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TECHNIKWISSENSCHAFTEN

UNION
DER DEUTSCHEN AKADEMIEN
DER WISSENSCHAFTEN

May 2019
Summary of the Position Paper

Biomass: striking a balance between energy and climate policies

Strategies for sustainable bioenergy use

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Union of the German Academies of Sciences and Humanities

Bioenergy is the most versatile of the renewable energy sources and provides more energy than wind and hydroelectric power, solar energy and geothermal energy combined. A coherent bioenergy policy must ensure that bioenergy use has no negative social and environmental impacts, and makes the greatest possible contribution to climate protection. The "Bioenergy" working group of the Academies' Project "Energy Systems of the Future" proposes:

- There is little risk associated with putting **residues and waste materials** to use as energy. Germany has major potential in terms of timber residues, straw and animal excrement. Converted into energy, these could cover up to 17 per cent of Germany's future primary energy demand.
- In order to be sustainable, bioenergy must be put to **system-beneficial use**: it can assume those functions in the energy system for which other renewables are unsuitable. Bioenergy could, for example, power ships and aircraft or provide heat for industrial processes.
- Climate models have shown that CO_2 will in the future have to be removed from the atmosphere in order to achieve the Paris climate targets. There are various options for producing such **"negative emissions"**, one of which is to capture carbon dioxide in bioenergy plants and put it into permanent underground storage (**BECCS**). This approach should be considered in relation to future bioenergy applications.
- **Certification systems** and a sufficiently high **CO_2 price** are ways of ensuring that bioenergy is beneficial to the climate. They are most effective if they cover not just bioenergy, but rather all agricultural products.

Bioenergy in the global land use system

Bioenergy is already providing one tenth of Germany's energy requirements. Biomass is, however, not only needed for supplying energy, but also for producing materials, food and feedstuffs. Since the global population is continuing to grow, so too is demand for biomass, and thus also competition for limited land area.

Any further expansion or intensification of human land use increases the pressure on the environment and nature. It is therefore absolutely essential for bioenergy to be generated and used in such a way that it produces the least amount of greenhouse gas emissions possible, and neither jeopardises biodiversity nor degrades the quality of soils and water resources.

Global potential

Biomass is traded on international markets. Bioenergy use in Germany thus has global consequences. Estimates of future **sustainable global bioenergy potential** range from between fifty exajoules per year, or roughly today's level of consumption, and several hundred exajoules per year. The range is so large because it is unclear to what extent agricultural yields can be raised and how much unused, degraded agricultural and pasture land on which energy crops could be cultivated is available.

Future dietary habits have a major influence on available land area. For instance, given a purely plant-based diet, the world could feed approximately twice as many people from the same land area as today. Consuming less meat and dairy products would mitigate conflicts between food security, bioenergy and nature conservation.

Greenhouse gas balance of bioenergy

Nitrous oxide emissions from nitrogen fertilisation are the greatest source of emissions from cultivating crop plants. However, changes in land use can also contribute considerably to climate change, in particular when forests are replaced by agricultural land. This is because forests store much more carbon in vegetation and soil than do arable and pasture land. **Indirect land use changes** occur when the cultivation of energy crops results in the area of agricultural land being expanded in other regions, often in non-European countries. Since the extent of such changes is disputed, reliable estimates of the greenhouse gas emissions caused by bioenergy are extremely difficult to obtain.

Putting forest wood and agricultural commodities to use for producing energy is thus associated with major environmental risks. Bioenergy should instead primarily be produced from **residues and waste materials**. If unexploited potential from timber residues, cereal straw and animal excrement were tapped and primary energy consumption were reduced to 2,000 terawatt-hours per year by 2050, as targeted by the federal government, residues and waste materials could provide **13 to 17 per cent** of primary energy. Designing bio-based materials to be low in pollutants and readily recyclable enables repeated use and energy recovery at the end of the product's life (**cascade use**).

