerous considerably cheaper options have been exhausted. Imports of biofuels also encounter limits if nature conservation, climate change and social criteria are taken seriously in relation to such imports.

With regard to rural development, however, there are substantial synergies with climate change mitigation, especially if priority is given to use in the heating and power sectors. On the other hand, there are conflicts of objectives with climate change optimisation if rural areas are promoted by ambitious expansion targets for biofuels. This should be avoided.

**117.** The German government and the European Commission should therefore abandon the idea of a harmony of objectives between climate change mitigation, security of supply and job security in rural areas where biomass funding is concerned. Where conflicts of objectives exist, clear priority should be given to the contribution that biomass funding can make to climate change mitigation within a nature-friendly framework.

### 5.1.2 Expansion targets for bioenergy sources

**118.** In accordance with the principle of subsidiarity, the EU has so far laid down mainly indicative targets. Compliance with these is not a binding legal requirement, and the member states are free to achieve them in various ways. Thus the member states currently have great freedom in designing their national bioenergy policies. In future, however, the European Commission plans to make these targets legally binding (EU Commission 2007a).

**119.** On the one hand there are general targets for the expansion of renewable energy sources (cf. Table 5-1). Here the proportion of renewable energy obtained from biomass can vary from one member state to another. On the other hand, targets have been set which are confined to a subset of biomass use, namely biofuels (EU Commission 2006b, 2005b). To date there is no exclusive expansion target for bioenergy as a whole that could serve as a basis for an optimised approach to biomass use for the various purposes.

Table 5-1

**EU targets for expansion of renewable energy sources and use of biofuels**

| Parameter | Timing | EU target in % | Documents | Status |
|---|---|---|---|---|
| Share of primary consumption due to renewable energy sources | 2010<br><br>2020 | 12<br><br>20 | White Paper on Renewable Energy Sources 1997<br><br>Renewable Energy Road-Map 2007 | Political<br><br>Planned as legally binding target |
| Share of electricity consumption due to renewable energy sources | 2010 | 22 | Directive 2001/77 on the promotion of energy produced from renewable energy sources | Legal, but indicative and flexible |
| Share of road transport fuel consumption due to alternative motor fuels (biofuels, natural gas, hydrogen) | 2020 | 20 | Green Paper on Security of Supply (COM (2000)769 final) | Political |
| Share of motor fuel consumption due to biofuels | 2005<br>2010<br><br>2015<br><br>2020 | 2<br>5.75<br><br>8<br><br>10 | Directive 2003/30 on the promotion of the use of biofuels and other renewable fuels for transport<br><br>EU Council, March 2006<br><br>Energy Review 2007; EU Council, 9 March 2007 | Legal, but indicative and flexible<br><br>Political<br><br>Planned as legally binding |
| $CO_2$e content of motor fuels | 2020 | 10 | Proposed change to Fuels Directive (COM (2007)18) | Legally binding |

SRU/SG 2007-2/Table 5-1; data source: EU Commission 2007a; 2007c

**120.** With regard to the revision of the Biofuels Directive and the expansion targets for renewable energy sources, the European Commission proposes to make the indicative targets legally binding (EU Commission 2007a). Moreover, the minimum level for admixture of biofuels is to be increased to 10 % by 2020, and the expansion target for renewable energy sources to 20 % of primary energy requirements. As far as renewable energy sources are concerned, there are plans for differentiating the targets on the basis of economically feasible national potentials (EU Council 2007, No. 33).

These objectives have since been reaffirmed, but also qualified, by the Council of the European Union in March 2007 and at various groupings of the Council. The target is to be achieved 'in a cost-effective manner'. The Council of the European Union regards the binding target as 'appropriate' only if sustainable production, commercial availability of the second generation of biofuels and the revision of the Fuels Directive to permit higher admixture levels are guaranteed (EU Council 2007, Annex I, No. 7).

In January 2007 the Commission of the European Union presented a proposed directive that also lays down a complementary climate protection objective for motor fuels. Following a methodological development phase for the establishment of a greenhouse gas life cycle assessment covering the entire life cycle of motor fuel production, greenhouse gases are to be reduced by 1 % per annum between 2010 and 2020. One of the most important means of achieving this 10 % target by 2020 will probably be an increase in the biofuel component. Other options are possible, however. The Commission regards this instrument as an additional fine-tuning element for optimising the proposed biofuel quota from a climate change point of view (EU Commission 2007b, p. 115).

**121.** With regard to the European targets for renewable energy sources and the ambitious national climate protection targets, the German environment minister put forward considerably more ambitious national expansion targets in a government statement in April 2007. These go substantially beyond the existing targets of the German government's sustainability strategy of 2002. By 2020, renewable energy sources are to account for 27 % of electricity consumption, 14 % in the heating sector, and 17 % of motor fuel consumption. In this way the German government intends to make an above-average national contribution to the expansion of renewable energy sources in the EU.

With the introduction of the Biofuel Quotas Act, the national expansion targets for biofuels exceed the EU targets in the short and medium term (Table 5-2). They are also laid down in legally binding form until 2015. This gives them considerably greater binding force than the EU targets that have hitherto only been laid down in political statements.

Table 5-2

**EU targets for expansion of renewable energy sources and use of biofuels**

| Parameter | Timing | National target in % | Documents | Status |
|---|---|---|---|---|
| Share of primary energy consumption due to renewable energy sources | 2010<br>2020<br>2050 | 4.2<br>10<br>50 | Federal Government's Sustainability Strategy of April 2002 | Political |
| Share of electricity consumption due to renewable energy sources | 2010<br>2020<br>2020 | 12.5<br>20<br>27 | Sustainability strategy, 2002; Renewable Energy Sources Act of 21 July 2004<br>BMU 2007 | Fixed by law<br>Political |
| Share of energy content of motor fuel consumption due to biofuels; further differentiation of quotas for petrol and diesel fuels | 2010<br>2015<br>2020 | 6.75 gradually increasing to 8<br>17 | Biofuel Quotas Act of 26 October 2006<br>BMU 2007 | Legally binding<br>Political |

SRU/SG 2007-2/Table 5-2; data source: Federal Government 2002; BMU 2007

## 5.2 Funding instruments

**122.** A wide variety of funding instruments, which differ depending on the production and energy use of the biomass, have been developed at European and national level. The funding sector is highly segmented and aims solely to increase the use of bioenergy, regardless of the widely differing contributions that the different crops, growing methods or uses make to mitigating climate change. Instruments for environmental quality assurance that seek to minimise the environmental impacts of renewable raw materials production or channel them into nature-friendly directions are still at a very early stage in concept development. Thus it is only recently that stepping up biomass production in Germany and the EU has ceased to be a goal that is unreservedly deserving of promotion. On the basis of an examination of cost differences between renewable and conventional energy for the period to 2015, the overall cost of the latest expansion targets of the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) is put at € 3.9 billion, with a downward long-term trend (NITSCH 2007, p. 64 f.). On the whole this assumes high energy prices for the conventional energy sources and correspondingly low cost differences. The estimate is therefore likely to indicate the lower end of the possible range of total costs. To date there is no overall estimate of the cost-benefit ratio of various expansion variants and priorities for the individual uses with regard to climate change mitigation up to the year 2020.

Funding instruments currently in use are:

- subsidies and tax concessions,
- the electricity feed compensation which is charged to the electricity consumer, and
- minimum quotas for biomass use, the cost of which is borne by the motor fuel consumer.

### 5.2.1 Existing funding instruments

**Subsidies and tax concessions**

**123.** Direct funding of biomass use takes the form of production subsidies and protective duties, tax concessions for use as biofuel and, in the heating market, investment grants for plants generating heat from biomass.

**124.** Since the reform of the Common Agricultural Policy in 2003, a premium of €45/ha has been paid for the growing of crops for use as energy. The area qualifying for funding in Europe was limited to 1.5 million ha (Regulation No. 1782/2003 Art. 88 ff.). According to the Commission's evaluation of 22 September 2006, only 38 % of the area-based premium for crops used for energy has been taken up, though the rate is growing fast. In view of its eastward enlargement, the EU intends to increase the maximum area to 4.5 million ha and relax the requirements for eligibility (EU Commission 2006c).

In addition, biomass production is also promoted by an exemption from the ban on cultivation of set-aside land. Production of renewable raw materials continues to be possible on set-aside land, where in addition to the set-aside premium it can continue to generate income from the sale of biomass (Art. 55 and 56 of Regulation 1782/2003). Such land can hardly perform the nature conservation function of set-asides. The member states are permitted to provide additional promotion for the growing of perennial energy crops on set-asides in the form of national subsidies of 50 % of the initial cost (Art. 56 (4) of Regulation 1782/2003).

**125.** On the other hand sugar beet production, which also supplies raw material for the production of bioethanol, still profits from the old system of agricultural subsidies in the form of production quotas and intervention prices, protective duties, import quotas and export refunds to promote sugar exports. However, the European sugar industry is increasingly coming under pressure from the EU market reforms and is also, under the WTO agreement, having to accept restrictions on its protection of the internal market. As long ago as 1995, for example, the EU undertook under the WTO agreement to reduce the subsidised export quantities and export refunds. Since then it has had to adjust the maximum quantities in line with the annual export opportunities. Following the entry into force of the reform of the sugar market system in 2006, the reference price will also be reduced by 15 % from 2008/2009 onwards and by a good 36 % from 2009/2010 onwards, compared with 2005/2006 (LfL 2007). Under these conditions it is no longer profitable to grow sugar beet in the EU on the present scale (ISERMEYER 2004). The promotion of bioethanol production is therefore seen by the sugar industry as an opportunity to offset economic setbacks resulting from the reforms. At present the use of sugar beet for chemical purposes (bioethanol) accounts for less than 1 % of total German production. With the commissioning of additional processing capacity, processing for bioethanol is expected to reach some 4 % of the crop from German land under sugar beet by 2008 (LfL 2007). Moreover, the new biofuel market permits a reduction in exports of sugar quantities in excess of the permitted production quotas ('C sugar'). Since they are not competitive, sugar exports in excess of the production quotas require export subsidies which largely have to be financed from production levies and thus impose costs on internal sales of sugar within the EU (SCHMIDT 2005, p. 11).

To safeguard the sale and processing of surplus sugar quantities within Europe, European bioethanol production, which is not internationally competitive, is protected by an import duty of 19.2 ct/l on the considerably cheaper Brazilian bioethanol (HENKE and KLEPPER 2006). Tariff-related and especially technical barriers to trade also exist for imports of biodiesel, for example produced from palm oil (REINHARDT et al. 2007, p. 13). As a rule the import duty increases with the degree of further processing of the renewable raw materials. There are also the technical specifications for motor fuels, which have hitherto impeded the use of certain biofuels (e.g. from palm oil and soybean oil) (for an overview see: DUFEY 2006, p. 25 ff.). Some of the technical barriers to trade are to be reviewed in the context of the European Commission's motor fuel strategy (EU Commission 2007c; 2005b; 2006b).

