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Opportunities and challenges facing new energy crops

Summary

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SUMMARY

In its role as an energy carrier, biomass has been an important political topic in the past few years and will remain one in the future. By the year 2020, 20% of the primary energy used in the European Union is supposed to come from renewable sources of energy in order to reduce both the emission of gases affecting the climate and our dependence on imported fossil sources of energy. Biomass is the most important carrier of renewable energy in both the European Union and Germany, accounting for about two thirds of this energy. Bioenergy carriers play a large role in the strategies for expanding renewable energy. In the past few years, the production of both biofuel and biogas has increased greatly in Germany as a result of state subsidies. This part of bioenergy is based in essence on the cultivation of energy crops (above all rape seed and corn).

The strong worldwide increase in food prices in the years 2007 and 2008, in particular, has however led to questions regarding the target for expanding biofuel production. The degree to which the growing production of biofuels contributed to this increase in food prices has been a matter of controversial discussion. One issue that became an important topic is that the production of food and that of fuel could compete for cropland. Agricultural prices have fallen considerably in the meantime as a consequence of the financial and economic crisis, and agriculture is now in the middle of a crisis of proceeds and income. In this situation, energy crops could once again attain significance as an option for raising incomes.

A further item of discussion is the degree to which ambitious production targets could lead to the importing of bioenergy carriers, thus triggering an expansion of croplands at the expense of the rain forest in exporting countries in the tropics. A large-scale clearing of rain forest land would even mean increased emissions of greenhouse gases instead of their reduction.

Such rapid changes in the public discussion pose special challenges to scientific policy consultation in this field. It is therefore necessary for policy consultants to carefully examine the possible future developments in addition to thoroughly studying the facts. A central concern of the present report is therefore to describe the status quo on the basis of the present state of our knowledge and to sound out the possibilities for policy measures that go beyond our perception of momentary problems. The presentation of the final report will mark the conclusion of the technology assessment project »Chances and Challenges Facing New En-

ergy Crops« (short title »Energy Crops«) that was requested by the Committee on Education, Research and Technology Assessment September 27, 2006.

FOUNDATIONS

Energy crops are understood to refer to agricultural crops whose utilization as a source of energy is the primary reason for their cultivation. Previous agricultural cultivation of energy crops focused on the *»traditional«* crop species used in the production of food and feed (e.g., rape seed oil for biodiesel). Yet the demands placed on energy crops differ from those on crops for food and feed (among them is the high proportion of ingredients that can be utilized for energy). An attempt is therefore being made to cultivate *specific types of energy crops out of »traditional« crops* (e.g., energy species of maize for biogas plants). The term *»alternative energy crops«* is taken to refer to agricultural crops that are new to Germany and Europe or have previously only been cultivated here in a marginal manner, such as Miscanthus.

Energy crops can be either completely or partially utilized for energy. Where *part of the plant* is used, that part can be either the seeds (e.g., for rape and grain), turnips (e.g., for sugar beets), stems (e.g., for cane sugar), or tubers (e.g., for potatoes). Where the *entire plant* is utilized, the entire grown biomass is used.

The goal of energy crop cultivation is the *acquisition of heat, electrical energy, and biofuels*. Yet it is a long road from an energy crop in the field to energy that is actually available. It is made up of different processing steps, in which different types of utilization are employed or are available. The fundamental alternatives are:

> The direct utilization of solid bioenergy carriers (combustion, gasification)
> The transformation into first- and second-generation liquid bioenergy carriers (into vegetable oil and bioethanol or into biomass-to-liquid (BtL) fuels, respectively)
> The transformation into gaseous bioenergy carriers (biogas, syngas, and hydrogen).

Overall, the technical field concerned with bioenergy is very complex. In addition to established technologies, there are also several usage paths and related technologies that are under development.

EXPANDING ENERGY CROP UTILIZATION AND THE COMPETITION FOR ACREAGE

The future development of competing uses of land between energy crop production on the one hand and the production of food and feed as well as the preservation of natural ecosystems on the other is dependent in a very complex manner on numerous fundamental socioeconomic conditions. The politically determined goals and strategies for promoting the growth of bioenergy and of the use of energy crops are just one factor among many. Since future socioeconomic developments and political arrangements cannot be predicted, the possible range of developments has been analyzed by using scenarios.

Global level

At the global level, the global scenarios of the Millennium Ecosystem Assessment (MA study) of the United Nations, which contain the fundamental directions of development with regard to globalization or regionalization and to proactive or reactive environmental management, were evaluated and compared with the results of other important studies of global scenarios. The MA scenarios provide a description of the conceivable fundamental future global economic, social, and political conditions. The MA was prepared by over 1300 scientists from 95 countries from 2001 to 2005. It constitutes the most comprehensive analysis of the status, trends, and scenarios related to ecosystems.

The coming decades will presumably see an *expansion of cropland* (arable land and permanent crops). One important cause of the opening up of new farmland is the growing demand for food, caused especially by the world's growing population. The increase in farmland is linked, for example, to significant declines in biodiversity in species-rich ecosystems and to the relevant releases of greenhouse gases. This expansion of cropland will however vary depending on the fundamental socioeconomic conditions.