Coherent climate protection policy

CO_2 removal technologies
Intergovernmental Panel on Climate Change (IPCC) scenarios show that even a very rapid and far-reaching reduction in greenhouse gas (GHG) emissions will not alone be enough to achieve the Paris climate targets. **"Negative emissions"** will also be necessary. One such option for reducing the CO_2 content of the atmosphere is to use bioenergy with carbon dioxide capture and storage (**BECCS**): if biomass is put to use for producing energy, the resultant carbon dioxide is captured and put into permanent underground storage.

In addition to BECCS, there are further CO_2 removal technologies, including:

- **Afforestation:** trees absorb CO_2 and store the carbon. Storage potential can be increased if wood is harvested and transformed into long-lasting products.
- **Biochar:** carbonised biomass is stored in the soil. Carbonisation prevents the carbon from being released as CO_2.
- **Direct air capture:** Technical installations capture carbon dioxide from the ambient air with chemical binding agents. The carbon dioxide is then compressed and stored underground.

While afforestation, biochar and BECCS require cultivated land, direct air capture is more costly, energy-intensive and logistically complex. Both BECCS and direct air capture entail using CCS technology, which is controversial in Germany. A **mix of technologies** will probably be the only way to meet the overall requirements for negative emissions. If BECCS is to contribute to climate protection, it must be borne in mind that not all bioenergy technologies are equally well suited to CO_2 capture.

Climate policy tools
A comprehensive bioenergy policy must view **energy, resource and land use as an integrated whole**. If, in the future, residues and waste materials are to a greater extent put to use for producing energy, close links with waste management will also develop. The various tools in individual policy areas will thus have to be much more closely coordinated with one another than in the past.

Given a uniform, sufficiently high CO_2 price, it will be possible to regulate CO_2 emissions from bioenergy over the entire life cycle. This price will have to include all greenhouse gases in all sectors of the economy, in particular also emissions from agriculture.

Alternatively, or in addition, these tools can help to ensure that bioenergy is of benefit to the climate:

- National or EU-wide **statutory regulations** can ensure that biomass produced in Germany is produced sustainably.
- All biomass imports could be **certified**. In addition to greenhouse gas emissions, certification should also include social and environmental sustainability criteria.
- In order to treat domestic and imported biomass equally, the greenhouse gas emissions of imports could be subject to a **border tax adjustment**.

However, regulating bioenergy only is largely incapable of preventing further deforestation, since only a small proportion of agricultural production is put to use for producing energy. In order to ensure effective protection of forests, these tools would therefore have to be applied equally to all agricultural and forestry products.

Bioenergy technologies of the future

The energy system of the future will probably put bioenergy to different uses than in the past. Given the limited potential of biomass, bioenergy should primarily be used in applications where other renewable energies come up against their limits. By offsetting the weaknesses of wind and hydroelectric power, photovoltaics and geothermal energy, biomass can make a valuable contribution to the energy transition.

In the long term, it makes sense to use biomass predominantly for **producing motor fuels** in applications in which purely electric powertrain systems are impractical, for instance in aviation, shipping or heavy goods vehicles. Another major application is the provision of **process heat in industry**, since biomass and biogas can also be combusted at high temperatures. In power generation, bioenergy should primarily be used to provide flexibility, while for heating, priority should be given to use in efficient CHP plants.

Development pathways

The areas in which bioenergy is used in the future will primarily be determined by three developments. A first deciding factor is the **acceptance or otherwise of CCS as part of the climate protection strategy**. If it is rejected by society, it will not be possible to use either BECCS or direct air capture for CO_2 removal. If society consents to using CCS, infrastructure for the transport and storage of carbon dioxide must be put in place in the near future.