**126.** The instrument of tax exemption is used to promote biofuels in particular. From 2004 to 2007 there was a general tax exemption from petroleum excise duty for all biofuels and for the biogenic components in fossil fuels. The tax exemption was intended to offset the difference between their production costs and the market price of the competing fossil fuels. The Biofuel Quotas Act (BioKraftQuG) of 26 October 2006 brought a differentiation of the existing funding approach. In view of the fast-growing demand for biofuels and the German government's expansion targets, it was proving too expensive to maintain the general tax exemption. The annual cost of this tax exemption would have risen to around € 2 billion by 2010 (HENKE and KLEPPER 2006, p. 6). Even at the relatively low oil prices prevailing in 2004 there were signs of substantial windfall-profit effects, in other words excessive assistance going beyond the difference in costs (Deutscher Bundestag 2005). For this and other reasons, funding from 2007 onwards was switched to a combination of instruments consisting of tax exemptions and a quota system.

In future the tax exemption no longer applies to motor fuels subject to an admixture quota. There continues to be a tax concession for biofuels especially deserving of promotion, but this is on a declining scale. Such biofuels include in particular pure biofuels (which do not count towards the quota), and second-generation biofuels (LAHL and KNOBLOCH 2006).

**127.** Plants for generating heat from biomass are promoted under the market incentives programme for the promotion of renewable energy. Such plants, differentiated on the basis of their nominal capacity, are promoted by means of investment grants and/or low-interest loans and debt relief. The promotion is intended to encourage a large-scale market introduction of energy from biomass in many areas of application. The funding rates are designed to overcome existing profitability thresholds. This is due to the fact that, as a rule, small plants involve higher costs in relation to their nominal capacity and give rise to higher heat supply costs when the relevant fuel costs are included. Also the choice of heating fuel results in different costs depending on consumption (LANGNIß et al. 2004, p. 57). These differences in the burden of costs are catered for by differentiating the funding on the basis of the heating fuel used.

### Biofuel quotas

**128.** Since 1 January 2007 the setting of compulsory biofuel admixture quotas has been the central instrument for promoting biofuel production for the transport sector. The quota shows a gradual increase. There are separate quotas for diesel and petrol, and an overall quota. The German government hopes that the quota system will result in an increase in petroleum excise duty revenue of initially some € 1 to 1.5 billion/a (Deutscher Bundestag 2006b; 2006a, p. 94). At least in the medium term, the cost difference between the production costs of biofuel and the market price of fossil fuels will largely be incorporated in fuel prices and hence borne by the transport sector. Estimates put the effect at 3 ct/l in 2007 (HENKE and KLEPPER 2006, p. 8). This figure can be expected to continue rising with the increase in the quota, assuming relatively constant supply costs and oil prices.

In connection with the Biofuel Quotas Act, an initial foundation has been created for quality assurance of biomass production. A new Section 37d has been inserted in the Federal Immission Control Act (BImSchG), empowering the German government to enact ordinances under which specific products can no longer be counted towards the compulsory quota. Important criteria to be developed here are minimum requirements for the management of agricultural land or for the conservation of natural habitats, plus a minimum level of $CO_2$ avoidance (Deutscher Bundestag 2006b, p. 13; LAHL and KNOBLOCH 2006). The Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) plans to present a corresponding draft ordinance by the end of 2007 (cf. Chapter 4.4).

### Feed compensation

**129.** Electricity generation from biomass is promoted under the German Renewable Energy Sources Act (Erneuerbare-Energien-Gesetz – EEG). This lays down declining rates for power from biomass which are passed on to electricity consumers and which vary with the combustion technology and decrease as the nominal capacity of the plants increases. In the past six years the share of the total funding volume of the Renewable Energy Sources Act that is accounted for by electricity from biomass has more than doubled, from 6.4 % to 15.4 %. The average compensation rate for electricity from biomass did not show a reduction of the kind seen for the other energy sources promoted under the Act. In absolute terms, only the average compensation for electricity from geothermal energy and solar energy was higher (Verband der Netzbetreiber e. V. 2006). Since the compensation rates for electricity from biomass are subject to smaller decreases in the next few years than is the case for other technologies, it may be assumed that the biomass share of renewable energy promotion under the Act will increase in both absolute and relative terms, and that by 2020 it will account for about one third of such compensation payments (NITSCH et al. 2005).

With the aid of the strictly defined compensation arrangements, the legislature is seeking to help the broadest possible spectrum of biomass-based energy conversion technologies to achieve economic viability. This is why smaller plants, which can be assumed to have a less favourable ratio of costs to income, receive more assistance than large plants. For example, the basic compensation funding rates for electricity from micro plants (not exceeding 150 kW) are 37 % higher. Including the bonus for renewable raw materials which is differentiated by plant size, the compensation may even be more than twice the compensation for large plants (5 to 20 MW). Combined heat and power (CHP) plants receive special treatment in the form of a bonus on the basic compensation. On the other hand, plants that use conventional (fossil) fuels in addition to biomass are excluded from assistance entirely (BMU 2004).

**Topical discussion about a 'Renewable Energy for Heat Act'**

**130.** Ideas are currently being discussed for an Act concerning heat from renewable energy, based on the model of the Renewable Energy Sources Act (EEG). And for some time now the environment ministry has been considering instruments for promoting the use of renewable energy sources to generate heat. However, the coalition government has yet to reach a consensus on this point. A research project commissioned by the environment ministry has investigated the practicability of alternative design options.

On the basis of an evaluation in terms of stable and reliable investment conditions, transaction costs, acceptance and dynamic innovative impact, the alternatives 'compulsory use' and 'bonus model' were favoured. The 'compulsory use' variant lays down a minimum quota of heat from renewable energy sources (including biomass), reinforced by an equalisation levy to ensure its implementation. In the 'bonus model', producers of heat from renewable energy sources are to receive, on the lines of the feed compensation under the Renewable Energy Sources Act, a heating technology specific compensation payment per energy unit (kWh) which is drawn from a contributory fund financed by a charge on fossil heating fuels (KLINSKI 2006).

The aim of the Renewable Energy for Heat Act is to institutionalise the promotion of heat energy production from renewable energy sources. In view of the heavy dependence of the existing funding on budget factors, the German government found that continuous assistance for its market introduction had not been possible to date. Moreover, the upward trend in heating fuel prices impaired the market incentive effect of the existing investment grant system. This reduced the achievement of the targets and the certainty that the investment would be profitable. The new funding instrument is intended to eliminate these weaknesses.

### 5.2.2 Criticism of funding instruments

**131.** Funding for bioenergy is segmented. Promotion focuses on the one hand on greater use of biofuels through minimum fuel mix requirements, tax concessions and farming subsidies, and on the other on use of biomass in electricity and heat production – primarily through special feed-in tariffs under the German Renewable Energy Sources Act (EEG) and investment grants for heating supply systems.

While there are historical reasons for this segmentation, when looked at from an economic and environmental standpoint it hinders overall optimisation of biomass use. In particular, it obstructs market processes, making it difficult to arrive at the most cost-effective ways of achieving greenhouse gas reductions. Rather than promoting market price-finding under an ambitious climate policy framework, funding focuses on fine-tuning specific technologies and on quantity targets for selected uses. This approach does not fully exploit the role biomass can play in climate change mitigation.

There is no sign of appropriate coordination of the individual instruments and their promotion purposes as part of an overall concept. The overall use of biomass for energy still lacks an over-arching organisational framework that identifies the nature-friendly crop area and energy potentials and weighs up the various use options from a technical or economic point of view before taking this as a basis for developing funding policies. It is logical that attempts are made to maximise biomass use for one's own individual purpose and thereby enter into competition for funding. Indeed, most of the available calculations of biomass to energy potential provide only partial views targeted to a particular purpose, and thereby implicitly make multiple use of the area available for bioenergy sources. One example of this is the potential calculation by the European Commission, according to which some 18 % of the agricultural land in the EU would provide sufficient biofuel to satisfy up to 14 % of motor fuel consumption by 2020. This impact assessment by the European Commission is incomplete, since it does not investigate how much additional land is needed to achieve the bioenergy share of the European expansion target for renewable energy sources and whether this can give rise to conflicts of use (EU Commission 2006a, p. 10, cf. also Chapter 3).

**132.** Existing funding instruments are concerned solely with quantity targets focusing on final energy content. However, when biomass is used for energy, the final energy content does not correlate with the greenhouse gas balance. This may result in a situation where usage paths without any significant beneficial effect on greenhouse emissions receive similar funding to highly climate-effective usage paths. According to calculations by the European Commission, for example, the EU target of a 5.75 % admixture of biofuel to conventional motor fuels permits a saving of between 15 and 45 Mt $CO_2$ depending on the energy crop and conversion technology (EU Commission 2007b, p. 112). The situation is further distorted by the segmentation of funding policies, which have developed different funding and compensation rates for different biomass uses and technologies. Since avoiding greenhouse gas emissions is usually a secondary criterion here, the funding policy in question cannot pursue this goal efficiently.

**133.** The situation is further complicated by the different control effects of the various instruments: whereas admixture quotas enforce quantity growth regardless of the costs in question, the quantity effect of a feed-in tariff or tax exemption depends on the funding level and the relative production costs. Thus in practice the admixture quota will be given priority over the other promotion measures. If the quota is very high, and if an energy crop is suitable for various uses, one can expect to see direct impacts on the effectiveness of the funding instruments in the other areas of use, not only for energy but also for materials. Certainly when the second-generation biofuels become marketable, a high biofuel quota of the kind decided by the German government and the EU will increase the financial resources needed by the other funding instruments for renewable energy in the heat and power sectors to achieve the same effects. The shortage of biomass caused by a high biofuel quota increases the cost of alternative $CO_2$ avoidance options. Thus setting priorities in favour of biofuels clearly benefits uses with a relatively small climate protection contribution and high greenhouse gas avoidance costs (cf. Items 35, 38, 145).

In view of the widely differing contributions of biofuels to climate change mitigation, the enforcement of admixture quotas can impair mobilisation of the savings potential of other greenhouse gas reduction options. In the light of the renewed priority given to climate change mitigation by the German government and the EU, this does not make much sense. The European Commission's proposed complementary instrument of a 10 % reduction in the greenhouse gas content of motor fuels by 2020 on the basis of life cycle assessment could partially correct the situation. This target would make it possible to mobilise efficient greenhouse gas reductions in the motor fuel sector, included those achieved without biofuel admixtures (e.g. plant-oriented measures in crude oil production, transport or refining). On the other hand, the climate change mitigation target and the admixture target are complementary, which means that the admixture target will continue to be pursued even if the greenhouse gas reductions for motor fuels can be achieved more efficiently by means (EU Commission 2007b, p. 115). A positive aspect here is the fact that the Commission's proposal envisages the establishment of a method and the adoption of a convention for comparative life cycle assessment of different motor fuels. This methodological convention will provide an indispensable basis for improving the climate protection relevance of the range of funding instruments.