One consequence of the global financial and economic crisis has been clearly sinking agricultural prices and an income crisis in agriculture. A clear increase in agricultural productivity per unit area cannot be expected unless this situation is quickly overcome and we see development *with strong economic growth and high investments in the agricultural secto*r (such as in the MA scenario »Global Orchestration«). The growth in incomes associated with economic growth however also means increasing consumption of animal source foods with a corresponding need for land for the production of feed. Nonetheless, under these conditions it is expected that overall the pressure for increasing cropland will

remain relatively small. There is thus some scope for expanding the use of energy crops.

Different scenarios provide different assessments about the question of how far a development with clearly rising energy prices – such as can be expected during rapid recovery of the world economy and strong growth of the overall economy – will lead to efficiency in the use of energy crops. While the scenario of economic liberalization in the MA study proceeds from a market-driven expansion of energy crop cultivation, the corresponding scenario in the Global Environment Outlook Report 4 (GEO4) by the United Nations Environment Program (UNEP) does not assume that the efficiency of energy crop cultivation will clearly increase despite rising energy prices. Strong global growth of energy crop cultivation based on increasing efficiency is thus uncertain without additional support based on climate policy or for other reasons.

A long-lasting slump in the world economy or increasing protectionist measures, such as could be observed in the course of the food price increase in 2007–2008 and also during the subsequent fall in prices, could lead to a *development with a stronger isolation of economic spheres*. In such a global development (as in the MA scenario »Order from Strength«), which would be accompanied by lower economic growth and a lower level of investment in the agricultural sector, only a weak growth in profits is to be expected. At the same time, strong growth of the population is expected, caused by the meager increase in prosperity. Of the different scenarios, this one assumes the greatest expansion of farmland, in particular at the expense of forest land in the developing and emerging countries. An increase in the utilization of energy crops would in this case especially intensify the competition.

Strong growth in energy crop utilization is however not automatically linked to a particularly strong expansion of farmland. In the context of a *climate protection policy that is pursued ambitiously around the world*, a considerable increase in energy crop utilization is possible (as described in the MA scenario »TechoGarden«) if it can be ensured that there will be strong increases in crop yields and in the efficiency of conversion procedures, including the development of high-yield utilizations of energy crops.

The MA scenarios demonstrate that the global amount of per capita agricultural cropland will decline from currently approximately 0.25 ha to 0.2 ha by 2050. A substantial increase in crop yields will be necessary in the coming decades just to ensure the world's current supply of food and to improve it where possible.

The *development of productivity per unit area* at the global level is therefore a decisive factor determining the scope for increasing energy crop utilization without additionally intensifying the competition between types of land use. The appraisal of the increases in yield that can be achieved in the future is tied to substantial uncertainties. These uncertainties are further increased by the fact that the consequences of climate change on the amount of crop land that is available globally and on the future development of yield represent a significant insecurity factor.

Only a few studies have examined how the growing production of biofuel has contributed to the increase in *prices for agricultural products and food on the world markets*. These studies have come to very different assessments. One basic fact is that only a small part of global agricultural production is traded internationally. This means that even limited restrictions on the supply (e.g., as a result of crop failures caused by drought) and increases in demand (e.g., as a result of growing incomes in the emerging market countries) have a relatively strong impact on global prices. If, because of political targets, the expansion of energy crop utilization takes place faster than free production capacity becomes available, this can contribute to an increase in prices without it being possible for the precise magnitude to be quantified.

National level

In order to analyze the future development of such competition at the national level, assumptions for forming corresponding scenarios for Germany (MA-D scenarios) were derived from the global MA scenarios. The focus of these assumptions concerns the use of energy crops in Germany in 2020, differentiated according to biofuels and energy crops for generating power and heat.

The MA-D scenarios show that *the competition for cropland can either intensify or decline in the future*, depending on the strategy pursued for increasing the use of energy crops and on the underlying general conditions. A continuation of the trend for energy crop utilization from the past few years and especially the planned quotas for biofuel would however lead to a noticeable increase in the global per capita need for land for Germany (for the domestic consumption of agricultural goods), while at the same time globally there would be a decline in agricultural area per person. The global need for land in Germany consists of the agricultural areas for growing energy crops, renewable raw materials, and food in Germany as well as those in foreign countries used for the net import of agricultural goods into Germany (i.e., import minus export). Thus the agricultural

areas for feed imports are taken into consideration, for example, in determining Germany's need for land.

High increases in yields for food and feed products lead to an increase in the amount of land available for cultivating energy crops and reduces the competitive pressure. High increases in energy crop yields make it possible for these crops to make a larger contribution to our energy supply from the same amount of land. The development of yield depends on the overall economic development and the investments in the agricultural sector. To some extent, it can however also be supported by a policy promoting research on breeding and on the techniques and systems of agricultural production.

The future political arrangement of the *external protection afforded bioenergy carriers* is one factor determining the extent to which future bioenergy carriers will be imported from countries in the tropics, particularly since biofuels (bioethanol from sugar cane, and biodiesel from palm oil) can be produced there at lower cost than in Germany. On the one hand, the high portion of imports leads, because of the higher productivity per unit area, to a lower need for land (MA-D scenarios »Global Orchestration« and »TechnoGarden«), while on the other these fuels stem from regions where food and feed production already exerts substantial pressure on the natural ecosystems (especially rain forests).

General conditions that lead to a *concentration on the cultivation of energy crops in Germany* do not automatically solve the problem of competition for land. If the future increase in productivity proves to be low and, at the same time, high targets are set for the use of energy crops, this will lead to a portion of the food production being displaced into other countries and thus indirectly to an aggravation of the competition for land at the global level (MA-D scenario »Order from Strength«). Ambitious crop targets could be derived from the aim to decrease the dependence on imported fossil energy carriers. The dilemma is that at the same time the amount of agricultural land that is available is limited. Under these conditions, therefore, the risks posed by exaggerated crop targets are particularly large.

