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Opportunities and challenges facing new energy crops

Summary

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SUMMARY

Biomass as an energy source is currently at the top of the political agenda and in the perception of the media. Several developments are brought together here. A scarcity of oil and natural gas in the coming decades and the sharp rise in the price of oil in recent years account for the search for alternative, potentially renewable energy sources. Germany's dependence on energy imports is increasingly being perceived as a problem, resulting in an intensified lookout for »domestic« energy sources. Ultimately the necessity of substituting fossil fuels with renewable energy sources results from the increasingly as urgent recognised issue of climate change. On the whole this situation has led to high hopes being placed on the conversion of biomass to energy.

In order to reduce the emission of greenhouse gases and the dependence on imports of fossil fuels, the EU has decided that 20 % of primary energy requirements are to be covered by renewable energy sources by the year 2020. Biomass is the most important renewable energy source both in the European Union as well as in Germany with a share of around two thirds of the total. It is also ascribed great significance in the development strategies for renewable energy. As a result of state support, both biofuel and biogas production in Germany have grown strongly in recent years. This part of bioenergy is based essentially on the cultivation of energy crops.

Increasingly however, the fear has been expressed that due to the development of the biofuel production, prices for foodstuffs will grow in parallel to fuel prices, because foodstuffs and biofuel production will be competing for the same cultivation areas. This would lead to the consequence that foodstuffs and the resources required to produce them becoming more expensive and even unaffordable for poor people. A further point of discussion is to what extent the ambitious expansion targets would lead to the import of bioenergy sources, thereby triggering an extension of the areas under cultivation in the tropical exporting countries at the expense of the rain forests which, were rain forests to be cleared, would actually result in an increase rather than a reduction in greenhouse gas emissions.

As the use of bioenergy and energy crops has not proven to be economic viable to date, their expansion will not happen on its own, but rather requires political shaping. The target of an intensified use of agricultural crops as renewable sources of energy thus represents an important question and challenge in the intersection between energy, environmental, agricultural, research and economic

policy. The diversity of potential options and strategies and the socio-economic and environmentally relevant effects involved is reflected in the large number of studies already available as well as in current research projects.

The TA project »Opportunities and Challenges facing new Energy Crops« (short title »Energy Crops«) was decided upon by the Committee on Education, Research and Technology Assessment on 27 September 2006, based on a total of seven project proposals from the parliamentary groups of the CDU/CSU, SPD andBÜNDNIS 90/DIE GRÜNEN. This report presents the results of the first project phase which focussed in particular on a comparative analysis of available studies. This was in order to provide an informed overview of the status of knowledge, contentious assessments and open questions.

FUNDAMENTALS

Traditional biomass (referring to traditional uses in particular in developing countries such as firewood and charcoal) is the most important renewable energy source on a worldwide basis (9 % of worldwide primary energy consumption) and of great importance in many developing countries. However the traditional use of biomass (single ovens such as stoves and tiled stoves in households) also plays an important role in heat generation in Germany.

In contrast, *modern biomass* refers to its use on a larger scale with modern technologies and as a replacement for conventional fossil fuels. The raw material base for modern biomass use is made up of energy crops in agricultural cultivation, forestry by-products, residual materials from wood processing as well as organic by-products and waste.

By *energy crops* we are referring to agricultural crops grown with the primary objective of use for energy. Energy crops are a part of modern biomass or bioenergy and can be used for energy in the fields of heat, electricity and fuels. In part the term energy crop is however also only used to refer to the use of the whole plant. Until now – not unlike food production – partial plant use has been predominant.

PRODUCT LINES OF ENERGY CROP USE

Before the energy crops in the field can become usable energy there is a long road to be covered with various process steps. Diverse alternatives exist for the production or supply of biomass as a primary energy source from a conversion to secondary energy forms right up to its final energy use as heat, electricity or fuel, meaning that different *product lines* can be used or are currently being developed.