**134.** The ambitious growth targets for 2020 will only be possible by means of substantial additional imports. On the one hand the potential domestic area is too limited, and on the other, growing in tropical countries is much cheaper. Developing internationally recognised and sanctionable minimum standards for energy crop production, further processing and transport, especially with regard to conservation of biodiversity, is likely to be a lengthy and demanding task. There is thus a risk that it will take too long to develop supporting instruments designed to prevent possibly irreversible consequences of the production and exploitation pressures in tropical countries (cf. Items 41 f., 75 f.). Furthermore, the pressure to take action to achieve legally prescribed admixture quotas will rob the EU of the important bargaining point: 'opening of markets in return for production quality standards'.

The power to issue secondary legislation laid down in Section 37d of the Federal Immission Control Act, and also the EU climate change mitigation target for motor fuels, are first practical steps planned for the next few years to establish minimum criteria for the growing of energy crops. Their scope is, however, already limited by the fact that they focus solely on specific funding instruments and give no indication of an integrated approach to providing environment support for biomass promotion and the resulting imports (cf. Item 95 f.).

**135.** The national biomass action plan scheduled for 2007 provides an opportunity to correct these undesirable developments. The plan should contain over-arching key points on potentials and targets, an integrated funding policy, climate change mitigation aspects, and the framework conditions for environmentally sound cultivation of biomass crops.

**136.** The market introduction of renewable energy sources in the heat and power sectors is a matter of special concern to the German government. With the aid of the market incentives programme for renewables and the Renewable Energy Sources Act it has proved possible in the past to give the markets a considerable boost and to mobilise considerable potential for using biomass in the heat and power sectors. These instruments alone have succeeded in raising many renewable energy technologies above the individual profitability threshold and triggering a number of innovations in this market segment. Even if giving priority to funding for the generation of heat and electricity from renewable energy sources should be preferred to their use as biofuels on climate protection and efficiency grounds, and even if the market incentive effect in certain sub-segments has been exemplary, the present range of funding instruments displays a number of contradictory incentive effects. To date, no satisfactory balance has yet been found between the goal of large renewable energy shares that has been explicitly and repeatedly affirmed by the German Advisory Council on the Environment (SRU 2004, Item 39 ff.; 2005a, Item 10), and efficient climate change mitigation.

**137.** Promotion of biomass utilisation under the Renewable Energy Sources Act has so far been confined largely to technological aspects. But aspects of regional policy and competition policy have also found their way into the design of the funding arrangements. Plants with lower efficiency are given greater assistance, while much more energy-efficient biomass uses combined with conventional fuels in large plants are not. The limitation of funding to plants with a nominal capacity of less than 20 MW means that investment resources are systematically directed into plant sizes with suboptimal energy efficiency. As long as emissions trading for greenhouse gases does not lay down any adequate long-term emission limits and associated $CO_2$ prices, indirect biomass promotion in such plants will do little to create incentives. For example, straight biomass power plants working on the condensing principle without heat take-off generally achieve gross efficiency levels (excluding internal consumption) of between 10 % and 30 %, whereas co-incineration of biomass in modern coal-fired power stations can reach net efficiency levels of up to 45 % (Institut für Energetik und Umwelt 2006, p. 19).

In addition to these efficiency deficits, one cannot exclude the possibility of windfall-profit effects (EU Commission 2005c, p. 34). A clear indication of windfall-profit effects is the trend towards increased use of renewable raw materials in agricultural biogas plants since the introduction of the ‘bonus system’ for renewable raw materials (‘NawaRo-Bonus’) in the most recent revision of the Renewable Energy Sources Act. In plant projects that investors evidently judged profitable under the previous compensation arrangements, there is currently a trend towards dispensing with the use of agricultural waste in view of the increased compensation tariffs and switching the substrate to energy crops grown specifically for this purpose. More than one third of plant operators plan to modify their substrate composition, or have already done so and have eliminated substrates that do not qualify for bonuses (Institut für Energetik und Umwelt 2005; 2006, p. 45 f.). However, compensation arrangements that do not have any capacity-increasing impact and merely increase profits on existing plants reduce the efficiency of the Renewable Energy Sources Act. Such windfall-profit effects do not promote either market introduction or climate change mitigation.

In view of the technology-oriented and regional-policy promotion objectives, plants for generating electricity from biomass for end products with virtually identical climate protection impacts receive different amounts of compensation. The structure of the compensation rates shows that clear preference is given to maximising use of regionally available bioenergy source potentials and catering for the specific cost factors of selected technical use options, rather than searching for cost-effective greenhouse gas avoidance options. For example, monitoring of the implementation of the Renewable Energy Sources Act is not evaluated rigorously on the basis of criteria that provide information about the climate-relevant costs and benefits, but primarily on the basis of indicators concerned with plant capacity in absolute terms and in relation to the areas of the federal states (Institut für Energetik und Umwelt 2006). Even the technology bonus is not based on the contribution of new technologies to climate change mitigation, but is primarily geared to establishing new processes on the market.

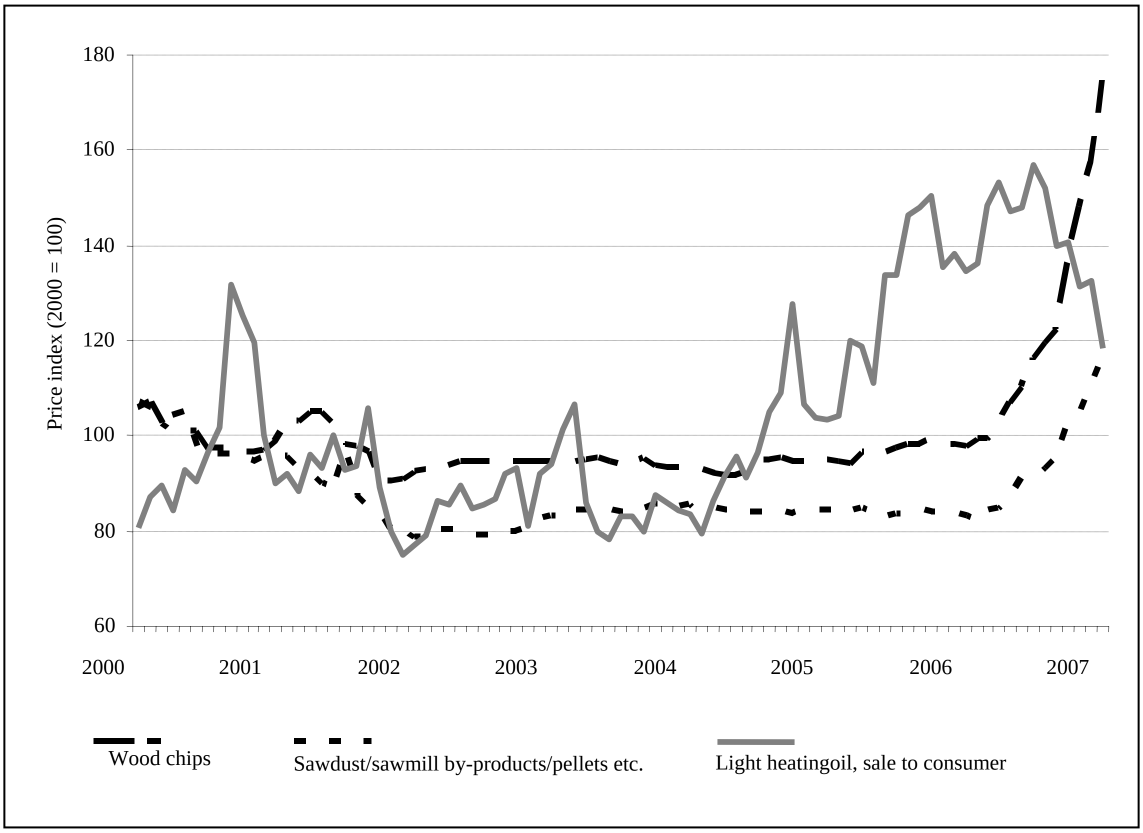
At first glance, these promotion criteria can be justified on the grounds of innovation-oriented interest in stimulating a market that will become self-sustaining in the long term. In the long term, however, such a promotion strategy has efficiency deficits. If the funding measures are not replaced in the long term by cost pressures and the innovative thrust of competition, there is a risk that individual technologies which continue to lack market viability will go on receiving artificial ‘life support’, while companies lose sight of other – possibly more efficient – innovations (Institut für Energetik und Umwelt 2006).

**138.** Similar problems can also occur even with existing market entry funding in the heating sector and with the variants currently favoured for a new Heating Act. Whereas comparatively inefficient plants with high emission avoidance costs enjoy a particularly high level of assistance, funding for some plant categories has in the past continued even after profitability was assured by the increasing prices of fossil fuels (LANGNIß et al. 2004; LANGNIß et al. 2006).

On the other hand there are now signs of a change in this situation as a result of the upward trend in heating fuel prices. A comparative study of price trends for wood chips/wood pellets and light heating oil reveals that although wood fuel prices were for a long time subject to less marked fluctuations than heating oil, they have now come under stronger upward pressure as a result of the heavy demand for heating fuel (Fig. 5-1).

Figure 5-1

**Development of selected heating fuel prices (price indices for commercial products 2000 = 100)**




SRU/SG 2007-2/Fig. 5-1; data source: Statistisches Bundesamt (Federal Statistical Office), various years

This clearly visible price increase starting at the beginning of 2006 follows a doubling of the number of funding applications for biomass boilers under the market incentives programme for the use of renewable energy sources between 2004 (23,190 applications) and 2005 (46,784 applications) (LANGNIß et al. 2006). What is more, the demand for heating fuel for the large-scale plants also supported creates a further increase in the price pressure. The extensive assistance for biomass use in the heating sector has not only contributed to close coupling of the market price trends for wood fuels and heating oil, but has also given rise to demand-driven upward pressure on wood fuel prices that is independent of the price of heating oil. Compensating reductions in operating and plant costs due to technological improvements and lower plant production manufacturing were hardly noticeable during the period 2002 to 2005, and there is hardly any reason to expect them in the future for the combustion technologies established on the market (LANGNIß et al. 2006; LANGNIß et al. 2004). Thus it will only be possible to achieve the goal of greater market penetration of biomass heating systems by means of long-term funding that compensates for expected future increases in heating fuel prices.

**139.** In a future payment model for heat generation from biomass, the intended reduction in the price of heat from biomass will have to be weighed against the associated negative incentives to waste heat. Instead of providing the recipients with additional incentives to optimise heat insulation, the production of space heat is encouraged beyond the level that is economical in the light of heating fuel prices. It must also be remembered that without optimised upgrading of individual heating systems, increased use of biomass in single or multi-family houses can lead to harmful increases in air pollutant levels. The heat bonus is not a suitable instrument for promoting the fitting of flue-gas purification systems to old biomass heating plants. Finally, it should be borne in mind that not only the replacement of oil and coal heating systems and the expansion of local and district heating are particularly deserving of assistance, but also the use of biomass for industrial process heat. A heat bonus would not seem to be an ideal instrument for setting these priorities in the heating sector.