The targets pursued by German funding policy constitute one factor that decides which *product lines of energy crop use* will be utilized in the future. The different product lines differ in the land they require and in whether they rely on domestic production (such as in the case of biogas). The scenarios with a stronger weighting on the use of energy crops for producing power and heat do better with regard to the development of competition for land than do the scenarios with a focus on biofuels. The business as usual scenarios for Germany

(regarding the use of renewable raw materials and energy crops) that are also discussed, which reflect the economic and political conditions that existed at the beginning of 2008 and which comprise high biofuel quotas, lead to a distinct intensification of the competition for land.

In some of the scenarios the assumption is made that the portion of fuel provided by the so-called *second-generation biofuels* will increase. Depending on the model used, one assumption is that there will be a continued biomass-to-liquids (BtL) production using energy plants (e.g., rapidly growing tree species) or straw (in the regional scenarios). The former would moderate the competition for land, while the latter would not cause any additional competition for land.

Decisive influence on the competition for land is exerted by the overall level of the goals for expanding energy crop cultivation, that is, by the sum of the future energy crop utilizations for power, heat, and fuel. An integrated consideration is needed. Depending on the other general conditions, limited goals for extending energy crop utilization contribute to a constant or clearly diminishing need by Germany for global acreage (MA-D scenarios »Adapting Mosaic« and »Global Orchestration«). Given favorable preconditions, ambitious goals for expanding energy crops are also possible (MA-D scenario »TechnoGarden«) without aggravating the competition for acreage. In addition to the competition over food production, we must also consider future competitive situations concerning the material use of regenerative raw materials.

Regional levels

Finally, the regional competition for the use of land and resources and the interaction between them were analyzed by using the four global MA scenarios to derive assumptions for a regional model of resource utilization (MA-R scenarios). Three regions were taken into consideration (a region with intense land cultivation, one with combined agricultural operations, and one with intensive animal husbandry).

At a regional level, there are obvious differences between agricultural locations and the respective focus of production. The scenarios and thus the different plans of policy for supporting energy crops that the scenarios are based on lead to *different developments in energy crop utilization* in the regions studied. While for example some regions (e.g., those with arable farming) tend to perform better in globally oriented developments (MA-R scenarios »Global Orchestration« and »TechnoGarden«), for other regions a regionally adjusted development is advantageous (MA-R scenario »Adapting Mosaic«).

The regional analyses come to the result that the *production of power* and heat (from biogas) will be expanded – in part substantially – in all the regions in the next decades under different fundamental conditions. There is only an exception when the fundamental conditions include an international demarcation between economic spheres (MA-R scenario »Order from Strength«), in which further expansion does not take place because there is a lack of competitiveness in the production of food.

The future development of *first-generation biofuels* (biodiesel and bioethanol) differs greatly from region to region and from scenario to scenario, ranging from an expansion in some to a reduction – even complete abandonment – in others. For example, according to the analyses of the scenarios in the MA-R scenario »TechnoGarden«, the limited availability of biodiesel will be completely stopped in regions in which there is intensive animal husbandry (in the target year 2050). Instead, biogas production is substantially expanded. In contrast, under the conditions of the MA-R scenario »Adapting Mosaic«, it is expected that the chances of bioethanol production are good in two regions (those with intensive arable farming or with combined agricultural operations).

The chances of the production of *second-generation biofuels* are good in regions with intensive arable farming under all of the general conditions that were considered if it is based on the use of straw. In all the scenarios, this is not true in regions with combined agricultural operations and with intensive animal husbandry. The extent that this potential can be realized depends on when the relevant biomass-to-liquids technologies are available commercially and on whether straw can be used technologically as the raw material basis, an assumption made in the scenarios.

The competition between uses not only concerns land area, but also *demands made on the environment for agricultural purposes*. The environmental consequences of agriculture are relevant above all in the areas of water, nutrients, emissions, and the diversity and stability of ecosystems. Such competitive relations exist for the use of biomass for food, for possible material utilizations, and for utilizations for energy. It is true for all the regions that a decrease in the competition for land between utilizations for energy crops and for food production (in the MA-R scenario »Global Orchestration« and »Order from Strength«) leads at the same time to a worsening of various environmental indicators, i.e., intensifies the competition for utilizing environmental goods. Thus if a reactive environmental policy predominates at the global and national levels, then at the regional level special consideration must be given to the negative consequences for the environment and preventive measures have to be taken. Under these con-

ditions, the environmentally sound organization both of energy crop cultivation and of agricultural production overall takes on particular importance.

A further example of regional differentiation is the *risk of humus being degraded*. The use of straw is sensible in a few regions since the resulting humus balance is positive, in contrast to other regions where it can lead to a negative humus balance. Especially in a region with combined agricultural operations, the humus situation is critical, both in the current situation and in those of different future developments (in all the scenarios).

Individual regional utilization systems that make synergies between resources possible and that take the regulating activities of the ecosystems into consideration *can even mitigate some of the competition* (for example, a region with intensive arable farming in the MA-R scenario »TechnoGarden«). This also means, by the same token, that even a decrease in the competition between production of food and that of bioenergy does not necessarily have to lead to an increase in undesirable ecological consequences.

