WBGU
Wissenschaftlicher Beirat Globale Umweltveränderungen
German Advisory Council on Global Change

Bioenergy Factsheet

1/2009

Bioenergy, and biofuels in particular, are emerging from a turbulent past. "Food or fuel" is a frequent slogan. But wholesale acceptance or rejection of bioenergy is not an appropriate response. In its latest report, "Future Bioenergy and Sustainable Land Use" (2009), WBGU demonstrates that the decisive issue is how bioenergy is produced and used.

WBGU's findings at a glance

- Bioenergy should be used to mitigate climate change and overcome energy poverty.
- The global bioenergy potential is considerable, but has clear limits.
- Growing energy crops involves significant risks arising from competition for land.
- Priority should therefore be given to the use of wastes and residues, since they raise far fewer problems than energy crops.
- Bioenergy is most effective in mitigating climate change when it replaces coal in the electricity sector, rather than when it is used as a transport fuel.
- Modernization of traditional biomass use in developing countries can significantly increase efficiency and thus improve access to energy.
- Policy-makers must establish a suitable regulatory framework at both national and international level in order to ensure that bioenergy use is sustainable.

What is bioenergy?

Plants absorb solar energy through the process of photosynthesis and store it in the form of biomass. In order to do this, plants take up carbon dioxide from the surrounding air as well as water and nutrients from the soil. Biomass is thus a store of both energy and carbon. Bioenergy can be produced directly through the combustion of biomass such as wood or straw. Biomass, e. g. that from harvest residues or kitchen waste, can also be converted into biogas and then used to generate electricity and heat. Industrial processes enable liquid fuels for transport to be produced from biomass. When biomass is converted into energy the stored carbon is released again as carbon dioxide.

How much bioenergy can be produced worldwide?

In the long term, up to 10 per cent of the global energy requirement could be met from bioenergy. The worldwide potential of bioenergy is limited, because land is also needed for food production and for nature conservation. Energy crops have an important part to play in the transition to the energy system of the future in which wind and solar energy will predominate.

WBGU estimates that the global bioenergy potential is at most one-tenth of the expected world energy requirement in the middle of the century (Figure 1). In this estimation, land needed for food security and nature conservation was excluded and climate protection was systematically taken into account. The potentials of both energy crops and wastes and residues were calculated. It is likely that only around half of this potential will be economically viable. The use of bioenergy from energy crops can play an important role until wind and solar energy become available in sufficient quantity around the middle of the century. After that almost all fertile land will be needed to produce food for the growing world population. In addition, the use of biomass as an industrial feedstock (e. g. for plastics) will become increasingly important.

How can the risks of bioenergy be avoided?

Using more bioenergy entails additional or more intensive land use. Bioenergy therefore competes directly with food security, nature conservation and climate protection. The risks of bioenergy can be avoided only by establishing the right political framework.

Risks to food security: The increasing use of energy crops heightens the demand for land, which is already rising worldwide. At the same time, the Food and Agriculture Organization of the United Nations (FAO) predicts that by 2030 the area of land used to produce food for the world population will need to be increased by around 13 per cent. Competition with the cultivation of energy crops can cause food prices to rise and lead to conflicts over land, thereby endangering the livelihood of around 1,000 million of the world's poorest people. Competition for water may also be exacerbated and more intensive land use can damage the soil.

Risks to nature conservation: Ever-increasing areas of semi-natural land are being converted for agriculture. Energy crop cultivation may displace existing food production, which must then be transferred to other virgin areas. This can lead to the clearance of forests elsewhere – sometimes even in other countries – as an indirect consequence of energy crop cultivation. By these mechanisms the uncontrolled cultivation of energy crops can further exacerbate the loss of biological diversity. Therefore, at least 10–20 per cent of the world's land needs to be conserved as protected area.

Risks to climate protection: The conversion of semi-natural land into arable land releases greenhouse gases. Whether energy crop cultivation has a beneficial or a damaging effect on the climate therefore depends to a large extent on the type of land that is used. Any calculation of the greenhouse gas balance must include these emissions. Under no circumstances should forests or wetlands be converted for bioenergy production; such conversion usually releases more greenhouse gases than are saved through the subsequent use of bioenergy. Therefore, the fact that the quantity of CO_2 released during combustion is equivalent to the amount previously absorbed by plants, does not imply that in the overall equation bioenergy causes no net CO_2 emissions.