The *combustion of solid biomass* represents a *direct conversion* of biogenic primary energy sources into final or useful energy. Forestry by-products (wood residues from forests, small-dimensioned wood), residual materials from wood processing (industrial wood residues through to scrap lumber), agricultural crop residues (straw) as well as energy crops may be used as primary energy sources. Woodlike biomass (short rotational plantations of poplars or willows) and stalk-type biomass containing lignocellulose (cereals, miscanthus) qualify as energy crops. The use of forestry by-products and of residual materials from wood processing is predominant to date. Alongside the traditional supply of heat to domestic furnaces (61.6 TWh final energy supply in Germany in 2006), the generation of heat in combined heat and power stations and heat supply stations (2.2 TWh) and in industry (9.3 TWh) has so far been of minor importance. Electricity generation using biogenic solid fuels takes place in combined heat and power stations and electricity generation plants (6.6 TWh).

There are a number of established technologies available for the combustion of solid biomass to generate heat and/or electricity. The provision of heat from biogenic solid fuels is already economical as a rule today and does not receive direct state support. Electricity generation on the other hand is still dependent upon assistance from the EEG(Renewable Energy Sources Act). The relatively low energy content of biogenic solid fuels implies use primarily in decentralised plants with small and medium performance. Where possible this should be in close physical proximity to the area of cultivation or the location of the accumulation of the biomass. On the other hand there are European and international trade flows for conditioned (processed) wood products such as pellets.

The *conversion to liquid and gaseous secondary energy sources* – also referred to as the »refinement of biomass« – is intended,

- to increase energy density,
- to improve transportability,
- to make the use with existing technologies for final energy use possible, and thus to converge with the existing energy system.

A number of procedures have been introduced among conversion technologies, which are widely used as well as being state-of-the-art. These include established procedures for conversion to biofuels (vegetable oil, biodiesel, bioethanol) and biogas production. Other conversion technologies, such as gasification and pyrolysis as well as biomass-to-liquid processes (BtL processes), are still in the research, development and demonstration phase.

As a result of the state support, the supply of biofuel (20.7 TWh biodiesel, 3.1 TWh vegetable oil and 3.7 TWh bioethanol in 2006 in Germany) and production of biogas (5.4 TWh electricity and 5.4 TWh heat) have grown strongly in recent years. Up until now biofuels have been based on the partial plant use of energy crops. With the expansion of biogas production in particular, whole crop use has however become more important.

The *gasification of biomass* will probably play a key role in future. This is also occasionally adjudged to be the case for pyrolysis. Through gasification, the raw material base should on the one hand be extended, through the use in this process of energy crops to agricultural crop residues, forestry by-products and wood processing residual materials right up to organic by-products and wastes. Through the whole crop use of energy crops, the energy yield per agricultural area should at the same time be considerably increased. On the other hand, the product gas from gasification opens up various uses, from electricity and heat generation to the production of synthetic fuels and biomethane right up to use as industrial feedstock.

The *breeding*of energy crops is still in its relatively early stages. The goal is, to make suitable breeding material available from as broad a spectrum of species as possible as quickly as possible. In addition appropriate crop rotations are to be developed, which harmoniously combine foodstuff and feedstuff production on the one hand and energy crop production on the other hand. Breeding focuses on second generation energy crops, which are to be used in Central Europe for the foreseeable future above all as whole crops for biogas plant production. Mass-growing plant species such as maize, sorghum and sunflowers are cultivated for whole crop use so that they exploit as much of the growing season as possible with vegetal growth. Maximum biomass yield represents a fundamentally new breeding target for the majority of agricultural species. The energy crops of the so-called third generation are currently more in a visionary stage in which, in addition to providing mass yields, they develop special substances and are directly converted to feedstock and energy in the »biorefineries« of the future. Perennial woody plants in particular such as short rotation poplars or willows qualify for thermal use. There is at present hardly any breeding of fast-growing tree species in Germany however.

EXPANSION TARGETS AND SUBSIDIES POLICIES

In view of the foreseeable exhaustion of fossil energy supplies, growing global energy requirements and the environmental and climatic complex of problems, it is the task of state provision to promote the development of energy options for the future. The relevant climate protection and energy policy are expressed as expansion targets for the use of biomass as energy and promotion policies for their achievement. The objectives and promotion instruments for the different energetic uses of biomass and the cultivation of energy crops are designed very differently. This is due on the one hand to the different policies and on the other hand the technical possibilities.

The *generation of electricity* from renewable energy can be carried out using various energy sources and includes great potential for the reduction of climate gases. Expansion targets exist in the EU and its member states as well as in the non-European countries investigated. Corresponding promotional instruments to achieve these have been established over the last ten years, particularly on a European level.