The differences between the natural environments in different regions, particularly with regard to their general conditions, the focus of production, and the energy crop utilization, make it difficult to formulate a uniform national policy and make it necessary to have policies, supports, and projects that are adapted to the regional situations. A central issue from a regional perspective is how and to what extent the regions can develop independent of the overall global and European conditions and, despite uncertain overall conditions, can ensure the appropriate energy crop utilization.

Independent of the regional differences, the use of coupling products and of cascades is to be preferred, i.e., the production of bioenergy out of wastes and residual materials. They do not trigger any competition for land and can even contribute to mitigating the competition to use environmental goods. An instrument of this kind that is in use is, for example, the »slurry bonus« (German Renewable Energy Act, EEG).

ENVIRONMENTALLY SOUND PRODUCTION OF ENERGY CROPS

The replacement of fossil energy carriers by biomass is supposed to contribute to a reorganization of our energy supply that is more compatible with our climate and environment. Depending on the type of cultivated crop, the cultivation technique, and the location, the cultivation of energy crops can, however, also

be associated with negative consequences for the environment. The cultivation of energy crops and the environmental consequences that are specific to land do not differ fundamentally from the growth of food or feed crops if – as has previously often been the case – identical cultures and cultivation procedures are employed.

What has been studied is how the cultivation of energy crops affects protected resources, specifically ground, water, air/climate, animals/plants, and the landscape/recreation, and in which areas there can be adverse effects specific to energy crops. Based on this, starting points for the environmentally sound cultivation of energy crops have been developed.

The additional demand for energy crops has contributed to an overall *expansion of the cultivated farmland* and to the cultivation of crops on land and in regions that previously had not been used for growing these crops. In 2009, energy crops were planted on some 17% of the arable farmland in Germany. This relatively high proportion of the farmland is however not what is primarily relevant for the environment. Relevant is above all the *small number of species of energy crops* that have been grown on this land: rape was grown on 55% of the arable land used for energy crops, corn on 30%, and sugar beets and grain on 13%. In addition to shifts in the proportions of land utilized for the respective crops, *new species and varieties of plants* can also be cultivated. Inasmuch as these are noninvasive, indigenous species, this contributes to a positive extension of crop rotation.

The impact of energy crops on the different protected resources (land, water, air/climate, animals/plants, landscape/recreation) is determined to a decisive degree by the *location-specific sensitivity of the ecosystem* and the spatial *character of the cultivation*. Statements about larger geographical areas such as regions or federal states can only represent the probability that consequences of many factors will occur and must be imprecise. Crops and cultivation procedures that are not appropriate to the sensitivities of a location can lead to adverse effects on protected resources.

The environmentally sound cultivation of energy crops could be achieved on the basis of the available knowledge and of object-specific regulations, procedures, and techniques. This basis would, however, have to be adapted to the expansion of energy crop cultivation. This concerns in particular the challenges posed by the storage and application of fermentation residues as well as by the monitoring of nutrient flow in cultivating energy crops for biogas facilities.

A substantial portion of the environmental problems associated with the cultivation of energy crops could be mitigated or even avoided if, in the context of *crop rotation*, the activities of plant cultivation could be better coordinated and related. In organizing energy crop rotation, the goals should be to achieve an even humus balance, to have ground cover for as much of the entire year as possible in order to reduce the loss of nutrients and the use of pesticides, and to reduce the amount of tillage.

Depending on the previous use of the land, *site-adjusted cultivation of perennial energy crops* can have positive consequences for the ground, the water balance, and biodiversity. In particular, short-rotation plantings are more stable, elastic, and resilient to extreme weather and to climate changes than annual crops.

CERTIFICATION OF BIOGENIC ENERGY CARRIERS

In 2006 and 2007, the concern was increasingly voiced that the increased support for the use of biofuels in the industrialized countries would provoke the danger of negative ecological and socioeconomic consequences in the exporting countries in the south. The plan to set sustainability criteria accompanied by obligatory certification gained acceptance among European policy makers. A number of EU member countries (in particular, Germany, Great Britain, and The Netherlands) intensively promoted the development of sustainability standards and certification systems. In January, 2008, the European Commission presented a *directive promoting renewable forms of energy that contained obligatory sustainability requirements for liquid bioenergy carriers in the transportation sphere and in their utilization in power plants to produce electricity and heat*. By resolution of the European Parliament and the European Council, this directive took effect in June, 2009, and must be implemented in national law in the member states by the end of 2010.

According to the directive, the use of liquid biofuels (as opposed to fossil reference fuels) must lead to at least a 35% *reduction in greenhouse gases*, a 50% reduction starting in 2017, and a 60% reduction in new plants (starting in 2017). Agricultural raw materials cultivated in the EU for the production of biofuels must meet the environmental and agricultural regulations of the cross compliance directive. As a matter of principle – and thus also outside the EU – agricultural raw materials may not be produced on land that had an *acknowledged high value for biological diversity* in or after January, 2008. This includes forests unaffected by significant human activity, areas declared to serve the purpose of environmental protection, and grasslands with high biological diversity. Further-

more, raw materials may not be produced on land with a high concentration of carbon, i.e., in wetlands and continuously wooded regions.