What biomass is most suitable for bioenergy?

The highest priority should be given to the use of organic waste, harvest wastes and residues, since the associated risks are minimal. The cultivation of energy crops can only contribute to climate change mitigation if no semi-natural land is converted into agricultural land and if perennial crops are grown.

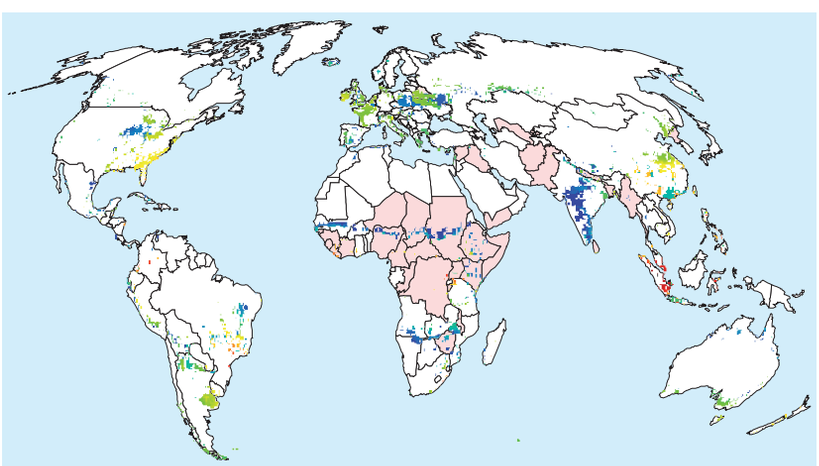

Figure 1: Possible land for energy crop cultivation in 2050. The countries coloured pink are areas in political crisis where there is little prospect of exploiting bioenergy potentials in the short to medium term. The global bioenergy potential is 80–170 exajoules per year, which is around one-tenth of the anticipated global energy requirement in 2050.
Source: WBGU, 2009

The use of **wastes and residues** is to be preferred to the cultivation of **energy crops**, because it does not require any new agricultural land. If, however, energy crops are cultivated, they should where possible be grown on previously unused, degraded land. This promotes nature conservation and climate change mitigation and helps prevent risks to food security. The cultivation of carefully selected energy crops can even serve to enhance the stock of organic carbon in the soil, thereby improving both the soil and the greenhouse gas balance. In addition, perennial crops such as Jatropha (a tropical oil plant), oil palms and fast-growing woody plants (such as poplars or willows) or energy grasses (e. g. Miscanthus) tend to have a more beneficial impact on the greenhouse gas balance than annual crops such as rape, cereals or maize, as well as protecting the soil. The best indicator for comparing the climate change mitigation effect of different crops is the ratio between the absolute reduction in greenhouse gases and the energy content of the biomass used.

Use bioenergy to mitigate climate change!

Bioenergy can make an important contribution to the global shift towards sustainable energy systems. Because it can replace fossil fuels, it can be highly effective in mitigating climate change, provided that conversion losses during production of the fuel are kept as low as possible. Bioenergy should primarily be used to replace fossil energy carriers with high specific CO_2 emissions – particularly coal. The best place for bioenergy is therefore in the electricity sector, rather than as a biofuel in the transport sector.

If used appropriately, bioenergy can save around 5–10 per cent of present greenhouse gas emissions. Bioenergy can also help to balance out the intermittent feed-in of electricity from wind farms and solar power plants in electricity grids ('control energy'). In the long term and in combination with the capture and secure storage of CO_2, bioenergy could even help to remove some emitted CO_2 from the atmosphere ('negative emissions'). With modern bioenergy the focus is currently on developing and producing liquid biofuels that can be used in the transport sector. This is a consequence of rising oil prices and the desire for a secure energy supply. Bioenergy use in industrialized countries should, however, be oriented primarily towards climate change mitigation. Because a great deal of energy is lost in the manufacture of biofuels, their use is on the whole not expedient. Moreover, as an energy carrier biofuels replace oil, which has lower CO_2 emissions per unit energy content than coal. The greenhouse gas reduction achievable through bioenergy is greatest when the resource is used in power plants to generate electricity. However, it is important that the bioenergy genuinely replaces coal and not an energy carrier such as natural gas that is relatively climate-friendly.

Use bioenergy to overcome energy poverty!