The regenerative *generation of heat* takes place primarily on the basis of wood (residues) from forests in decentralised systems and is frequently economic, which is why it has »survived« without a superordinate subsidies policy. Expansion targets do not exist either at the level of the EU and its member states or in the non-European countries selected. Defined targets, comprehensive promotion and the improved monitoring of development form the precondition for an expansion of heat generation from biomass, which is seen as advisable in the sense of diverse, decentralised application options and low CO_2 avoidance costs.

Alternative *fuels* can be produced in foreseeable future only on the basis of energy crops, and these are first and foremost of interest for energy policy reasons. For this reason this sector was accorded a special weighting in the recent past – both in the objectives as well as through subsidies. The proportion of biofuels in the EU is to be increased to 5.75 % by 2010 and to 10 % by 2020; the USA is aiming for a biofuel share of 15 % in ten years. The establishment of the instruments is still in progress and that is why an analysis of their effects is hardly possible at present. For biofuels – unlike for electricity and heat – there is an opportunity to obtain very large quantities in a very short time through international markets.

The *support mechanisms introduced* are primarily feed-in tariffs, investment grants, quota systems and combinations of these instruments. In view of the current situation the following conclusion can be drawn:

> *Feed-in tariffs* with a predetermined period of validity and guaranteed purchase at fixed rates are capable of reducing the risks involved for those considering investment. The promotion of innovative technologies has however only been successful thus far with technologies which are close to the market and can more or less be considered to be technically mature.
> *Quota systems* ensure that a minimum proportion of the generation of energy is provided by renewable energy. Quota systems in the sector of electricity and biofuels could slow down technical developments as a result of politically determined quantitative restrictions. In minimum price systems however, technological developments generate higher profits, which can in turn stimulate innovation.
> *Investment assistance* is also a good catalyst for new technologies. Nevertheless this instrument is insufficiently used in many EU states.
> The appropriate *interaction of different support mechanisms* to minimise risks is seen as the key factor for a successful and efficient introduction of renewable energy.

In the objectives for the expansion of the use of biofuels it remains unclear in many cases, where these should come from and how this can be reconciled with the food supply. In all of the sectors observed, concrete *environmental and sustainability criteria* have hardly been established. The recently initiated debates on competing uses could lead to an increase in consideration. Initial indications to that effect are provided by the current discussion on sustainability standards for biofuels in the EU member states.

THE STATE OF RESEARCH AND EVALUATION OF CASE SCENARIOS

There are a large number of specialised publications on bioenergy and energy crops, which deal with the individual aspects of technical development, the use and the long-term effects. In the meantime however, there are also a number of studies which summarise the current state of knowledge and are more or less oriented towards policy consulting. They are concerned with renewable energy, bioenergy, energy crops or particular product lines or areas of use.

A *comparative analysis of the studies with potential assessments and development strategies* was undertaken within the scope of the TAB project. The objective of this analysis is to compile the core statements of the studies, to compare the assessment of the future cultivation of energy crops as well as to provide important insights into ecological and economic impacts. Seven studies were included in the comparative analysis.

The *Studies of Germany* have a common context and were all financed by the BMU. The starting point is the federal government's climate protection goals, within the scope of which renewable energy is to become the principle energy supply source in the longer term, with a share of approximately 50 % by about the middle of the century. Potentially conflicting targets were included between, on the one hand, the contribution to the reduction of greenhouse gas emissions and, on the other hand, potential negative effects in the fields of environmental protection and nature conservation. The *Studies on a European level* are more heterogeneous.

What is common to all of the studies is that they ultimately contain *scenarios of the potential of bioenergy*. In doing so the *technical potential* is calculated as a rule. While doing so, how the *economic potential* of bioenergy will develop in future under different basic conditions is not described. Exceptions to this are the »FORRES 2020« and »EU Bioenergy« medium term studies, which analyse the market penetration of renewable energy or bioenergy under different basic political conditions with the aid of technical-economic models. The structure of the scenarios is based on climate protection policy (and supplementary environmental or nature conservation policy) objectives. As a result they represent *normative scenarios* and analyse the extent to which a desired future can be achieved. Thereby only a section of the possible energy futures is considered in the studies. From the objectives of the studies, it results that they only investigate the attainability of climate protection goals in association with expansion targets for renewable energy.