In contrast to, for example, the German draft of a biomass sustainability directive, the EU directive does not contain any explicit criteria for protecting land, air, and water outside the EU. The *social and socioeconomic criteria* are not yet part of the certification criteria. However, the EU Commission is obligated to report every two years to the European Parliament and the Council on the social consequences of an increased demand for biofuels in the EU and in third countries with regard to the relevant countries exporting bioenergy carriers (for the first time in 2012). The Commission is supposed to propose corrections to the EU directive if it is proven that the production of biofuel has a significant impact on the prices of food.

Indirect changes in land utilization are also not taken into consideration in the greenhouse gas summary. The EU Commission has to present a report on this issue to the European Parliament and the Council by the end of 2010. It is obvious that there is no methodology available for including the indirect effect of a change in land utilization in the greenhouse gas balance that is sufficiently reliable, whether argumentatively or in its consequences for trade flow and land use. There are different suggestions for solving this problem. One proposal is to amend the certification criteria by adding the limitation of energy crop cultivation to unused land of low biodiversity or by requiring an increase in the yield of existing plantings and the use of biogenic refuse. Another topic put up for discussion is the integration of a country-dependent risk adder in the context of greenhouse gas balancing.

Some demands point beyond the narrow question of the production of energy crops. These include the demands that a transparent and participatory planning of land utilization be established in the exporting countries and that a global, multilateral agreement be reached to protect ecologically valuable regions or *a global standard for land utilization be established*.

OPTIONS FOR ACTING

Options for acting are identified and discussed for the topics: growth targets and the strategic direction of funding policy, environmentally sound production of energy crops, and certification. The core statements are presented in the following sections.

Growth targets and strategic direction of funding policy

At the focus are the fundamental policy decisions in the elaboration of German (and European) funding policy for bioenergy and energy crops that exert a decisive influence on competition between types of land utilization and on efficient climate protection.

There is no controversy over the fact that the politically desired expansion of bioenergy and, in particular, of the energy crop utilization should not lead to threats to the security of the food supply (as a result of an increased competition between types of land utilization) or trigger the destruction of rain forests or other very natural ecosystems. To achieve these goals, policy making can exert influence in various areas:

> *Energetically or materially renewable raw materials – balancing short-term and long-term perspectives*: A rather long-term perspective is to work toward a broad spectrum of material, industrial uses, in which the use as energy does not come until the end of the life cycle of material utilizations. If in contrast a short-term (or medium range) perspective is given preference, the preferred support for the utilization of agricultural biomass for energy would be maintained in order to keep the potential of such biomass from lying idle.
> *Biogenic waste and residual materials – making better use of unexploited potentials*: In order to take advantage of the low costs for avoiding CO2 and of the favorable results in the life cycle assessment, the use of bioenergy based on biogenic waste and residual materials should be taken more strongly into consideration when further decisions are made concerning supporting instruments (e.g., in the context of market incentive programs). This is to make better use of potentials currently not being fully exploited.
> *Stationary or mobile use – balancing the efficiency of climate protection afforded by energy croplands and the contribution to climate protection provided by transportation*: If the decision-making criterion is to achieve the greatest possible contribution to the renewable supply of energy from the land available and from the possible supply of biomass, then priority should unequivocally be given to the stationary sphere and the supporting instruments be aligned accordingly. On the other hand, if – despite the fundamentally lower degree of efficiency of mobile uses – fossil fuels are supposed to be replaced by renewable ones, then biofuels constitute the only alternative available. In this case, the expansion strategy should take biofuels into consideration.
> *Agriculture as the supplier of raw material or producer of bioenergy*: If agriculture is essentially viewed as a supplier of raw material for bioenergy carriers (possibly in international competition) that attempts to achieve a major contri-

bution to climate protection at the lowest possible cost of producing the energy carriers, then regional policy goals for cultivating energy crops should be secondary. If in contrast the use of the regional bioenergy potential is supposed to play an important role, then the funding instruments should be aligned to the conversion path with the raw materials and energy (especially biogas and pure fuels) being furnished regionally, creating favorable general conditions for regional innovations and uses. Funding continuity and the creation of stable innovation networks with actors from the regional value chain are important for the development of regional bioenergy utilization.

- *Purposefully organize the relationship between domestic bioenergy production and the importing of bioenergy carriers*: If the least costly production is to be used, then the existing external protection against bioenergy carriers should be reduced. A graded solution is to provide eased market access (e.g., considerable cuts in customs) to only those developing and emerging market countries that maintain minimum standards. After all, the magnitude of the growth targets and the choice of bioenergy lines for which there is an international market for bioenergy carriers determine which significance bioenergy carriers can attain and whether there are issues of external protection to be clarified.
- *The sustainable intensification of agricultural production*: The expansion of agricultural development assistance and the support of international agricultural research are supposed to contribute to increasing global agricultural production and to preventing competition for land. The challenge to European (and German) agriculture is to achieve higher yields while at the same time using less (energy intensive) equipment and emitting fewer greenhouse gases.
- *Next-generation biofuels – clarifying open questions*: Since the conversion procedures for second-generation biofuels are still in development and testing, questions concerning the prospects of implementation and the economic and ecological advantageousness should be clarified as early as possible.
- *Coordinating growth targets and funding policy in an overall plan*: To avoid aggravating the competition for food production and material utilizations, coordinated targets should be set for the use of energy crops in the fields of power, heat, and fuel. The possible negative consequences can only be effectively avoided by employing such an overall strategy for using energy crops. The coordinated targets should be set in a very transparent manner. Setting cautious and modest growth targets and allowing for their flexible adjustment should take account of the fact that the estimates of the future German, European, and global potential for producing energy crops are fraught with substantial uncertainty and dependent on numerous factors.