## 5.3 Conclusion

**Prioritising climate change mitigation objectives**

**140.** In principle, promotion of biomass can make different contributions to achieving agricultural, energy and environmental policy targets. It is however necessary to take account of the inherent costs and of the conflicts between these targets. As far as the goal of supply security is concerned, the additional cost of bioenergy production must not be out of proportion to the objective of energy price stabilisation and containment. The subsidy requirements for biofuels from national and European energy crops are so great that one is forced to concede that in this case the 'insurance premium' is out of proportion. This means there in the case of biomass promotion there is no harmony between agricultural policy and energy policy objectives. There are also clear conflicts of objectives between climate change mitigation and security of supply. The main contribution of climate-optimised biomass use will be not to replacing petroleum in the transport sector, but rather to replacing fossil fuels in heat and power generation. As far as the pursuit of agricultural policy objectives is concerned, it should be noted that further subsidies are only justified if they pursue general welfare objectives, such as nature conservation and climate change mitigation. In view of these conflicts of objectives and the problems of justifying competing objectives, priority for biomass promotion must be given to its contribution to climate change mitigation.

**Integrated biomass strategy to avoid segmented funding**

**141.** Funding of bioenergy is highly segmented and present obstacles to optimisation of biomass use on the basis of climate protection criteria. A relevant proportion of the climate protection potential of bioenergy use thus remains unexploited. Instead, segmentation promotes a funding race between the various biomass uses. Extremely high biofuel quotas that have to be achieved regardless of economic viability will push up the costs of biomass use in areas that can contribute most to climate change mitigation. There is thus a risk that significant public and private funds will be wasted due to a lack of coordination between the various instruments available.

The power to issue secondary legislation laid down in Section 37d of the Federal Immission Control Act, and also the EU climate change mitigation target for motor fuels, are first practical steps planned for the next few years to establish minimum environmental criteria for the use of bioenergy. Their scope is already limited, however, because they focus solely on specific funding instruments and give no indication of an integrated approach to providing an environment policy pillar in biomass promotion. A conflict thus exists between environmental criteria set out in Section 37d of the BImSchG and the over-ambitious nature of the fuel quotas. Resolving this conflict will prove extremely difficult.

Against this background, the key task of any potential biomass action plan is to set out and prioritise the main points of a strategy on biomass potential and its optimal use in climate change mitigation, for a workable funding policy, and for a framework to allow environmentally sound cultivation of biomass crops.

# 6 Routes to an optimised biomass strategy

**142.** The German Advisory Council on the Environment regards the reduction of greenhouse gas emissions as the most important objective of biomass use. In order to exclude non-sustainable forms of use, however, this objective must only be pursued in compliance with the environmental framework conditions described in Chapter 4. A sustainable biomass promotion strategy must therefore meet two fundamental requirements:

- It must optimise biomass use to avoid greenhouse gas emissions (cf. Chapter 5.3).
- It must produce a legislative framework at national, EU and international level to allow environmentally sound cultivation of energy crops. This framework cannot be developed without taking account of existing instruments for environmentally sound agriculture (cf. Chapter 4.3).

The preceding chapter made it clear that funding for bioenergy is segmented. To date there is no sign of appropriate coordination of the individual instruments and their promotion purposes as part of an overall concept. A transitional strategy is therefore needed until the basis for rigorous climate policy orientation of funding instruments is created. During this transitional phase the existing instruments should be reviewed with regard to amount, scope of application and expansion targets, and corrected where they present obvious obstacles to cost-effective climate change mitigation through biomass. In the long term, efforts should be made to take account of the greenhouse gas savings of bioenergy in a substantially reformed and broadened greenhouse gas emissions trading system. Ideally this would be a global emissions trading system at the primary trade level, though this would be difficult to put into practice. Partly for this reason, the German Advisory Council on the Environment is of the opinion that it makes sense to develop biomass promotion in two phases, a transitional phase of promoting the market introduction of biomass technologies, followed by a second phase of long-term exploitation of the $CO_2$ avoidance potential of biomass use under an efficient climate change mitigation regime.

The crucial question is how to develop the phase of promoting the market introduction of biomass technologies from the existing funding set-up, while at the same time designing it from the outset as a transition that is ultimately to be superseded by the second phase of efficient climate change mitigation. It goes without saying that compliance with the boundary conditions mentioned above must be ensured in both phases. This section sets out to provide a road map that leads from the present and planned funding system to biomass use geared to efficient climate change mitigation combined with environmental quality assurance.

## 6.1 Promoting market introduction on a short-term perspective

**143.** In many cases the use of innovative technologies involves industry in breaking new market ground. Energy technology innovations are faced with a risk-prone market environment, where imperfect markets often mean that market forces only leave room for technology options with short-term profit prospects. By contrast, production technologies that will only become competitive in the medium to long term often enjoy lower priority. This phase of market development can be accelerated by transitional technology promotion. Such promotion should however focus on technologies which can become competitive in the foreseeable future and whose medium to long-term climate protection contribution falls within a reasonable reference framework of macro-economically cost-effective climate change mitigation measures. With realistic estimates of learning curve effects, it is possible to identify promising technologies as regards their economic potential and assess their environmental soundness using life-cycle analysis. In the biomass sector, usage paths with equally high economic and environmental potential are very limited. Such promising technologies need to be promoted using instruments that, by means of stable framework conditions, ensure a positive innovation and investment climate for rapid transition to market maturity.

**144.** Although the funding instruments currently in use have positive effects on the market development of various biomass usage options, there is still a need for reforms. It is important to avoid situations where the promotion measures provide long-term finance for non-viable technology options and thereby tie up scarce resources. Regular evaluation of funding to identify windfall-profit effects is also necessary. Rising energy prices, technical advances and learning curve effects in plant production result in dynamic developments in profitability among funding recipients, and this calls for a flexible response to avoid promotion of technologies that have already become established on the market. There are still considerable deficits here. Although the differentiation of promotion by individual technology options which is currently practised increases the chances of achieving market maturity faster in these sectors, this approach systematically marginalises other possible alternatives and runs the risk of getting stuck in a dilemma between permanent subsidies for non-viable options and windfall-profit situations. Moreover, the scope of application of the funding should also be restricted if new climate-friendly energy options create new environmental problems.

**145.** The trends in $CO_2$ avoidance costs provide a basis for a more efficiency-oriented promotion policy.

The Öko-Institut study (FRITSCHE and ZIMMER 2006) determined avoidance costs for 2010 and 2030 specifically for different biomass usage paths. It examines a high-price and a low-price scenario for energy. Using waste consistently results in the lowest avoidance costs. This use option is however limited by the fact that, at least in the long term, the potentials of biomass waste are relatively low.

Although this study shows that second-generation biofuels (Biomass-to-Liquid – BtL) have considerably lower avoidance costs than first-generation biofuels, the average avoidance costs for bioethanol are very high at 368 €/t $CO_2$e in 2010 and 117 €/t $CO_2$e in 2030. Only replacement of diesel by BtL diesel, at 64 €/t $CO_2$e, is relatively favourable at low fossil energy prices. If availability of the waste is low, or if fossil energy prices rise, the avoidance costs are over 100 €/t $CO_2$e. In the biofuels sector as a whole, replacement of diesel by pure rape oil is by far the most favourable alternative, with avoidance costs of 63 €/t $CO_2$e, and is already available. Other studies also show considerable ranges of avoidance costs for the individual biofuel types, which are due to different methodological assumptions and uncertainties (ECMT 2007, p. 87; CONCAWE et al. 2006).

In the field of energy conversion, the assumed greenhouse gas reduction factors for the individual biomass usage paths are crucial for the determination of avoidance costs. The reduction factors depend largely on the energy sources replaced. For example, FRITSCHE and ZIMMER (2006) arrive at greenhouse gas avoidance of 142 g $CO_2$e/kWh and hence at avoidance costs of 181 €/t $CO_2$e for replacement of gas-fired micro CHP by biogas micro CHP plants. In the TUM study (WAGNER et al. 2004), natural gas and coal power plants were replaced by biogas plants with a reduction factor of 829 g $CO_2$e/kWh. This resulted in avoidance costs of around 30 €/t $CO_2$e. The following overview is a summary of the $CO_2$ reduction factors (g $CO_2$e/kWh) in various studies; in the electricity sector they take account of emissions by the upstream chains (g $CO_2$e/kWh). The three columns on the right show, for three price differential scenarios, the $CO_2$e avoidance costs based on the reduction factors.

Table 6-1

**$CO_2$e avoidance costs in the electricity sector**

| Study** | Reduction factor* | $CO_2$e avoidance costs for a cost difference (in ct/kWh) of | | |
|---|---|---|---|---|
| | | 2,6 | 3 | 5 |
| | g $CO_2$/kWh$_{el}$ | €/t $CO_2$e | €/t $CO_2$e | €/t $CO_2$e |
| DLR, IFEU, WI | 466 | 56 | 64 | 107 |
| UBA Var. 1 | 790 | 33 | 38 | 63 |
| UBA Var. 2 | 480 | 54 | 63 | 104 |
| Prognos | 438 | 59 | 68 | 114 |
| EWI, IE, RWI | 930 | 28 | 32 | 54 |
| TUM | 829 | 31 | 36 | 60 |
| Average | | 40 | 46 | 76 |

*The reduction factors are reduced across the board by a deduction of 100 g $CO_2$/kWhel compared with KLOBASA and RAGWITZ (2005) to take account of the $CO_2$e emissions of the upstream chain.

**Abbreviations of the individual studies:

• DLR, IFEU, WI: Nitsch, J.; Gärtner, S.; Barthel, C.: Ökologisch optimierter Ausbau der Nutzung erneuerbarer Energien in Deutschland, Stuttgart, Heidelberg, Wuppertal 2004

• UBA Var. 1+2: Nitsch, J.; Fischedick, M.; Staiß, F.; Allnoch, N.; Baumert, M.: Klimaschutz durch Nutzung erneuerbarer Energien, Umweltbundesamt (Ed.), Berlin 2000

• Prognos: Zwischenbericht V: Analyse der Wirksamkeit von $CO_2$-Minderungsmaßnahmen im Energiebereich und ihre Weiterentwicklung, Basel: 2003

• EWI, IE, RWI: Schulz, W.; Kalies, M.; Hillebrand, B.: Gesamtwirtschaftliche, sektorale und ökologische Auswirkungen des Erneuerbare Energien Gesetzes (EEG), Köln 2004

• TUM: Geiger, B.; Hardi, M.; Brückl, O.; Roth, H.; Tzscheutschler, P.: $CO_2$-Vermeidungskosten im Kraftwerksbereich, bei den erneuerbaren Energien sowie bei nachfrageseitigen Energieeffizienzmaßnahmen, München: Lehrstuhl für Energiewirtschaft und Anwendungstechnik, TUM 2004

SRU/SG 2007-2/Table 6-1; data source: KLOBASA and RAGWITZ 2005; own calculations

The widely varying $CO_2$ reduction factors are explained by the assumptions regarding the energy sources replaced. The individual studies use different methods to determine the power plants replaced by bioenergy plants. The cost differential is calculated as the cost per unit of electricity generated from biomass, less the supply cost of a unit of electricity from the technology replaced. For example, there is an additional cost of 2.6 ct/kWh if gas is replaced by biogas. The size of the cost differential depends on the raw material prices and the technology used. If fossil fuel prices rise faster than biomass prices, one can expect a fall in the cost differential and hence in $CO_2$ avoidance costs. At any rate the cost differential will fall as a result of technological advances in energy generation, since learning curve effects mean that the cost of supplying electricity from the young technologies of the renewable energy sources will fall faster than the supply costs of conventional power plant technology. If, in addition, greater use is made of process heat in electricity production, a possible increase in the cost differential can be expected to be offset by the increased reduction factor, thereby reducing $CO_2$ avoidance costs.

