

Bioeconomy strategies across the globe

Over the last two years, numerous countries have begun to develop more or less comprehensive bioeconomy strategies. The following article looks at the differences between the various concepts and, in particular, the role that they assign to food security.

Published in 2009, the OECD strategy “The Bioeconomy to 2030: Designing a Policy Agenda” gave an important stimulus to the development of national and regional bioeconomy strategies. In 2010, Germany’s Ministry of Education and Research published “The National Research Strategy BioEconomy: Our Route Towards a Bio-based Economy”, which was then complemented in 2013 by Germany’s “National Policy Strategy on Bioeconomy”. In 2012, the European Commission issued its Communication on “Innovating for Sustainable Growth: A Bioeconomy for Europe”, while the USA published its National Bioeconomy Blueprint in the same year. There are many more countries that have since then come up with bioeconomy strategies (see page 13).

■ Chief characteristics of bioeconomy strategies

A number of countries are promoting individual biotechnology sectors but have not yet developed a comprehensive bioeconomy strategy. These include the red biotechnology sector (pharmaceuticals and personalised medicine), the green biotechnology sector (transgenic plants and cloned animals) and the white or industrial

biotechnology sector, which makes use of renewable primary materials to make bioplastics and biofuels, among other products.

For most countries, the development of the bioeconomy or of specific biotechnology sectors promises innovation, economic growth and job creation. In some cases, the aim is to bring benefits to rural areas by enabling them to supply and process renewable raw materials. A number of countries also justify the development of the bioeconomy with the need to reduce their dependency on oil as well as with their willingness to combat climate change. Through more efficient production processes and the sequestration of carbon in bio-based products, the bioeconomy is said to lead to a reduction in the negative impacts the economy has on the environment. The development of food biotechnology or innovation in the medical sector is regarded as a positive contribution to improving the health of citizens. In addition, the issue of food security is addressed in a number of strat-

egies. To achieve food security for its citizens, a country needs to make sure that sufficient food of adequate quality and diversity is available and accessible to all the people at all times, even in times of crisis. As the bioeconomy creates additional demand for renewable raw materials, hence using agricultural land and other inputs, there may be multiple impacts on food security.

The instruments used to promote the bioeconomy are similar in many strategies. Most countries concentrate on investment in research and development, in the field of life sciences. Moreover, they aim to help the transfer of innovation from the laboratory to the market, often by setting up clusters between academia and business, with the companies involved being supported by tax relief or risk financing, and by forming public-private partnerships. Of equal importance in these strategies is specialist training by offering curricula established in co-operation with companies. Some strategies also anticipate legal and regulato-

The „red“ biotechnology sector focuses on developing pharmaceuticals and personalised medicine and plays a key role in many national bioeconomy-related strategies.



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ry reforms to support the bioeconomy. The European Union and the German strategies stress the need for stronger stakeholder engagement and the exchange of information with citizens.

■ Individual strategies in more detail

The European Commission

The European Commission's Communication on "Innovating for Sustainable Growth: A Bioeconomy for Europe" can be regarded as quite a broad strategy. It includes the sectors of primary production, traditional wood processing sectors as well as the chemical and bioenergy sectors, making use of biotechnology. The new technologies emphasised in the Communication are biotechnology, nanotechnology and information and communication technologies (ICT).

The European strategy makes several references to the challenge to ensure global food security. It acknowledges that an increasing demand for biomass and competing uses for biomass may be problematic for food security. The need to feed a growing population and the need to sustainably manage natural resources and mitigate climate change create trade-offs, requiring a strategic and comprehensive approach. The measures proposed include the sustainable intensification of agricultural production at global level, the use of waste as a resource, and a radical change in consumption patterns in the EU. A Bioeconomy Panel has been created with the aim of enhancing coherence between policies, initiatives and economic sectors and creating an open dialogue on the research process behind the bioeconomy. A Bioeconomy Observatory has also been created to assess the progress and impact of the bioeconomy.