Environmentally sound protection of energy crops

The expansion of energy crop cultivation in Germany leads to new environmental challenges to agricultural policy. In order to ensure an environmentally sound organization of energy crop cultivation, the general administrative regulations for agriculture could be adjusted and their enforcement given more significance. The following options for acting are available:

- *Three-part crop rotation*: Since some energy crops (e.g., corn) can be included as part of narrow crop rotations, a crop rotation consisting of at least three parts should be included as good practice at the field level.
- *An evener humus balance*: The cultivation of energy crops can lead to a depletion of humus as a result of a higher portion of humus-degrading crops being included in the crop rotation, of the greater removal of biomass if the entire plant is utilized, and of agricultural residual materials (e.g., straw) being utilized for other purposes. For this reason, it should be made a requirement that the average humus balance over three years should be even.
- *Further going protection of permanent grasslands*: A growing demand for energy crops can lead to an expansion of their acreage. The plowing of grassland that is possible in the context of cross compliance should always be subject to authorization, even if the reduction versus the base value is less than 5%. Beyond a 5% threshold, the plowing of grassland should no longer be permitted.
- *Soil conservation by means of year-round ground cover*: The maintenance of year-round ground cover should be included as a necessary requirement in the cross-compliance rules in order to ensure that acreage is kept in good condition, both agriculturally and ecologically.
- *Environmentally sound use of fertilizers and pesticides*: As a consequence of high growth targets and the related high disbursement of fertilizer and pesticides, the cultivation of energy crops can lead to an increase in the release of nutrients and pollutants and in related risks to the environment. In addition to the further development of environmentally sound means of fertilization and plant protection, the cultivation of energy crops needing a smaller amount of fertilizer and pesticides should therefore be encouraged.
- *Maintaining the level of ground water*: Especially short-rotation plantings and other fast- and tall-growing crops can lead to substantial regional damage to the water balance since strong evaporation would decrease the formation of ground water. For this reason, plans should be developed that serve to decrease the need for water by energy crops, their systems of cultivation, and the process chain.
- *Ensuring the protective goals in nature reserves*: Countries should examine and adjust, if necessary, their own regulations for nature reserves with reference to

the changed conditions for energy crop cultivation. The potential of an invasion by »alternative« energy crops, known as invasive neophytes, should be reexamined and, if appropriate, restrictions issued for cultivation in sensitive regions.

> *Strengthening regional competence*: The amount of information offered to farmers regionally should be expanded to include both the specifics of energy crop cultivation and details regarding regional sites.

> *Cultivation of short-rotation plantings*: The legal framework for the cultivation of short-rotation plantings should be made more specific by making a clear distinction between the cultivation of rapidly growing species of trees and forestry in the context of a revision of the German Federal Forest Act. This should be completed as quickly as possible.

> *Consideration of the impact on the climate*: Measures to enrich the ground and modified techniques for cultivating energy crops (cultivation techniques, type and intensity of fertilization and irrigation, etc.) should be developed to decrease the emissions of gases affecting the climate (particularly CO_2 and N20). Incentive systems should also be created to encourage low-emission cultivation, such as in the context of environmental programs for agriculture.

Certification of biogenic energy carriers

Sustainability standards and the obligatory certification of those bioenergy carriers that are used to satisfy politically prescribed quotas or whose production is supported by public funds apply both to domestically produced bioenergy carriers and to imported ones. Socioeconomic requirements are also being discussed in addition to the planned environmental standards. The political and administrative task of the coming years consists initially in the national execution and implementation of the system planned by the EU directive and in ensuring compliance with the guidelines. Because the practical implementation presumably cannot be achieved without encountering any difficulties and will be a long-term process, there are also parallel options for acting to further develop the EU guidelines in the sense of expanding their range.

> *Implementation of the agreed system of certification*: The certification agreed by the EU should build on the structures of voluntary certification systems (e.g., that for wood). In the course of the needed adjustment of these systems, previous experience gained from the certification of other agricultural products is supposed to be systematically evaluated and used for improvements. The certification guidelines are supposed to be unified stepwise and made more specific in order to ensure that certification is uniform and to limit the discretion of the certifying companies. A transparent, independent, and reliable verification of

the observance of the regulations in the certification systems is the precondition for the systems' functionality and the credibility. An effective system of sanctions should therefore be established.

- *Spread to other bioenergy carriers and material use*: The harmonization or rather extension of sustainability standards to all the types of bioenergy carriers is in principle an obvious step. As long as solid and gaseous bioenergy carriers are not imported in larger amounts, such a certification would only apply to domestic or European production. A corresponding task of certification would only be justified if the sustainability requirements go beyond the existing European standards for agriculture or if it should possibly replace the regulatory modification made necessary by the cultivation of energy crops. A harmonization of biomass to material utilization also appears plausible, but a general certification for material utilizations might only be practicable in the context of the establishment of a global biomass production standard.
- *Expansion of the certification criteria*: Three starting points for the further development and extension of the certification criteria follow from the EU's sustainability regulation itself or from the history of its origin or its predecessor systems. They are a systematic implementation and evaluation of the reporting requirements, a strengthening of the existing requirements and the addition of further ecological and social or socioeconomic criteria, and the (stronger) inclusion of civilian initiatives and nongovernmental organizations from the relevant developing countries.
- *Consideration of indirect changes in land use*: The issue of employing indirect changes in land use as a certification criterion is the most difficult aspect in the development of sustainability regulations. No solution has been found to this issue in any of the existing or suggested systems. The introduction of a »risk adder« and the limitation of energy crop cultivation to unused (or abandoned) acreage of low biodiversity are discussed as potential solutions.
- *Broadening to the global production of biomass*: Especially the difficulties in using prescribed sustainability standards and an obligatory certification to prevent undesired indirect effects resulting from the stronger cultivation of energy crops suggest that the long-term perspective is in the global extension of sustainability standards to all types of biomass production.