The various forms of biomass use for energy display a very wide range of costs. Even anticipating technological advances and declining costs, and also high emission rights prices for ambitious long-term climate change mitigation, it is clear that certain technological options do not have an economically viable future. Even a technology approach with an open mind about the future should therefore refrain from broad market introduction of technologies that will not be viable even in the long term. In this technological phase, the individual funding instruments should be subject to systematic review based on the above criteria and should be revised if necessary. This means:

**146.** Where funding under the Renewable Energy Sources Act is concerned, the restriction of funding to small-scale facilities and those that only convert biomass should be reviewed. With regard to technical efficiency and climate change mitigation, the use of biomass is also desirable in larger-scale power plants.

Also, funding amounts and the declining scale used to allocate funding should be reconsidered. Paradoxical effects of declining-scale funding, such as promotion of several micro biogas systems of suboptimal size at a single location, should be avoided.

Bonus payments for use of renewable raw materials (NaWaRo-Bonus) should be reviewed as regards their negative effect on the use of waste in biogas facilities. Any change in feed-in tariff structure that merely results in fuel substitution and does not lead to an improvement in the greenhouse gas balance of electricity from biomass should be avoided. Regional policy aspects should not play any part in the fixing of feed-in tariffs.

**147.** When funding heat use, the provision of funding as a market incentive should be further advanced. It appears particularly important in this regard to strictly link the availability of funding to the use of available exhaust gas cleaning technology and, in the interests of climate change mitigation, to priority substitution of coal and heating oil. It is also important to review the funding instruments with regard to greater use of biomass in local and district heating and for industrial process heat. When redesigning funding-based incentives, greater weight should be given to climate change mitigation potential over purely quantity-based targets. To finance a programme of this type, consideration should be given to imposing special levies on fossil fuels used for heating.

The currently debated introduction of a Renewable Energy for Heat Act with technology-differentiated payments for heat in-feed does not serve the purpose. Promoting the use of energy for heating could lead to efforts in the field of energy efficiency being neglected. Also, energy source-dependent funding would make it difficult to implement the installation and modernisation of biomass-fuelled heating systems that is so necessary for abating air pollution.

**148.** Direct promotion of biomass cultivation and the implicit preference for energy crops in Community measures to encourage set-asides in agriculture should be reversed, as should the payment of premiums for energy crop cultivation. Promotion of bioenergy should occur solely on the user side, as this is the only way to ensure optimisation of biomass use. In rural development programmes, which are to be stepped up, special consideration should be given to cultivation methods and crops that give rise to synergies in the attainment of nature conservation goals (cf. Chapter 3). Subject to nature conservation conditions, these could include the funding for cultivation of perennial crops that is already practised. However, the basic problem of duplication of funding – on the supply side by the instruments of the first pillar of the European agricultural policy, and on the production side by the use-oriented funding instruments – can only be solved in the context of further fundamental reform of the European agricultural policy. Here there should be reduction of price support mechanisms and farm-related or area-related premiums in favour of rewards for performance in the field of landscape and nature conservation.

**149.** The ambitious national and European growth and expansion plans for biofuels should be subjected to a critical review in the light of several aspects: other more profitable areas of use, the relatively high cost of climate change mitigation at least in the next decade, the sometimes dubious and generally limited contributions to climate change mitigation, a realistic assessment of technological developments, and an import pull for which it will be difficult to provide environmental support. There has yet to be a serious comprehensive review of the politically imposed targets with an assessment of the economic and environmental costs and benefits for climate change mitigation. The individual estimates of consequences by the European Commission suffer from methodological weaknesses (Item 109) and in some cases suggest conclusions that conflict with the political objectives (Section 5.1).

The national biofuel quota should therefore – taking account of the aspect of trust in relation to investments already made in conversion plant in reliance on the rising quota – be frozen as close as possible to the present level. The target set by the EU Council of a 10 % quota by 2020 is in need of downward correction. As long as the conditions linked to this target (sustainable production, availability of second-generation technology, commercial viability) are not in place, the German government should make every effort to ensure that this target for 2020 is at least not made legally binding.

**150.** As indicated by the above remarks (Items 109, 112), the contribution of biofuel both to climate change mitigation and to security of supply is widely overestimated. The total costs of the targeted growth path are not transparent and are not examined in relation to their benefits. The task of limiting the global environmental and social side-effects of an import pull is made more difficult by an admixture quota that is too high. There is an urgent need to develop a comprehensive life cycle analysis of the greenhouse gas emissions of biofuels, in order to obtain a realistic picture of the climate protection potential of biofuels (cf. Item 35). Such a comprehensive analysis will reveal that many motor fuels currently receiving assistance no longer make any appreciable positive contribution to climate change mitigation. Moreover, an excessively high quota also impedes a transition to the climate change optimisation recommended by the SRU.

As soon as possible, taxation-based promotion of second-generation biofuels should be made dependent on their contribution to climate change mitigation. In the preliminary discussions on the Biofuel Quotas Act, representatives of the automobile and petroleum industries put forward a proposal that envisaged basing funding more strongly on $CO_2$ instead of the fuel quota. Volkswagen proposed – with regard to second-generation biofuels – graduated tax exemptions on the basis of a sustainability index which was to take account not only of $CO_2$, but also of impacts on biodiversity, fertiliser use and other factors (LEOHOLD 2006; DÖHMEL 2006). However, it would be difficult to ensure the objectivity of a multi-dimensional sustainability index of this kind, and it would be prone to abuse. Its verification would involve considerable input. It therefore makes more sense to lay down for specific production processes a set figure for the reduced greenhouse gas emissions per motor fuel unit as an assessment basis for the tax exemption. A prerequisite for this, however, is the methodological convention which is in any case needed for life cycle assessment of the greenhouse gas savings of various motor fuels (Item 35).

On the other hand, an alternative that is preferable from a climate change point of view is the use of biogas as a motor fuel. Care should however be taken that production of the biogenic waste and renewable raw materials needed for biogas production does not lead to an increase in adverse environmental impacts on agriculture (Section 3.2). Furthermore, the economic limits of this option are marked by the increased cost of preparing the biogas for feeding into the existing natural gas infrastructure, and the necessary extensions to the infrastructure.

## 6.2 Efficient climate change mitigation as a long-term perspective

**151.** In the course of the next decade, priority should be given to avoiding greenhouse gases where this is most cost-effective. Following the technology promotion phase, sufficient experience has been accumulated regarding the technology and the potential of renewable energy sources to expose them to competition on the various markets. For the various funding areas, this means a medium-term withdrawal from quantity-based funding and the broadest possible integration into a cross-sectoral emissions trading scheme. A long-term goal here would be emissions trading at the primary trade level (see box) (SRU 2005; 2006). Also conceivable – but more complicated and less efficient – are models that closely approach such emissions trading at the primary trade level or are based on a suitably simulated price for greenhouse gas emissions.

**Emissions trading at the primary trade level**

Emissions trading at the primary trade level focuses on heating fuel wholesalers (cf. SRU 2002, Item 473). Traders who put heating fuels into circulation in Germany or the EU have to produce certificates to the competent authority – corresponding to the $CO_2$ emissions produced during combustion of the relevant fuel. As in the present emissions trading scheme, the total quantity of emission rights issued must not exceed the agreed emissions budget. In view of the limited number of rights issued, there is an upper limit on the carbon content of the total quantity of heating fuel put into circulation. As a result of this artificial shortage, heating fuel traders have an incentive to reduce the quantities they sell, to switch to carbon-poor or carbon-neutral fuels, or to acquire additional rights on the market that enable them to sell fuel quantities not yet covered. Parties selling rights must liberate them by means of reduced sales or fuel substitution. The result is a relative increase in the costs of fossil fuels compared with fuels with a lower emission potential. As far as the consumer is concerned, emissions trading – much like the eco tax – makes itself felt solely through the absolute and relative changes in heating fuel prices. There is no need for all companies or private households to trade in emission rights. In view of the comparatively small number of actors, the transaction and verification costs would be relatively low. Because of the expected keen competition between trading companies for allocation of emission rights, the emission rights will have to be auctioned by the state.

There are still a number of points of detail to be solved. In this emissions trading system, heating fuels from biomass are only regarded as having a neutral impact on climate to the extent that the energy-induced $CO_2$ emissions of the production process are already taken into account in emissions trading for the fossil fuels used for this purpose. In view of their adverse effects on climate, it is essential to register the climate-relevant gases methane ($CH_4$) and nitrous oxide ($N_2O$). Two approaches are possible. One alternative is to take account of set emission factors and their conversion into carbon dioxide equivalents in the emissions trading scheme, so that certificates would also have to be produced for marketing heating fuels obtained from biomass. Among other things, the necessary life cycle analyses would have to take account of leakage rates in biogas production. The certificate requirement would exist at the level of the heating fuel wholesaler (intermediate products for biodiesel or pellets) or the grid operator (electricity or gas). In cases of own production and consumption of biomass it would be necessary to investigate the practicability of participation in emissions trading. This approach is very complex and takes no account of the greenhouse gas emissions of the rest of the agricultural sector. Another possibility would be to use emissions trading solely for energy-induced carbon dioxide emissions, and to use a separate instrument for reductions in methane and nitrous oxide emissions and for avoiding land-use changes with negative climate consequences in the agricultural sector as a whole. Since there would be no need for complicated conversion operations for the various climate-relevant emissions in the monitoring context, two separate instruments would be easier to handle. For example, one could consider a levy payable by the agricultural sector for set area-related or livestock-related emission factors of different agricultural uses. Emissions trading for these gases might also be possible, but – like the above-mentioned combined approach – suffers from high transaction and verification costs. It would however be possible to effect clearing of the emission rights at the trade level and to achieve sufficiently quantifiable targets for all climate relevant gases, which would improve the overall efficiency of the two instruments.

**152.** What seems to be the most probable path towards such a system is the use of two separate instruments. One instrument, which is addressing vehicle manufacturers, envisages a less ambitious CO2-limit for the vehicle fleet as a whole in the view of the hoped-for climate protection contribution by biofuels. The second instrument, targeted at the oil industry, requires it to make a contribution to close the gap to the official target of 120 g/$CO_2$ by 2012. Instead of the biofuels quota, however, this should be done more efficiently and effectively by means of a greenhouse gas reduction target for motor fuels. The EU Commission's proposed target of a 10 % reduction in the greenhouse gas emissions of motor fuels over their entire life cycle (cf. Section 5.1.2) could be a meaningful instrument here. It would leave the petroleum industry free to choose the most efficient way of reducing greenhouse gas emissions over the life cycle of motor fuels. The target would however have to be examined to see whether it can be achieved within a cost corridor that is comparable with other efficient climate change mitigation measures.