EXPANSION SCENARIOS AND ENERGY CROP USE

The reduction objectives for climate gas emissions and the sustainable supply of energy can only be achieved with a considerable *increase in the conversion and use efficiency* of all energy sources. An essential element of the expansion scenarios for renewable energy is therefore a considerable increase in energy efficiency as opposed to the trend.

In future the *proportion of the various energy sources making up renewable energy* will shift significantly. The current contribution of biomass (68 % in 2005 including biogenic waste in refuse) will continue to dominate for the foreseeable future. After 2030 however, the potential will be largely exhausted, resulting in a considerable reduction in its relative contribution.

The potential of *bioenergy from sources other than energy crops* (hence wood and the various biogenic residual material fractions) will remain more or less constant in the long-term. The biggest differences among the studies are to be found in the assumed potential for wood and straw. Biogenic residual materials that are convertible to energy are strongly linked to the basic agricultural, forestry, waste management and nature conservation law conditions, which can change according to the scenario. The estimated potential displays in part substantial differences.

The potential of the bioenergy sources based on *energy crops* is in contrast primarily dependent on the available cultivation area, and the generation of bioenergy from energy crops is increasing with time in the expansion scenarios. At the same time there are the greatest uncertainties in the sector of energy crops in the medium and long-term assessment, among other things because there are various competing claims for use for the available land under cultivation in future.

The energy potential achievable from the estimated land potential for energy crops displays substantial differences depending upon the *product lines* used. Based on the differing efficiency of the diverse opportunities for use, the use of the entire quantity of biomass in stationary plants for the generation of electricity and heat, can exploit an energy potential which is roughly twice as high as when it is exclusively used for the production of biofuels. With energy crops, a strong promotion of biofuels leads to the limitation of the potential for the electricity and heat sector and vice versa. The present expansion targets for biofuels (see above) result in a considerable land requirement.

When assessing the potential of energy crops for conversion to energy, we must first of all ascertain the *available land potential*. The areas available in future for the cultivation of energy crops are dependent on a multitude of factors, which can be divided into the categories of land availability, land productivity and competing land requirements for the food supply.

Initially the current *set-aside areas*, i.e. those areas not used for the production of biomass which are compulsorily disused, and those voluntarily disused areas which are seen as potential cultivation areas for the energy crop cultivation are included in the land potential assessment.

The assumed *cut in surpluses* in the studies analysed provides an important contribution to land potential. Farmland, on which surpluses of so-called market organisation products (cereals, sugar, oil crops, protein plants, milk, beef and others) are produced and exported predominantly on the world market, are viewed as potential land for bioenergy sources. Underlying this is the *agricultural policy scenario of a further liberalisation* of European agricultural policy and the international agricultural markets. As a result, the prevailing trend towards reform of the Common Agricultural Policy is continued, and a successful international trade liberalisation is expected within the framework of the WTO.

The *assumptions on environmental protection and nature conservation*, which are dependent on scenarios in the studies, have an influence on land potential. Varying sets of assumptions in the scenarios make considerable contributions to the different land potential for energy crops. The German Advisory Council on the Environment (SRU) criticises the fact that in the biomass-related scenarios, existing natural and environmentally legal regulations have not been sufficiently taken into consideration.

One essential factor concerning the potential of energy crops is ultimately the future *productivity increase in agriculture*. The improvement in productivity will lead to less land being required for the production of the same amount of food. The productivity increase in crop production additionally signifies that increasing energy yields can be attained per area through the cultivation of energy crops. The assumptions on future yield developments have a decisive influence on the potential assessments. There are arguments both for an optimistic as well as for a pessimistic assessment of the future development.

There are clear differences in the *results of the land potential assessment* between the studies. For Germany, the land potential for energy crops in *expansion scenarios with a focus on a maximum supply of biomass* ranges from 1.72 to 3.54 million ha in 2010 and by as much as from 2.03 to 5.55 million ha in 2020. The land potential is significantly lower, but increases also with time if environmental protection and nature conservation policy restrictions are taken into consideration. The *expansion scenarios that take environmental protection and nature conservation requirements into consideration* display even greater differences, with land potential for energy crops in 2010 ranging from 0.15 to

2.87 million ha and in 2020 from 1.1 to 4.71 million ha. The differences are based on the extent to which limitations imposed by environmental protection and nature conservation requirements are included in the scenarios.