PERSPECTIVES FOR ACTION REGARDING ENERGY CROP UTILIZATION

Overall, it is possible to identify four different fundamental directions of energy crop utilization or, in other words, four perspectives for acting on growth targets and funding policy. It is also possible to attribute to each of them focal points from the action fields of the environmentally sound production of energy crops

and certification. Each of the perspectives for action has its own specific advantages and disadvantages.

Maintaining biofuel priority

At the center of this perspective is the retention of the EU's binding growth target of 10% for the portion to be made up of biofuel and of Germany's target of 12–15% (each for the year 2020). Behind this are the targets for expanding the use of nonfossil fuel and thus for making a contribution to reducing the emission of greenhouse gases in the field of transportation and for achieving a higher degree of supply security.

To avoid additional competition for land, a consequence of this focus would have to be to freeze the amount of power and heat produced using energy crops in Germany at more or less today's level (or possibly even reducing it). Even given favorable overall conditions, it will be difficult to achieve this biofuel target in 2020 primarily on the basis of the German (or European) production of first-generation biofuel.

This is the reason that these quotas were set under the condition that second-generation biofuels (especially BtL) could constitute an appreciable portion by the target year. This is however highly uncertain. On the one hand, a prediction currently cannot be made as to whether this conversion technology will be sufficiently advanced by then and whether it will be possible to operate it economically. On the other hand, it is currently unclear to what degree residual materials can be utilized or energy crops (e.g., short-rotation crops) will be needed as the raw material basis. The possibility cannot be excluded that achieving the growth target for biofuels could be endangered if inadequate progress is made.

Due to its low energy productivity per unit land, this action perspective will lead to bioenergy (in this case, specifically the use of energy crops) providing a relatively small contribution to the availability of renewable energy. Similarly, limited savings can be expected in the emissions of greenhouse gases. The uncertainties in the level of NOx emissions and in their impact on the climate as a consequence of the use of nitrogen fertilizer are of particular significance in first-generation biofuels and can further diminish the amount these fuels contribute to protecting the climate.

If biofuels were made available primarily by domestic (or European) production, this would prevent the global pressure to expand farmland from increasing further. This is true, however, only as long as none of the European feed and

food production is forced out of the EU as a consequence of European biofuel production. Focusing on the European production of biofuels requires related external protection. This is true not only for first-generation biofuels but presumably also for second-generation biofuels since production of the latter will possibly be cheaper in countries in the tropics with large supplies of wood. In the context of global development, the retention or extension of such regulations concerning external protection belong more to a compartmentalization of economic spheres, which would overall lead to particularly strong expansion of farmland with all of its consequences.

The result of a concentration on domestically produced biofuels is that, of the options for acting on environmentally sound energy crop production, those options are particularly urgent that are related to the cultivation of energy crops for producing biofuels. Examples are the protection of permanent grasslands and the environmentally sound use of fertilizers and pesticides. In this perspective, certification would not have a high priority if the energy crop utilization is focused on domestic production and if the possible negative effects of energy crop cultivation on the environment are prevented by means of an extension of the administrative regulations on farming. The overriding task in certification would be the successful implementation of the agreed system of certification.

Shifting priority to the production of power and heat from energy crops

This focus is directed at utilizing the agricultural potential of energy crops in the most climate-efficient product lines. Currently and for the foreseeable future, the production of power and heat in cogeneration systems shows the better potential for saving greenhouse gas emissions. It can, for example, utilize biogenic solid fuel or biogas. Furthermore, the utilization of the whole plant creates a higher productivity of energy per unit area than first-generation biofuels. Corresponding growth targets for the production of power and heat on the basis of energy crops would have to be set and funding policy adjusted accordingly. In this way, bioenergy can provide a higher proportion both of renewable power and of the total power use than anticipated by the Lead Study 2008 (Leitstudie 2008 of the German BMU). The goal of this perspective for action is to reach the maximum possible energy productivity per unit area and to make a relatively high contribution to the renewable energy supply and largest possible contribution to avoiding greenhouse gases.

The consequence of this focus would have to be the stagewise termination of the biofuel quota until it is completely abolished. This would require a change to the European targets for utilizing biofuel. Furthermore, this would encounter

the resistance of the European biofuel industry, which has just established itself in the last few years on the basis of the government funding of biofuels. A compromise solution could be to freeze the quota at the current 5.75% to protect the legitimate expectations behind the investments that have been made and to take advantage of these investments. Termination of the biofuel funding would also mean that stronger efforts would have to be undertaken in developing more efficient vehicles and new propulsion systems in order to reach the climate protection targets in the transportation sector.

Uncertainties exist in this focus in the extent to which ambitious goals for the extension of cogeneration can be achieved. This is strongly linked to the expansion of local and district heating. Putting the focus on the stationary use therefore requires measures targeted at overcoming the respective obstacles since the advantage of the stationary use for producing power and heat is tied to cogeneration.