Alternatively it is conceivable that conventional motor fuels could be made subject to a climate change tax of the order of the expected medium-term emission rights price, thereby simulating emissions trading at the primary trade level for motor fuels. However, such an instrument would only have a limited controlling effect on fuel use and composition. It would be more likely to create incentives to reduce fuel consumption through changes in driving habits and reduced mileage. This would however be irrelevant as far as the climate protection target was concerned

**153.** In the field of electricity generation from renewable energy sources, integration in the existing greenhouse gas emissions trading scheme would be possible after the end of the market introduction phase. This would result in a relative competitive advantage compared with conventional fuels that would come close to the climate protection potential of the renewable energy sources.

Greater efficiency in achieving the climate change mitigation targets in the heating sector should be sought by means of increased, emission-related taxation of heating fuels. Such taxes on heating fuels can be introduced in advance of a cross-sectoral emissions trading scheme at European level in the wholesale trade for heating fuels, and can then be absorbed fairly easily into the subsequent emissions trading scheme.

For models of this type to be integrated into emissions trading, a near-reality picture of the greenhouse gas balance is needed for the use of biomass for a range of different energy needs (cf. Section 3.1.2). Most studies to date display serious methodological weaknesses that result in overestimation of the climate protection contribution of biofuels. On the one hand there is a need to extend life cycle analysis to include $CO_2$ equivalents, in order to at least include the relevant emissions of $CH_4$ and $N_2O$ that occur during the production of bioenergy. These greenhouse gases play a major role in agricultural production. On the other hand, the entire biofuel production chain should be assessed for possible changes in land use, crop cultivation, biomass processing and fuel economy in the types of engines involved. Land-use changes play an important role here with regard to the soil's capacity to store $CO_2$, something that has not been taken into account adequately in many $CO_2$ balances to date. Soil erosion and loss or organic substances from the soil can be largely avoided by means of appropriate management of agricultural and forestry soils, adapted where necessary to changed climatic conditions.

## 6.3 Conclusion

**Transition to a strategy optimised for climate change mitigation**

**154.** A sustainable biomass promotion strategy must meet two fundamental requirements:

- It must optimise biomass use to avoid greenhouse gas emissions.
- It must produce a legislative framework at national, EU and international level to allow environmentally sound cultivation of energy crops. This framework cannot be developed without taking account of the existing instruments for environmentally sound agriculture.

The primary objective of biomass use should be to reduce greenhouse gas emissions. Funding for bioenergy is highly segmented, however, and to date there is no sign of coordination of the individual instruments and their promotion purposes. In the long term, climate change mitigation should be made more efficient, and efforts should be made to take account of the greenhouse gas savings of bioenergy in a substantially reformed and broadened greenhouse gas emissions trading system. Ideally this would be a global emissions trading system at the primary trade level, though this would be difficult to put into practice. A transitional strategy is therefore needed until the basis for rigorous and efficient climate policy orientation of funding instruments is created. Partly for this reason, the German Advisory Council on the Environment is of the opinion that it makes sense to develop biomass promotion in two phases, a transitional phase of promoting the market introduction of biomass technologies, followed by a second phase of long-term exploitation of the $CO_2$ avoidance potential of biomass use under an efficient climate change mitigation regime.

**Market introduction of biomass technologies**

**155.** The market entry phase should basically build on existing instruments for biomass promotion, although the funding amounts and expansion targets should be reviewed to allow optimal transition to the climate change mitigation phase. The funding instruments should take greater account of the energy-related advantages of using biomass in heat and electricity generation. For this reason neither the effectiveness of the Renewable Energy Sources Act, nor that of the funding instruments in the heating sector, should be diminished by the price-hiking effects of biofuel quotas.

When granting funding to assist market entry, measures should be taken to avoid promoting technologies whose medium and long-term contribution to climate change mitigation bears no meaningful relation to climate change measures that are cost-effective at the macro-economic level. With realistic estimates of learning curve effects, it is possible to identify promising technologies as regards their economic potential and assess their environmental soundness using life-cycle analysis. In this phase of technology promotion, the various funding instruments should be subject to systematic review based on the above criteria. This means:

**156.** Where funding under the Renewable Energy Sources Act is concerned, the restriction of funding to small-scale facilities and those that only convert biomass should be reviewed. With regard to technical efficiency and climate change mitigation, the use of biomass is also desirable in larger-scale power plants. Also, funding amounts and the declining scale used to allocate funding should be reconsidered. Paradoxical effects, such as expansion of economically suboptimal micro biogas plants triggered by the allocation of funding on a declining scale, should be avoided. Bonus payments should be reviewed as regards their negative effect on the use of waste in biogas facilities.

**157.** When supporting heat use, the provision of funding by a market incentive programme should be further advanced. It appears particularly important in this regard to strictly link the availability of funding to the use of available exhaust gas cleaning technology and, in the interests of climate change mitigation, to priority substitution of coal and heating oil. It is also important to review the funding instruments with regard to greater use of biomass in local and district heating and for industrial process heat. When redesigning funding-based incentives, greater weight should be given to climate change mitigation potential over purely quantity-based targets. To finance a programme of this type, consideration should be given to imposing special levies on fossil fuels used for heating.

The German Advisory Council on the Environment considers that the currently debated introduction of a Renewable Energy for Heat Act with technology-differentiated payments for heat in-feed does not serve the purpose. Promoting the use of energy for heating could lead to efforts in the field of energy efficiency being neglected. Also, energy source-dependent funding would make it difficult to implement the installation and modernisation of biomass-fuelled heating systems that is so necessary for abating air pollution.

**158.** Direct promotion of biomass cultivation and the implicit preference for energy crops in Community measures to encourage set-asides in agriculture should be reversed, as should the payment of premiums for energy crop cultivation. Promotion of bioenergy should occur solely on the user side, as this is the only way to ensure optimisation of biomass use. In rural development programmes, which are to be stepped up, special consideration should be given to cultivation methods and crops that give rise to synergies in the attainment of nature conservation goals (cf. Section 4.2.1.2).

**159.** The ambitious national and EU growth and expansion targets for biofuels in transportation should be subjected to critical assessment. There has yet to be a serious official review of the consequences and costs of the politically imposed targets. Considerably more climate change mitigation would be possible if the existing biomass potential were exploited by different uses. The environmental side-effects arising in third countries as a result of the foreseeable rise in imports for biofuels are difficult to control in the short and medium term. The national biofuel quota should therefore – taking account of the aspect of trust in relation to investments already made in conversion plant in reliance on the rising quota – be frozen as close as possible to the present level. Moreover, the target set by the EU Council of a 10 % quota by 2020 is in need of downward correction. As long as the conditions the EU Council has linked to this target (sustainable production, availability of second generation technology, and commercial viability) are not in place, the EU fuel-mix quota should not be made a binding legal requirement.

**160.** As soon as possible, taxation-based promotion of second-generation biofuels should be made dependent on their contribution to climate change mitigation. It makes more sense to lay down a set figure for reduced greenhouse gas emissions per motor fuel unit as an assessment basis for tax exemption of specific production processes .

**Integration in a cross-sectoral emissions trading system**

**161.** In the course of the next decade, priority should be given to avoiding $CO_2$ where this is most cost-effective in relative terms. For the various funding areas, this means a medium-term withdrawal from quantity-based funding and the broadest possible integration into a cross-sectoral emissions trading scheme. In the long term the ideal to aim for would be emissions trading at the primary trade level (SRU 2005; 2006), as this is simpler than the emerging sectoral trading systems and would involve lower transaction costs and fewer drop-outs. What should not be fully excluded, however, is the second-best solution – that of a pricing policy which simulates emissions trading at primary trade level.

- For models of this type to be integrated into emissions trading, a near-reality picture of the greenhouse gas balance is needed for the use of biomass for a range of different energy needs. It is necessary to expand the scope of the balance to include $CO_2$ equivalents, to allow at least the inclusion of bioenergy-related emissions of methane and nitrous oxide in production processes. The entire biofuel production chain should also be assessed for possible changes in land use, crop cultivation, biomass processing, and fuel economy in the types of engines involved. Land-use changes play an important role with regard to the soil's capacity to store $CO_2$, an aspect that has largely been disregarded to date.

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# 7. Summary

## 7.1 Introduction

**162.** The recent report by the Intergovernmental Panel on Climate Change (IPCC) ensured that climate change is one of the main focuses in environmental policy. To be effective, climate change policy must prescribe significant reductions in greenhouse gas (GHG) emissions. Besides improving energy efficiency, reductions can be achieved by using renewable energy sources in place of fossil fuels. The EU thus intends to increase the share of renewables in primary energy use to 20 % by 2020. The German government confirmed its commitment to meeting this target in an announcement made in April 2007, stating that by 2020 some 14 % of the energy used in heat production, 17 % used for transportation fuel and 27 % used in electricity generation will come from renewable energy sources. In meeting these ambitious targets, substantially greater use will be made of biomass, which at 70 % already makes up the largest share of renewable energy in use.

Given the potential of biomass in reducing emissions of climate-damaging gases, we welcome the importance placed on increased biomass use by the European Commission and the German government. Nonetheless, any increase in the use of biomass for energy production must focus on the realistic contribution it can make to combating climate change. Biomass can only serve climate change mitigation if the framework, and not least the relevant funding policies and legal requirements, for cultivation and use of biomass crops take adequate account of environmental constraints.

## 7.2 Opportunities for Biomass Use

**163.** From an environmental standpoint, cultivating and using biomass for energy production has vast potential in that as an energy source, it spares the increasingly limited supply of fossil fuels. Biomass use for energy is also climate-friendly because the carbon dioxide released during burning is equivalent only to that absorbed by the crops during their growth. However, one of the basic requirements in ensuring that using biomass to produce energy results in lower emissions of GHGs compared with fossil fuels is that renewable resources be cultivated and used in an environmentally compatible way and aimed at combating climate change.

Cultivating biomass crops can also have a positive impact on the environment. One option would be to plant former intensively farmed cropland with extensively farmed biomass crops.

The potential for using biomass is increased relative to how efficiently it is used and the size of the reduction in greenhouse gas emissions achieved through its use.

**164.** Compared with other energy carriers, biomass has multiple advantages. For example, it can be made available as a solid, liquid or gaseous fuel. Hence, unlike other renewable energy sources, biomass can be utilised for all energy-related needs (heat, electricity and propulsion). One great advantage with biomass and the energy carriers produced from it is that their excellent storage properties allow for flexible energy supply, both in terms of time and distance.

The availability of new technologies provides further opportunities for biomass. Numerous new processes have been developed and optimised, allowing Germany to strengthen its position as a leading technology supplier.

## 7.3 Limitations in Biomass Use

**165.** The advantages in using biomass as an energy carrier are, however, countered by limited land availability and consideration of environmental needs.