When *assessing the energy potential* which results from the corresponding land potential for energy crops, a whole series of assumptions is once again necessary. Thus substantial differences are indicated in the energy yields of energy crops per unit of area subject to product line and area of use. The use of solid fuels, such as wood from short rotational plantations in heat or combined heat and power applications, as well as the use of biogas and vegetable oil in heat and power applications, results for example, in considerably higher energy yields/ha than the use of energy crops for the production of fuels as well as their exclusive use as electricity.

The scenarios analysed work with different assumptions and do not disclose all of their assumptions, thus making the comprehensibility and the comparison considerably more difficult. Moreover the proportion of energy crops in the potential of bioenergy is not shown in a number of the studies. In result, the available assessments of the *energy potential for Germany* show an even greater range of variation as the assessment of land potential.

CONSEQUENCES OF THE CULTIVATION OF ENERGY CROPS

In addition to the analysis of the case scenarios, the state of knowledge of the ecological and economic effects of the cultivation of energy crops as well as of competing uses was evaluated. Important results are summarised below.

ECOLOGICAL EFFECTS

The environmental effects of bioenergy are usually ascertained on the basis of ecobalances, whereby particular attention is placed on the energy and greenhouse gas balances. The ecobalance results of process chains on the conversion of biogenic residues and waste materials to energy are best when compared to fossil energy sources, as the partly high environmental pollution resulting from the agricultural supply of biomass is omitted here. Likewise the energetic use of wood or perennial energy crops containing lignocellulose display good results, as the supply of these energy sources is associated with comparatively low negative environmental effects. The increased use of biomass for the supply of electricity and heat can make a greater contribution to the slowdown of climate change than the production of biofuels. However the heat market is shrinking and can also be served by other regenerative energy sources with in part more favourable ecobalances. The growing fuel market in contrast has as yet no regenerative alternatives to biomass. The ecobalances of the biofuels in use or in the process of development differ significantly in part. Biofuels from tropical countries and those in development, such as BtL or ethanol from lignocellulose, have so far tended to have greater potential as substitutes for fossil energy sources and for reductions in climate gas emissions than domestic biofuels (e.g. biodiesel from oilseed rape, bioethanol from maize).

The cultivation and processing of bioenergy sources can also give rise to a broad spectrum of environmental burdens. These range from overfertilisation and acidification of the agricultural soil through to additional burdens caused by unhealthy particulate emissions and a loss of biodiversity. The majority of ecobalances indicate a conflict of objectives between on the one hand the substitution of fossil energy, and the minimisation of greenhouse gas emissions and on the other hand a positive environmental overall balance. In view of these advantages and disadvantages in the different evaluation categories, no final statements and recommendations for action can be derived solely on the basis of ecobalances. The difficulty of arriving at scientifically verified and generalisable overall evaluations is increased still further if environmental effects are included, which are not recorded with the environmental parameters of the ecobalances. With the extension of the cultivation of energy crops, relevant negative effects on biodiversity, the availability of phosphate, the hydrologic balance and cultural landscape may arise, which cannot be mapped with ecobalances. Negative environmental effects occur in particular when the cultivation of energy crops leads to the conversion of grassland, to the intensification of previously extensively used or disused areas or to rain forest clearance and peat soil use in tropical countries.

ECONOMIC EFFECTS

The costs of the generation of bioenergy are made up of the costs for the supply of biomass or agricultural energy crop production, the transport of the biomass, the conditioning and the conversion to secondary or final energy sources. The *generation of bioenergy from residual materials* is as a rule less expensive than that from energy crops, at least as long as inexpensive residual materials are available for use as bioenergy. In the case of the rapid expansion in the use of bioenergy and the introduction of new conversion technologies based on residual materials (e.g. wood residues from forests), taking restrictions in environmental and nature conservation law into consideration at the same time, the potential will not be sufficient in the foreseeable future and will lead to an increase in the price of the relevant biomass.

With *energy crops*, the costs of agricultural production make up a large part of the overall costs and thus have a considerable influence on the economic viability of energy crop use. That is why inexpensive sources of biomass are most likely to bring about a reduction in costs. The costs of energy crop production are however dependent on the development of the agricultural prices.