Putting the focus on the production of power and heat (from energy crops) means it is logical to give priority to the utilization of biogenic residual material and wastes for bioenergy and to fund it preferentially. The utilization of biogenic residual material and wastes for energy makes it possible to contribute to avoiding competition for land. Furthermore, other advantages are linked to it, such as lower costs for avoiding CO2 and favorable results on the life cycle assessment (also known as ecobalance) because the environmental burdens from the agricultural generation of biomass cease to exist.

Giving priority to the production of power and heat creates favorable preconditions for the use of regional bioenergy potentials since as a rule the necessary biomass does not merit transportation over longer distances and can therefore not be obtained from international markets. This is just as true, for example, for the utilization of energy crops in biogas plants as it is for the utilization of biogenic residual material and wastes. Furthermore, it is linked to good chances for agriculture to serve as the producer of bioenergy. Increasing the funding of regional innovation and user networks on bioenergy would thus support the focus discussed here.

Of the options for acting with regard to environmentally sound energy crop production as discussed here, options are particularly relevant that are related to the cultivation of energy crops for producing power and heat. This is true, for example, for the maintenance of at least three-part crop rotations with annual crops in order, for example, to prevent a concentration of corn being cultivated around biogas plants.

An expansion of certification to all species of bioenergy carriers, even solid and gaseous ones, may be an alternative or addition if the sustainability requirements go beyond the existing European standards for agriculture or possibly are supposed to replace the adjustment of the regulatory measures that is necessitated by the cultivation of energy crops.

Changing course by shifting to the material use of renewable raw materials

In this focus, biomass is viewed as the foundation of a broad spectrum of material utilizations that will become more and more important in the future. The use for energy is not supposed to take place until the end of the life cycle of material utilizations. As far as possible, coupling and cascade utilizations should be developed and utilized. The goal of this perspective for action is to build up an alternative to petroleum as an important base material in the chemical industry and in many industrial applications. This is important since petroleum will increasingly be scarce in the future and thus more expensive. The search for an alternative, renewable raw material should also be done for climate protection reasons.

The material utilization of some renewable raw materials has already become economical. Yet under the present general conditions, growth in the material utilization of renewable raw materials is expected to be slow. To achieve rapid growth, government funding of new fields of utilization is therefore needed. Thus, there would have to be shift from the funding for energy to that for material utilization. Given this focus, the transformation of the funding policy should be begun as early as possible. This is important so that the agricultural biomass needed for material utilization in the future is then available and has not been blocked in the meantime by investments and plant capacities focused on energy utilization.

Strong expansion of material utilization would depend on strong efforts in research and development. For example, the plan for a biorefinery is still in a relatively early stage of development. In this focus, the research and development of the conversion technology for second-generation biofuels should be arranged as openly as possible so that this technology can also be employed, where sensible, for making raw materials available for material utilization. Furthermore, high priority should be given to the assessment of the potential and means for utilizing coupling and cascade that are now waiting for development as well as to the development of the respective research and technology strategies.

The problem of a focus on material utilization is the very wide variety of means of using material, which is significantly larger than using for energy. This makes it much more difficult to develop dedicated funding strategies. The consequence of an early realignment toward material utilization would further be that the potential of utilizing energy crops would not be completely exhausted in the short to medium term.

Giving priority to material utilization would increase the urgency of developing sustainability standards for the material utilization of renewable raw materials and including them in the certification systems. The problem in this is that a general certification of material utilizations may only be practicable in the context of the establishment of a global production standard for biomass.

Importing bioenergy carriers

The goal of this perspective for action is to organize the use of energy crops as efficiently as possible in terms of land used, climate protection, and cost. Because of the higher production per unit area, the stronger avoidance of greenhouse gas emissions, and the lower production costs, quotas for biofuel would largely be met through imports from countries in the tropics (e.g., biodiesel on the basis of palm oil and bioethanol on the basis of sugar cane). In this regard, a resumption and successful conclusion of the DOHA round of the WTO negotiations leading to a corresponding reduction in the external protection regulations in agriculture would play an important role. Correspondingly, a reduction in the customs and support regulations for bioenergy carriers would also be necessary in the EU.

Since in this perspective energy crop cultivation in Germany will not tend to undergo any large expansion, the further development of administrative regulations on farming and the adjustment of them to the challenges posed by cultivating energy crops will not have high priority. Setting standards and certification are instead core elements of this focus. This focus depends on there being a sustainable production of bioenergy carriers in the exporting countries and on successfully getting control of the problem of indirect changes in land use. The priority given to expanding the certification criteria (with regard to further ecological and social or socioeconomic criteria) would also increase.

This is also the greatest risk in this focus. The detection of indirect changes in land use by means of certification systems is uniformly judged to be very problematic. If the import of biofuels directly or indirectly causes the conversion of rain forests or peat soil into agricultural production area, the result would be substantial additional emissions of greenhouse gases.

The goals of this perspective for action are furthermore consistent with letting quantitative-based funding of the individual spheres of utilization lapse in the medium term. This should be replaced by integrating them in a cross-sectoral emission trade that is as comprehensive as possible, such as has been demanded by the German Advisory Council on the Environment. This is linked to the certification of bioenergy carriers by the fact that the reduction of climate gas emissions must also be recorded and certified for the emission trade.

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