Bioenergy can improve access to modern forms of energy in developing countries and thus contribute to overcoming energy poverty. Modern bioenergy should be deployed in rural areas to replace traditional forms of bioenergy that are inefficient and harmful to health. Bioenergy can also help modernize the energy sector in urban areas and strengthen the export sector.

Ninety per cent of current bioenergy use occurs in developing countries, in antiquated ways and with major risks to human health. More than one-third of the world population burns wood, dung or harvest residues in an open fire for cooking or heating. More than 1.5 million people die each year from the effects of indoor air pollution – more than are killed by malaria. Simple and cost-effective technologies for modern bioenergy use are available and can improve access to energy in both urban and rural areas. In addition, the use of more efficient cooking stoves can drastically reduce wood consumption. Security of supply improves, and health risks are reduced. Micro biogas systems or locally produced vegetable oil can be used to drive electricity generators, mills, water pumps and tractors. In tropical and subtropical latitudes, in particular, the sustainable cultivation of energy crops has great potential that can be tapped to modernize the energy sector. Where the energy supply is already based on renewables such as hydropower, biomass can be exported for conversion to electricity or used in the short term in the transport sector. The same rule applies: electricity generation should take precedence over transport fuels. To ensure that food security is not jeopardized, developing and newly industrializing countries need integrated strategies for sustainable bioenergy use.

With modern biomass gasification, electricity can be generated from coconut waste.

Adopt sustainable bioenergy policies!

At national and international level, policy-makers must establish an enabling environment that ensures that bioenergy benefits rather than harms the climate, semi-natural land is conserved and the world food supply is secured. WBGU recommends:

- **Making bioenergy a consistent part of international climate policy:** Until now the Kyoto Protocol has not taken account of all emissions attributable to bioenergy. The present modalities therefore promote bioenergy use even when it has a harmful impact on the climate. The rules determining how emissions are counted in connection with emissions reduction obligations must therefore be amended so that they reflect the true contribution that bioenergy makes to climate change mitigation.

- **Introducing standards and certification for bioenergy and sustainable land use:** Compliance with sustainability standards should be a precondition to the use of bioenergy products. As a first step, a statutory minimum standard and a certification system for all types of bioenergy should be introduced at EU level. In the long term a worldwide standard extending to other agricultural products should be established.

- **Defusing competition for land:** Countries launching energy crop production should implement strategies designed to strike a balance between different land uses. By promoting rural development and agricultural research, food production in developing countries can be strengthened. A diet containing fewer meat and milk products, especially in industrialized countries, helps to further ameliorate competition for land.

- **Targeting bioenergy promotion policies for sustainability:** The only uses of bioenergy that should be promoted are those that contribute sustainably to climate change mitigation. Promotion of liquid biofuels should therefore be phased out. Promotion should concentrate on bioenergy use for electricity and heat production.

- **Tapping the sustainable bioenergy potential in developing countries:** In development policy the use of bioenergy to overcome energy poverty should have priority. Developing countries should be supported in drawing up national bioenergy strategies. Pilot projects involving particularly sustainable energy crops or the use of wastes and residues should be promoted. Germany should enter into more bioenergy partnerships with developing countries.

Efficient wood stoves – an opportunity for developing countries.

- **Building the structures for sustainable global bioenergy and land-use policy:** An International Conference on "Sustainable Bioenergy" should be convened. The aim should be to arrive at a shared vision of the opportunities and risks of bioenergy. Consensus should be reached on appropriate standards for the production and use of different forms of bioenergy.

- **Global land-use management as future challenge:** Too little attention is currently paid to the likely spread of land-use conflicts. A new Global Commission for Sustainable Land Use could identify the key challenges arising from global land-use issues and act as a knowledge hub. This work should form the basis for a global approach to land-use management.

WBGU

The German Advisory Council on Global Change (WBGU) is an independent scientific advisory body set up by the German government in 1992 in the run-up to the Earth Summit in Rio de Janeiro. Working on an interdisciplinary basis, WBGU draws up scientific reports which are used to provide policy-makers with recommendations for action and research.

The report "Future Bioenergy and Sustainable Land Use" can be downloaded at http://www.wbgu.de

WBGU Secretariat
Reichpietschufer 60–62
10785 Berlin, Germany
Phone and Fax:
+49 30 263948 0
+49 30 263948 50
Email: wbgu@wbgu.de
Internet: www.wbgu.de

Pictures: Prof. Dr. M. Schulz-Baldes

ISBN 3-936191-29-5

2009, ***WBGU***