Bioenergy sources which have a high energy density, such as biofuels, have low transport costs and for this reason are traded globally. Biofuels exhibit substantial differences in an *international comparison of the production costs*, whereas for example the production costs for bioethanol from sugar cane in Brazil are the lowest and this production of bioethanol is already competitive today without relying on state aid. The lower production costs in tropical countries are attributable to high biomass yields and low soil and labour costs. The *prices for fossil energy sources* essentially determine the economic viability of energy crop use. Rising prices for fossil energy sources do not only mean higher prices for bioenergy sources, but also rising costs in the cultivation of energy crops. In addition, rising prices for agrarian raw materials on the world market tend also to lead to rising prices for biomass from energy crop cultivation, which is decisive for the overall costs of energy crop use. As a result the increasing economic viability of bioenergy use (due to rising oil prices etc.) will presumably not be impeded, yet probably slowed down. There is agreement insofar as the fact that the markets for fossil energy, for energy crops and bioenergy sources as well as for agricultural products and foodstuffs are in the meantime linked together and influence each other.

With regard to *new conversion technologies*, economic benefits of gasification technology are seen in the field of electricity generation, whereas combustion technologies are predominant in the supply of heat, particularly in small heating systems and heat-driven combined heat and power stations. Moreover, new product lines in heat and electricity generation are closer to economic viability than the production of BtL. However there are hardly any alternatives to fossil energy sources in the fuels sector at present.

The use of energy crops is currently not generally economically viable. That is why appropriate subsidies policies (see above) have been implemented, in order to make possible and develop the use of energy crops. Support costs are essentially determined by the development of fossil energy prices and the production costs of energy crop use. The future developments of these are uncertain, meaning that *assessments of subsidy requirements* are fraught with not inconsiderable uncertainties.

Furthermore, an initial assessment is available of the potential *occupational effects* of sustainable raw materials and the use of energy crops. This shows that the employment effects in the field of conversion as well as the indirect and induced employment effects outweigh those in agriculture. Furthermore, the manpower requirements in agriculture as a whole, as a result of technical advances and associated improvements in productivity in agricultural production, are decreasing, a situation which can only be slowed down through the use of energy crops (as well as through biomass as a whole), but not reversed. When balancing the macroeconomic effects, only minor positive net employment effects appear. The extent of the net employment effects depends crucially on the difference in price compared to fossil energy sources. Positive effects can also come about as a consequence of a technological pioneering role, assuming conversion technologies can be exported to an appreciable extent.

COMPETING USES

Competing uses exist on several levels. Energy crops compete with other types of land use on the one hand, and there are competitive relationships within the energy crop cultivation between the various potential energetic uses (product lines) on the other hand. The cultivation of energy crops is in competition with:

- food and feed production,
- other land uses such as residential settlement and transport or nature conservation as well as
- use as industrial feedstock (biomass).

Within energy crop cultivation, there is a fundamental competitive situation between stationary use for heat and electricity generation and mobile use as biofuel. Energy crops (in the same way as other biomass categories) can be used as a rule with different product lines. For this reason, various competitive situations exist additionally within the two basic alternatives of stationary and mobile use. The economic viability of the different product lines can be greatly influenced at the same time by the structuring of state support.

POLITICAL TOPICS

On the basis of the preceding analyses, essential social and political fields of conflict and areas of action are discussed, which are associated with an expansion of energy crop use.

RESEARCH AND INNOVATION POLICY

So that the cultivation of energy crops can make a substantial contribution to the expansion of renewable energy, further research and development is necessary for different product lines and along all of the process chains. Overall, an *integration of research efforts* is necessary across product lines and disciplines. Co-ordination is required, among other disciplines, between plant breeding, plant cultivation research, agricultural economics, environmental research, research on conversion technologies and sustainability research.

It will not be possible to put all of the different product lines for energy crop use into practice at the same time in view of the limited availability of land. This is because the expansion of the conversion technologies currently available will tie up land potential for longer periods of time. The current – and future – *structuring of the support for bioenergy* thereby has a considerable influence on the chances of the various energy crop product lines and also on the development of their technologies.

In the initial stages of an intensified use of bioenergy, it proved sensible to work in research and development on a very broad range of product lines for the use of bioenergy and energy crops. In the coming years the question will arise, as to whether *prioritization* will become necessary, meaning that a focus should be directed towards those conversion technologies and product lines which have the best gains in efficiency and the greatest international prospects.