Secondly, it is uncertain how successful the commercial introduction of **liquid biofuels made from lignocellulose** (e.g. wood or straw) will be. If manufacture is to be competitive, the technology for industrial-scale biorefineries will have to be further developed. Another decisive factor is how the respective markets develop for fuels and raw materials, and for secondary and co-products. In many cases, producing fuel from lignocellulose is only economically viable in large plants, which is inconsistent with today's pattern of decentralised bioenergy use.

Thirdly, expanding **infrastructure for combined heat and power generation (CHP)** can assist with putting bioenergy to flexible use for electricity and heat generation, not only in small, more decentralised, but also in large, centralised plants. If combined heat and power generation is to be able to develop to its full potential, however, district heating grids need to be expanded and supported by energy policies.

Residues and waste materials can already be put to greater energy use in the short to medium term. Technical adjustments will have to made to the plants to increase the efficiency with which they can be processed.

If biogas is upgraded to **biomethane**, it can be fed into the natural gas grid and flexibly used in any sector. The environmental footprint can be improved by using residues and waste materials as well as ecologically beneficial crops (e.g. grasses), instead of conventional energy crops.

If bioenergy is to be able to contribute to climate protection in both the short and the long term, on the one hand, **existing technologies** such as biomethane production and combined heat and power generation should be further developed, and on the other hand, new technologies such as BECCS and biorefineries should be **researched and** successfully **demonstrated**.

Comprehensive bioenergy strategy

Since there is not enough biomass available for all conceivable applications, various areas of use **will compete for the biomass potential**. The legislative and economic framework should as a priority direct biomass to those applications where it is of greatest benefit. For example, bioenergy should only heat those buildings in which heat pumps cannot be used or cannot be used alone.

A **comprehensive bioenergy strategy** must ensure that bioenergy makes the greatest possible contribution to climate protection and to a secure and affordable energy supply, places no burden on the environment and nature, and at the same time, is accepted by society.

Creating system knowledge

Integrated models of energy and land use systems make it possible to evaluate different biomass scenarios and to assess how far they can help to achieve climate protection targets. The models should in the future also include CO_2 removal technologies such as BECCS. Systematic research into the **opportunities and risks presented by CO_2 removal technologies** is required in order to be able to develop the models appropriately.

A **platform for discussing transformation pathways** could help to shed light from various perspectives on bioenergy development pathways and to rank them. The platform should bring together all of the relevant stakeholders around one table: from energy, agriculture and forestry industry associations to environmental interest groups and consumer advice centres, to representatives of local authorities, civil society and the general population. Such a platform could provide a framework for kick-starting a broad discussion around disputed technologies such as CCS and other CO_2 removal technologies. The social impact of industrial bioenergy use in biorefineries or BECCS plants compared to decentralised heat generation could, for instance, also be discussed.

Systematic monitoring using suitable indicators could be applied to the different development pathways, ideally taking into account the insights into the different aspects of evaluation gained from the discussion platform. The system knowledge created in this way could assist in further developing bioenergy use in a **system-beneficial** direction. This would advantageously reduce constant changes of course in bioenergy policy and increase planning certainty for all stakeholders.

In this discussion, it is vital to focus on and communicate the huge **urgency for climate policy action**. CO_2 removal technologies such as BECCS are accordingly not in any way an alternative, but rather are complementary to ambitious CO_2 mitigation strategies. Should Germany entirely dispense with CCS and CO_2 removal technologies, minimising the climate impact of industrial processes in particular and offsetting unavoidable emissions from agriculture will become more difficult. Dispensing with one climate protection option would tend to reduce the likelihood of achieving climate protection targets. The risks presented by new climate protection technologies therefore always have to be balanced against the risks of climate change.

The Academies' Project "Energy Systems of the Future"

The Position Paper *Biomass: striking a balance between energy and climate policies. Strategies for sustainable bioenergy use* evolved within the framework of the Academies' Project "Energy Systems of the Future". In interdisciplinary working groups, about 100 experts are working on different courses of action for the pathway to an environmentally sustainable, safe and affordable energy supply.

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