The US strategy

The National Bioeconomy Blueprint of the United States of America understands the bioeconomy as "an economic activity that is fuelled by research and innovation in the biological sciences". The technologies of specific interest here are genetic engineering,

DNA sequencing, manipulation of biomolecules and the use of microorganisms or industrial enzymes, as well as the direct engineering of microbes and plants. Similarly to the EU Strategy, the US strategy expresses the wish to replace petrochemical products by bio-based products and thus mitigate climate change.

The US strategy recognises that, in the years to come, a growing population will require more food, while at the same time the availability of arable land resources is set to diminish. The response to this is the increase of crop yields by a combination of classical breeding techniques and biotechnology. It is said that yield increases have already been achieved through biotechnology-enabled pest control. A further aim is to enhance disease resistance and improve the nutritional value of food. Moreover, the strategy has a development policy dimension, referring to the activities of the United States Agency for International Development (USAID). Together with the Bill & Melinda Gates Foundation, the agency supports agricultural research designed to benefit smallholder farmers in developing countries.

The German bioeconomy strategies

The German National Research Strategy and the National Policy Strategy on BioEconomy cover all the sectors that develop, produce, process or utilise biological resources.

The research strategy focuses on gaining a better understanding of the elements and structures of biological systems, such as plants/algae, enzymes and microorganisms. Biotechnology is now applied in many different sectors: in the medical sector, in industry (fine chemicals and bioplastics), in the agricultural economy (pesticides, feed additives) and in environmental services (wastewater purification). A strong theme in the strategy is the need to strengthen interdisciplinary research (see also article on pages 14–15).

Both German strategy documents refer to food security as a priority. Like the European Commission strategy, the Policy Strategy emphasises the trade-offs that may appear between a number of goals: securing food, replacing fossil-based raw materials, protecting the climate by using renewable raw materials efficiently, conserv-

What do we mean by "bioeconomy"?

The strategies use either the terms "bioeconomy" or "bio-based economy", and these terms are often used interchangeably. **Bioeconomy** is characterised by economic activities deriving from scientific and research activities that are linked to different forms of biotechnology. It turns life science knowledge, meaning the scientific study of living organisms, into sustainable, eco-efficient and competitive products. The term "bio-based" refers to the primary material from which products are produced. The "bio-based economy" usually includes all sectors that develop, produce, process or use plants, animals or microorganisms. Strategies using the term "bio-based" cover all sectors using biomass, from primary production sectors, like agriculture and forestry, through traditional sectors using biomass, such as wood-based construction, to modern sectors making use of biotechnology. A bio-based industry would largely replace fossil-based raw materials by renewable raw materials.

The term **green economy** is sometimes used in close relation to the bioeconomy. According to the UN Environmental Programme, "a green economy is one that results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities." The bioeconomy and green economy share a number of characteristics, such as resource efficiency and low carbon dioxide release, but they are not fully congruent. The green economy may make use of bio-based products, but it is not limited to these. Renewable energies, such as wind and solar energy, can also be important contributors to the green economy while not being bio-based.



Photo: GIZ/W. Jantapan

Palm oil, being a sought-after raw material for the biofuel industry, is also an interesting source of income for farmers in the South. But the associated large-scale conversion of land that has also caused wide areas of rain forests to be clearcut has brought on much criticism.

ing biodiversity and soil fertility, and securing and creating employment. Conflicts may appear due to competing claims to land-use for the production of food, feed and renewable raw materials for energy and industry. It is stressed that the import of biomass to Germany should not create negative social, economic and environmental consequences in producer countries. A number of measures supported at international level aim at the intensification of agricultural production, the reduction of food waste, use of co- and waste products and changing consumption patterns.

Russia

The State Coordination Programme "Bio 2020" was drawn up under the auspices of the Ministry of Economic Development of the Russian Federation with the participation of a wide range of other ministries, agencies and academies. The bioeconomy embraces all economic sectors that use renewable resources, including the medical sector, agriculture and food processing, forestry and fisheries as well as environmental protection. Consistent with other strategies, life sciences are considered as the basis for designing new materials, increasing agricultural productivity and protecting the environment.