AGRICULTURAL AND REGIONAL POLICY

Following decades of low world agricultural prices and subsidised agricultural exports, *rising agricultural prices* could mean new opportunities for farmers, including those in developing and newly industrialised countries. On the other hand, rising food prices will exacerbate the economic and social hardship of people with low incomes, whose expenditure on food makes up a large part of their income. Competition for land and safeguarding the food supply are thus increasingly becoming an important political issue.

The introduction of subsidised bioenergy generation is in opposition to the abolition of product-related *subsidies* for food production. The subsidisation of bioenergy is in part not production neutral (e.g. the EEG funding), meaning that the achievement of the potentially highest yield by area is rewarded. The support of energy crop use can lead to an extension of the cultivation of energy crops to cover far more than the previously disused areas and result in the displacement of food production from Germany (or the EU).

Another development is possible if the use of bioenergy sources is increasingly supported or mandated. Whether the demand for bioenergy sources thus generated is then covered by the cultivation of energy crops in Germany or through *imports* is primarily dependent upon production costs, transport costs and external protection. It is to be expected that political conflicts will increasingly arise concerning the support of the domestic energy crop generation and the structuring of external protection.

Finally, the future *regional distribution* of energy crop cultivation constitutes an agricultural and regional policy issue. There are to date very few studies concerning regional distribution. In any case, the different German regions exhibit different advantages for energy crops, meaning that an irregular regional distribution of energy crop cultivation can be expected.

CLIMATE PROTECTION AND ENVIRONMENTAL POLICY

The expansion of renewable energy plays a central role within the framework of climate protection policy. All of the expansion strategies make provisions for the further expansion of the use of bioenergy and that its contribution will continue to dominate for the foreseeable future. Through subsidies policy, considerable influence can be exerted to determine which energy crops are cultivated and which product lines and areas of use are expanded. With a stationary use for the generation of electricity and heat, the same energy crop area can provide roughly twice the energy potential than that for the production of biofuels. As the agricultural areas available for the cultivation of energy crops are limited, it is probable that there will continue to be a controversial discussion in future on which use should have priority.

With the extension of the energy crop cultivation, the question will be increasingly raised whether this will call forth an *intensification of agriculture* and new environmental problems. The political task of the coming years will be to ensure an environmentally friendly energy crop production and to create or further develop the necessary framing conditions. Potential conflicts with *nature conservation* represent a further issue alongside the environmental effects of energy crop cultivation. Overall, climate protection goals on the one hand, and environmental protection and nature conservation goals on the other hand, will remain in conflict for the foreseeable future.

The *area under cultivation in developing and newly industrialised countries* was extended in the past as a result of rising demand for food and feed. The increasing support and demand for biofuels in particular threatens to intensify this development. The reclamation of new cultivation areas for energy crops is partly achieved through the direct clearance of rain forest and partly through the conversion of grazing land (for cattle) as well as the displacement of small farmers, who in turn then develop new areas at the cost of rain forest. It is thereby a great challenge to shape the global expansion of energy crop cultivation in such a way that it does not as a result run counter to climate protection goals.

TRADE AND DEVELOPMENT POLICY

First of all it must be remembered that the use of *traditional biomass* still dominates on a global scale. It remains an important development policy task to improve the efficiency of traditional bioenergy use, to ensure or achieve a sustainable supply of bio-solid fuels as well to develop as yet unused bioenergy potential.

With politically determined expansion targets and corresponding subsidies policies, as well as their increasing economic viability, *modern uses of bioenergy* have also been gaining in importance globally in recent years. As a result the cultivation of energy crops has been expanded. In particular countries with large cultivation areas and cheap production costs in tropical regions want to use their opportunities and extend the production of biofuels, both for domestic use as well as for export.

Future trade policy will thus have a strong influence on the future development of energy crop use. The EU will remain under pressure to dismantle its external protection in the agricultural sector and also for bioenergy sources based on energy crops. The results of international negotiations concerning the further liberalisation of trade policy will set appropriate framework conditions here.