### 7.3.1 Limited Potential for Biomass Production in Germany

**166.** Use of biomass, either as biogenic waste or as renewable raw materials, can meet only a portion of Germany's primary energy needs. The annual volume of waste from the forestry and timber sector, farming, disposal of animal carcasses, the food industry, and wastewater and waste management lies at around 100 million Mg. With existing technology and given environmental constraints, only 65 % (70 million Mg) can be used in any meaningful way. This gives Germany a potential four or five percent biomass share in meeting primary energy demand. In the short term, the potential for using biogenic waste is higher than that for using renewable raw materials. Using biomass waste for energy is not yet fully established, however. It makes sense, therefore, to give priority to exploiting biomass waste potential while taking account of environmental restrictions (e.g. in use of straw and forestry waste) rather than growing more renewable raw materials.

The potential in renewable raw materials is limited first and foremost on account of the limited availability of agricultural land for their production. This puts cultivation of biomass crops in direct competition with food and feed production, and it may only be expanded in line with the needs of nature conservation and landscape management.

Consequently, it can be assumed that by 2030, the area of arable land used for biomass crops can be increased from 1.6 million hectares to between three and four million hectares.

The potential energy yield will depend on the type of energy crops grown and the ways in which they are used. Use in the stationary energy sector in combined heat and power (CHP) promises significantly greater energy potential than transportation biofuels grown on the same area of land. Looking at the overall potential regarding biomass waste and renewable raw materials, domestic biomass can meet at maximum only 10 % of primary energy use by 2030.

Merely producing enough biomass for all petrol and diesel placed on the market to contain at least 6.75 % biofuel by 2010 and even higher percentages further into the future – the targets set in the third sentence of Article 37a (3) of Germany's Immission Control Act (BImSchG) – would use up the entire potential available land. These ambitious targets thus promote the import of biomass and biogenic energy carriers.

### 7.3.2 Biomass Crops: Environmental Threats and Needs for Regulation

**167.** The push to cultivate and use biomass hits an obstacle given the associated environmental risks at national and international level. Biomass produced using intensive farming methods poses a threat to the environment. These risks must be mitigated by changes to the legal framework.

**168.** At national level, threats to the environment have less to do with any harmful aspects of new crop-growing practices. A greater risk is posed by increased use of crops that have strong adverse effects on the environment: rapeseed and maize are increasingly being cultivated in place of less environmentally harmful crops. Over-exploitation of vegetation types that capture and store $CO_2$, for example woodlands and forests, can affect their sink function. Changes in land use such as digging over permanent grassland and draining bogs and fens can have a similarly negative effect on the climate.

Looked at from a legal standpoint, the same standards should apply to cultivating renewable raw materials as for food and feed production. The changes in farming practices that can be expected in response to the targeted promotion of biomass crops are cause enough to step up efforts towards making farming environmentally compatible. The existing environmental standards contained in the best practice provisions of national legislation and in EU cross-compliance requirements must be implemented in a determined manner and advanced where appropriate. The following measures would seem appropriate to counter the impact of increased biomass farming:

- Introduce a fertiliser tax to penalise excessive use of nitrates
- As regards use of plant protection products, further define, legally enhance and forcefully implement the requirements for integrated plant protection
- Compliance with, at minimum, three-way crop rotation with no exceptions. At the same time, scope should be created to allow legally prescribed annual limits on the number of crops allowed and the maximum amount of land they may cover on a holding.
- A general ban on digging over permanent grassland

Also, conservation area charters should be reviewed as to whether they adequately exclude environmental threats arising from farming of renewable raw materials. They should be aligned as appropriate, particularly as regards crop-growing restrictions. An assessment should also be made as to whether protection of fringe and structural elements should be boosted with additional compensation rules.

Specific standards for biomass crops are needed when it comes to the extraction of residues which in excessive quantities can have adverse effects on the nutrient cycle. A need could also arise for regulatory provisions regarding farming of genetically modified crops. In the case of crop-specific and site-specific effects, prevention measures should be an integral part of spatial planning policy. Per-hectare premiums for growing renewable raw materials should only be made available when neither protected nor sensitive areas are affected by inappropriate crop-growing practices.

Research on the environmental impacts of intensified farming of renewable raw materials can hardly keep up with the rapid growth in energy crop production. For reasons of damage limitation and precautionary environmental protection, there is thus an urgent need to slow down the promotion of renewable raw materials. Without such action, there is a risk that to ensure attainment of (dynamically increasing) renewable energy targets, environment-related requirements will be formulated in such a way that they provide less than adequate protection.

**169.** Given that the EU's and Germany's ambitious biomass policies will significantly increase biomass imports from non-EU countries (particularly newly industrialising countries and developing countries), it must be ensured that the rise in imports does not lead to greater use of environmentally harmful production practices in the producing countries.

Intensified biomass production on an international scale goes hand in hand with a considerable risk of over-use of natural resources in the producing countries. This must be countered with binding standards. In this connection, although private certification systems are not an adequate substitute for binding standards on biomass crops they do provide a useful conceptual approach for their advancement.

There is thus a need for binding environmental standards and for making compliance with them a prerequisite for marketing biomass and biomass products in the EU and in Germany. The Council believes it would be preferable for such standards to be made an integral part of an international agreement to which key import and export countries are signatories. This consensual approach in which acceptance of the environmental standards is embodied in an international agreement would aid both implementation and enforcement of those standards. Further, restrictions on international trade enacted under international environmental treaties have not yet become a point of contention in the debate on global trade law.

Another option, secondary to the above but nonetheless available if attempts to negotiate an international agreement should fail, is that of imposing environmental standards unilaterally on producer states. WTO law would not be a barrier to this type of approach in principle. It can be expected that restrictions on international trade that are specifically designed to rule out environmentally harmful production methods would be incompatible with WTO non-discrimination rules, especially the National Treatment Clause. However, under GATT Article XX (b) and (g), such restrictions may be justified where they involve action to protect human, animal or plant life or health, and to conserve exhaustible natural resources. Trade restricting standards are thus an option when it comes to protecting primary forests, bogs and fens, and other wetlands. In such circumstances, WTO law is not in opposition to the enactment of environmental standards, including internationally applicable ones, based on the powers to issue secondary legislation set out in Section 37d of Germany's Federal Immission Control Act (BlmSchG).

## 7.4 Solutions and Priorities

### 7.4.1 Prioritising Climate Change Mitigation and Devising an Integrated Energy Strategy

**170.** In principle, promotion of biomass can contribute to varying degrees to achieving agricultural, energy and environmental policy targets. Account must however be taken of the inherent costs and of the conflicts between these targets. Due to insufficient analysis of the environmental impacts, especially regarding climate change impacts of land use changes, there is a tendency to over-estimate the greenhouse gas reductions that can be attained using biomass for energy production. Largely for this reason, the jury is still out on the issue of biomass use and its environmental effects. In case of doubt in instances where multiple objectives are pursued, climate change should be given priority to ensure environmentally compatible cultivation. Nonetheless, the findings arrived at so far lead to the conclusion that stationary use of biomass for electricity and heat production is more advantageous than its use as a transport fuel. Prioritising the use of biomass in the transport sector does not sufficiently exploit the potential of biomass in climate change mitigation. For this reason, efforts should only be made towards achieving moderate expansion in the use of biofuels in transportation. Stationary use harbours great potential for greenhouse gas savings, especially in heat supply and in combined heat and power generation. Promoting combined use of biomass in this way should thus be pursued further.

Looking at biomass use according to available forms, with the exception of waste substances for use in fermentation and of renewable raw materials, minimum use should be made of biomass in transport fuel production. Solid biomass, particularly wood, should ideally be used to produce heat. Its use for high-temperature process heat in industry would appear to make sense because no other renewable energy source can serve as a substitute. With regard to power generation and room-temperature heating, wind, solar and geothermal energy are available as alternative renewable substitutes in the long term. Another important aspect is increased use of district heating networks in place of individual heating systems. Thus, with regard to its climate change mitigation potential, biomass use should not be assessed in isolation from other renewable energy sources. The aim should be to develop an integrated approach to allow optimal use of all energy carriers in efforts to combat climate change.

### 7.4.2 Integrated Biomass Strategy to Avoid Segmented Funding

**171.** Funding for bioenergy is segmented. Promotion focuses on the one hand on greater use of biofuels through minimum fuel mix requirements, tax concessions and farming subsidies, and on the other on use of biomass in electricity and heat production – primarily through special feed-in tariffs under the German Renewable Energy Sources Act (EEG) and investment grants for heating supply systems.

While this segmentation has its historical reasons, when looked at from an economic and environmental standpoint it hinders overall optimisation of biomass use. In particular, it obstructs market processes in arriving at the most cost-effective ways of achieving greenhouse gas reductions. Rather than promoting market price-finding under a stringent climate policy framework, funding focuses on fine-tuning specific technologies and on quantity targets for selected uses. This approach does not fully exploit the role biomass can play in climate change mitigation. No realistic overall estimate has been made of the full costs and benefits of this kind of funding policy to tax payers, consumers and climate change efforts for the period up to 2020.

Instead, segmentation promotes a funding race between the various biomass uses. Extremely high biofuel quotas that must be achieved regardless of economic viability will push up the costs of biomass use in areas that can contribute most to climate change mitigation. There is thus a risk that significant public and private funds will be wasted due to a lack of coordination between the various available instruments.

Powers to issue secondary legislation contained in Section 37d of Germany's Immission Control Act (BlmSchG) and the EU climate change target for motor fuels (10 % reductions in GHG emissions by 2020) set out the first practical steps to be taken in the coming years to lay down minimum environmental standards for the use of bioenergy. Their scope is, however, already limited because they focus solely on specific funding instruments and give no indication of an integrated approach to providing an environment policy pillar in biomass promotion. A conflict thus exists between environmental criteria set out in Section 37d of the BImSchG and the over-ambitious nature of the fuel quotas. Resolving this conflict will prove extremely difficult.

Against this background, the key task of any potential biomass action plan is to set out and prioritise the main points of a strategy on biomass potential and its optimal use in climate change mitigation, for a workable funding policy, and for a framework to allow environmentally sound cultivation of biomass crops.

This sustainable biomass promotion strategy must meet two fundamental requirements:

- It must optimise biomass use to avoid GHG emissions
- It must produce a legislative framework at national, EU and international level to allow environmentally sound cultivation of energy crops. This framework cannot be developed without taking account of general instruments for environmentally sound agriculture.

Advancing biomass promotion should take a two-phase approach:

- An interim funding phase to assist market entry of a broad range of technologies
- A subsequent phase to promote effective climate change mitigation activities based on further fundamental reform of the EU Emissions Trading Scheme for greenhouse gases.

### 7.4.3 Existing Funding Instruments

**172.** The market entry phase should build on existing instruments for biomass promotion, although the funding amounts and expansion targets should be reviewed to allow optimal transition to the climate change mitigation phase. The funding instruments should take greater account of the energy-related advantages in using biomass in heat and electricity generation. Neither the effectiveness of the Renewable Energy Sources Act (EEG), which sets out fixed rates of payment for renewables-generated electricity fed into the public grid, nor that of promoting heat generation should be diminished by the price-hiking effects of biofuel quotas.