The introduction of social and environmental standards is being increasingly discussed as a result of the fear that the expansion of biofuel production in tropical countries will lead to the displacement of small farmers and to a disruption of the regional foodstuffs supply, as well as to the loss of rain forests. The introduction of internationally accepted, applicable and verifiable *certification* is demanded by various environmental organisations, but also by individual governments, industrial enterprises and associations. Various national and international activities for certification are currently taking place. A preliminary assessment indicates that voluntary certification systems cannot replace the introduction and implementation of state environmental protection and nature conservation regulations in developing and newly industrialised countries. The chances of establishing binding certification within the framework of the WTO are estimated to be slight.

KEY ISSUES FOR THE 2ND PROJECT PHASE

In the first project phase, an inspection and comparative analysis of the numerous studies available on energy crops and bioenergy was undertaken, which is summarised in this report. Based on this analysis and the project concept decided upon by the Committee on Education, Research and Technology Assessment, three issues with great political relevance requiring in-depth analysis, which to date have not yet been comprehensively investigated scientifically, have been identified for the second project phase. The key issues for the second project phase are:

> dimensions of environmentally friendly energy crop production,
> expansion of energy crop use and national and international competition for land, and
> certification of biogenic energy sources.

DIMENSIONS OF ENVIRONMENTALLY FRIENDLY ENERGY CROP PRODUCTION

The expansion of bioenergy production is primarily sought to meet climate protection and energy policy objectives, and should be arranged to be as environmentally friendly as possible. In view of the limitations of the land available for cultivation (see the second key issue) as well as the rivalry of bioenergy source production on outstanding locations worldwide (see the third key issue), it is necessary for the cultivation of energy crops, that that the highest possible biomass yields per area are striven for in Germany and the majority of European countries. This could lead to conflicts with the environmental policy objectives of reducing the environmental impacts of agriculture within the scope of sustainable agriculture.

The question of specific demands on environmentally friendly energy crop production has as yet been looked at relatively little, and where at all, then dealt with primarily in individual scientific investigations. In this key issue, the essential areas of conflict will be identified, available possible solutions presented and political options for action analysed.

THE EXPANSION OF ENERGY CROP USE AND NATIONAL AND INTERNATIONAL COMPETITION FOR LAND

As the cultivation of energy crops is extended, the question is gaining increasingly in importance as to what extent this is causing competition with food production and leading to shortages of or price increases for foodstuffs. The available studies work consistently with potential assessments and expansion strategies for the use of bioenergy, in order among other things to answer the question of what the maximum contribution is that the cultivation of energy crops can make to the supply of energy in future. To an extent, the competition for land with nature conservation and landscape protection is taken into consideration. A potential rivalry to the production of food has hitherto only been discussed rudimentarily.

Within the key issue, conceivable future developments of the use of energy crops will be described, subject to more favourable and less favourable socio-economic and political basic conditions (using so-called explorative scenarios). Existing scenario analyses both of the worldwide situation (where necessary on the basis of important individual countries or regions of the world) as well as especially for Europe and Germany will be compiled and used. As a result a contribution to a realistic assessment of future energy crop production should be made. Furthermore, the respective characteristics of the competition with food production are estimated for the potential developments of energy crop cultivation. The objective is to work out the potential dimensions of the problem of competition with food production and the possibilities of taking this into consideration in political expansion strategies on bioenergy.

CERTIFICATION OF BIOGENIC ENERGY SOURCES

With the expansion of energy crop cultivation the question is increasingly raised, to what extent biogenic energy sources should or must be imported in future. Individual countries or regions in Latin America and Southeast Asia have considerable potential for energy crop production, which will not necessarily however be environmentally friendly or sustainable. There is a risk that expansion will occur at the cost of tropical rain forests. For this reason there are demands by many parties to develop and introduce certification for the ecological and socially responsible production of cross-border traded biogenic energy sources – which is preferably binding worldwide.

There are discussions about the possible structuring and implementation of appropriate certification systems in many international bodies or forums. The Agency for Renewable Resources (FNR) has commissioned the development of a preliminary proposal for a certification system on the initiative of BMELV. No independent proposal will be developed in this key issue of the TAB project, but rather the fundamental opportunities and limitations of the certifications of bioenergy sources and the ability to shape these politically that will be worked out.

OUTLOOK

The three issues requiring in-depth analysis relate to each other and cover central questions of the future use of energy crops. Through analysing them we will indicate which possibilities exist for sustainable energy crop use, which specific advantages and disadvantages are displayed by the different design options and which courses of action are available in different policy areas. The results of the second project phase will be documented in the final report.

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