When granting funding to assist market entry, measures should be taken to avoid promoting technologies whose medium and long-term contribution to climate change mitigation bears no meaningful relation to the cost-effectiveness of the overall climate change measures. With realistic estimates of learning curve effects, promising technologies can be identified as regards their economic potential and, using life-cycle analysis, assessed for environmental soundness.

The various funding instruments should be subject to systematic review based on the above criteria. This means:

- Where funding under the Renewable Energy Sources Act is concerned, the restriction on providing funding only to small-scale facilities and those that only convert biomass should be reviewed. With regard to technical efficiency and climate change mitigation, the use of biomass is also desirable in larger-scale power plants. Also, funding amounts and the decreasing scale used to allocate funding should be reconsidered. Paradoxical effects such as further promotion of less than viable micro-scale biogas facilities sparked by allocating funding on a decreasing scale should be avoided. Bonus payments for use of renewable raw materials (*NaWaRo-Bonus*) should also be reviewed as regards their negative effect on the use of waste in biogas facilities.

- When funding heat use, the provision of funding as a market incentive should be further advanced. It appears particularly important in this regard to strictly link the availability of funding to the use of available exhaust gas cleaning technology and, in the interests of climate change mitigation, to priority substitution of coal and heating oil. It is also important to review the funding instruments as regards greater use of biomass in district heating and for industrial process heat. When redesigning funding-based incentives, greater weight should be given to climate change mitigation potential over purely quantity-based targets. To finance a programme of this type, consideration should be given to putting special levies on fossil fuels used in heating.
- The enactment of legislation, as currently under debate in Germany, to promote renewables-generated heat supply (*EE-Wärmeenergiegesetz*) by means of different payment rates according to the technology used will not achieve its intended goals because promoting the use of energy to generate heat could lead to efforts towards energy efficiency being neglected. Also, energy source-dependent funding would make it difficult to implement the installation and modernisation of biomass-fuelled heating systems so necessary in abating air pollution.
- Direct, unconditional promotion of biomass cultivation and the implicit preference for energy crops in Community measures to encourage set-aside in agriculture should be reversed, as should the payment of premiums for energy crop cultivation. Promotion of bioenergy should occur solely on the user side as this is the only way to ensure optimisation of biomass use. In rural development programmes, which are to be stepped up, special consideration should be given to cultivation methods and crops that give rise to synergies in the attainment of nature conservation goals.
- The ambitious national and EU growth and expansion targets for biofuels in transportation should be subjected to critical assessment. The national biofuel quota should – taking account of the sphere of trust regarding the investments already made in conversion plant in response to the rising quota – be frozen as close as possible to the present level. The target set by the EU Council of a 10 % quota by 2020 is in need of downward correction. As long as the conditions the EU Council has linked to this target (sustainable production, availability of second generation technology, and commercial viability) are not in place, the EU fuel-mix quota cannot be made a binding legal requirement.
- Taxation-based promotion of second generation biofuels (biomass-to-liquid and lignocellulose bioethanol) should be re-focused without delay to concentrate on their contribution to climate change mitigation. It would make sense for possible tax exemptions to be based on a set amount relative to the reductions in GHG emissions achieved per fuel unit in specific production processes.

### 7.4.4 The Long-Term Perspective: Emissions Trading

**173.** In the second phase of the climate change policies called for in this report, efforts should focus on avoiding GHG emissions wherever it is most cost effective to do so. For the various funding areas, this means a medium-term withdrawal from quantity-based funding and the broadest possible integration into a cross-sectoral emissions trading scheme. In the longer term, the aim should be towards fundamental reform of the existing emissions trading system at primary trade level. In contrast to the sectoralised trading system that is currently evolving, this would be far easier to implement, the transaction costs would be lower and there would be fewer drop-outs. What should not be fully excluded, however, is the second-best solution – that of a pricing policy which simulates emissions trading at primary trade level.

For models of this type to be integrated into emissions trading, a near-reality picture of the greenhouse gas balance is needed for the use of biomass for a range of different energy needs. It is thus necessary to expand the scope of the balance to take in $CO_2$ equivalents to allow at minimum the inclusion of bioenergy-related emissions of methane and nitrous oxide in production processes. The entire biomass production chain, especially that for biofuels used in transportation, should be assessed for possible changes in land use, crop cultivation, biomass processing and fuel economy in the types of engines involved.

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## Publications

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The Council's environmental reports and special reports published **from 2007** onwards are available both from book shops and directly from the publisher: Erich-Schmidt-Verlag GmbH und Co., Genthiner Str. 30 G, 10785 Berlin, Germany.

They are also available online at http://www.esv.info/neuerscheinungen.html.

Environmental reports and special reports published **between 2004 and 2006** are available from book shops or from the publisher: Nomos-Verlagsgesellschaft Baden-Baden; Postfach 10 03 10, 76484 Baden-Baden, Germany or www.nomos.de.

*Bundestagsdrucksachen* are available from: Bundesanzeiger Verlagsgesellschaft mbH, Postfach 100534, 50445 Köln, Germany or www.bundesanzeiger.de

Most publications issued since 1998 are available as PDF files and can be downloaded from the SRU website (www.umweltrat.de).

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**Ministry of the Environment, Nature Conservation and Nuclear Safety**

# Charter Establishing an Advisory Council on the Environment at the Ministry of the Environment, Nature Conservation and Nuclear Safety

1 March 2005

### Article 1

The Advisory Council on the Environment has been established to periodically assess the environmental situation and environmental conditions in the Federal Republic of Germany and to facilitate opinion formation in all government ministries, departments and offices that have jurisdiction over the environment, and in the general public.

### Article 2

(1) The Advisory Council on the Environment shall comprise seven members who have special scientific knowledge and experience with respect to environmental protection.

(2) The members of the Advisory Council on the Environment shall not be members of the government, a legislative body of the government or the civil service of the Federal Government, state governments or of any another public entity, universities and scientific institutes excepted. Further, they shall not represent any trade association, or employers' or employees' association, nor shall they be in the permanent employ of or party to any non-gratuitous contract or agreement with any such association, nor shall they have done so in the 12 months prior to their appointment to the Advisory Council on the Environment.

### Article 3

The task with which the Advisory Council on the Environment is charged shall be to describe the current environmental situation and environmental trends, and to point out environmentally related problems and suggest possible ways and means of preventing or correcting them.

### Article 4

The Advisory Council on the Environment is charged exclusively with the mission stated in this charter and may determine its activities independently.

### Article 5

The Advisory Council on the Environment shall provide the federal ministries whose area of competence is involved, or their representatives, the opportunity to comment on important issues that emerge as a result of the Council's performing its task, and to do so before the Council publishes it reports on these issues.

### Article 6

The Advisory Council on the Environment may arrange hearings for federal offices and *Länder* offices concerning particular issues, as well as invite the opinions of non-governmentally affiliated experts, particularly those who represent business and environmental associations.

### Article 7

(1) The Advisory Council on the Environment shall draw up a report every four years, to be submitted to the Federal Government in May. The report is to be published by the Council.

(2) The Advisory Council on the Environment may make additional reports or statements on particular issues. The Federal Ministry of the Environment, Nature Conservation and Nuclear Safety may commission the Council to make further reports and statements. The Council is to submit the reports and statements mentioned in clauses (1) and (2) of this article to the Federal Ministry of the Environment, Nature Conservation and Nuclear Safety.

### Article 8

(1) Upon approval by the Federal Cabinet, the members of the Advisory Council on the Environment shall be appointed by the Federal Ministry of the Environment, Nature Conservation and Nuclear Safety for the period of four years. Equal participation of women and men shall be aimed for as provided for in the law governing appointments to federal bodies (the *Bundesgremienbesetzungsgesetz*). Reappointment shall be possible.

(2) The members of the Council may give written notice to resign from the Council to the Federal Ministry of the Environment, Nature Conservation and Nuclear Safety at any time.

(3) Should a member of the Council resign before serving the full four-year period, a new member shall be appointed for the remaining period. Reappointment shall be possible.

### Article 9

(1) The Advisory Council on the Environment shall elect, by secret ballot, a chairperson who shall

serve for a period of four years. Re-election shall be possible.

(2) The Advisory Council on the Environment shall set its own agenda, which shall be subject to approval by the Federal Minister of the Environment, Nature Conservation and Nuclear Safety.

(3) Should a minority of the members of the Council be of a different opinion from the majority of the members when preparing a report, they are to be given an opportunity to express this opinion in the report.

**Article 10**

The Advisory Council on the Environment shall be provided with a secretariat to assist it in the performance of its work.

**Article 11**

The members of the Advisory Council on the Environment and its secretariat are sworn to secrecy as concerns the Council's advisory activities and any advisory documents that it classifies as confidential, and as concerns any information given to the Council that is classified as confidential.

**Article 12**

(1) The members of the Advisory Council on the Environment are to be paid a lump-sum compensation and to be reimbursed for their travel expenses. The amount of compensation and reimbursement shall be determined by the Federal Ministry of the Environment, Nature Conservation and Nuclear Safety, with the consent of the Federal Ministry of the Interior and the Federal Minister of Finances.

(2) The financial funding for the Advisory Council on the Environment shall be provided by the Federal Government.

**Article 13**

To accommodate the new date of submission to the Federal Government under Article 7 (1), the Federal Ministry of the Environment, Nature Conservation and Nuclear Safety may extend the appointments of the Council members in office when this Charter enters into force to 30 June 2008 without requiring the approval of the Federal Cabinet.

**Article 14**

The Charter Establishing an Advisory Council on the Environment at the Federal Ministry of the Environment, Nature Conservation and Nuclear Safety (GMBl. 1990, no. 32, p. 831), issued on 10 August 1990, is superseded by this charter.

Bonn, 1 March 2005

The Federal Minister of the Environment, Nature Conservation and Nuclear Savety

Jürgen Trittin

This special report provides an overview of the findings of various studies of available biomass potential and of the present state of knowledge with regard to the environmental and social consequences of increased biomass use.

The German Advisory Council on the Environment (SRU) expounds a concept for ensuring that biomass funding is systematically geared to the ambitious objectives of German and European policy on climate change mitigation. Especially in view of the limited biomass potential, there is a need to optimise the contribution of biomass to climate change mitigation. Bioenergy funding practice to date shows no signs of such a strategy. The planned biofuels quota in particular will divert a large proportion of the biomass potential available in Germany into the transport sector. However, biomass can be used up to three times more efficiently and at considerably lower cost for heat and combined heat and power generation. The high biomass targets will also attract a flood of imports. Considerable impairments of the environment in the exporting countries can be expected as a result.

The SRU therefore advocates a change of strategy and makes the following recommendations:

- The biofuels quota should be frozen.
- Funding should promote the use of biomass in heat and combined heat and power generation.
- There should be national and international environmental standards to accompany the production and use of biomass.

The SRU has been advising the German Federal Government on environmental policy issues since 1972. The composition of the Council – seven university professors drawn from a variety of disciplines – ensures a comprehensive and scientifically independent appraisal that takes account not only of scientific and technical, but also of economic, legal, ethical and political science considerations.