As in the EU strategy, the technologies of special interest are nanotechnology and information technologies. A number of academies will be involved in the relevant research efforts in various fields, and three technological platforms have been formed: "Medicine for the Future", "Bioindustry and Bioresources – BioTech 2030" and "Bioenergy". These platforms aim at harmonising the interests of various stakeholders.

The Russian strategy mentions that the Russian Federation has an almost unlimited availability of renewable raw material resources. This is probably the reason why food security is of no concern. The only aspect connected with food security is food safety. The strategy considers the application of biotechnology in the agricultural and food sector as an approach to enhancing food safety.

Argentina

Argentina has not developed a separate bioeconomy strategy, although some sectors applying biotechnology fall under the national plan "Argentina Innovadora 2020". The Argentinian Ministry of Science, Technology and Innovation defines the bioeconomy as an economy that uses biomass in an integrated and sustainable way for the

processing of food, biofuels, thermal energy, chemicals and other materials. Having such a strong agricultural sector, Argentina places the emphasis on biotechnology in farming and food processing, although red biotechnology (vaccines and biosimilars) also plays an important role.

The goal is to achieve genetic improvement of food plants as well as technological advances in food processing with a view to increasing the quantity and nutritional quality of food products. Argentina seeks to increase its food exports and, in addition, develop various bio-based industrial products. The focus here is on bioenergy, biopolymers and chemical components. Argentina is already one of the largest producers of genetically modified soy, maize and cotton. It is active in research on genetically modified potatoes and other food crops. Some public concern about the large-scale use of herbicides in connection with genetically modified foods has arisen there in recent years.

India

The Ministry of Science and Technology of India drafted a National Biotechnology Development Strategy in 2007, which was updated in 2014. It uses the term "bioeconomy", which it understands as "translating life sciences knowledge into socially relevant eco-friendly and competitive products". It applies biotechnology in agriculture, health, energy, the environment and bio-manufacturing. The red biotechnology sector dominates the Indian biotechnology market and specialises in the production of vaccines and diagnostics.

Interestingly, the 2014 strategy paper contains a full chapter on Food and Nutritional Security, which largely deals with (bio)fortification of food crops to address micronutrient deficiencies, such as iron deficiency. The idea is to

develop special food products that can address moderate and acute child malnutrition. It is hoped that new processing techniques, including nanotechnology applications, will extend the shelf life of foods.

India is cultivating genetically modified cotton varieties on eleven million hectares of land. It is continuing its testing of rice, mustard, rubber, sorghum and peanuts, although no genetically modified food products are currently authorised for commercial cultivation. The country is planning further research into transgenic crops capable of resisting biotic and abiotic stresses. India aims to use 20 per cent biodiesel in its fuel mix by 2025, but seeks to avoid a conflict between food and fuel production. Research into jatropha cultivation on degraded soils is still ongoing, although this work is not included in the current Biotechnology Strategy. Rather, the strategy highlights lignocellulosic ethanol produced from agricultural and forestry waste, as well as biofuels from algae.

Malaysia

In Malaysia, a National Biotechnology Policy was drafted in 2005. It is a long-term policy through to 2020 and split into individual phases. The aim is to

transform Malaysia into a high-income, inclusive and sustainable economy. It led to the creation of a Bioeconomy Transformation Programme in 2012. It is a platform provided by the government for the private sector to maximise commercial opportunities based on biotechnology. The policy has also established BiotechCorp (Malaysian Biotechnology Corporation), a one-stop centre for biotechnology, as well as three national research institutes.

The agricultural sector contributes significantly to the national economy in Malaysia. Bio-based farm inputs, feedstock additives, high-value food varieties and the development of novel livestock and aquaculture play a strong role. Nevertheless, to date, no genetically modified crops are authorised for commercial purposes. Malaysia is the second largest producer of palm oil. While demand for palm oil is rising, Malaysia is trying to halt further land conversion for palm oil production. So research has concentrated more on increasing yields. In 2013, a research team deciphered the full genome of the oil palm *Elaeis guineensis*, which helps select the most productive variety at an early growing stage. Furthermore, residues from palm oil production are transformed into cellulosic ethanol.

■ What role for food security in bioeconomy strategies?

Bioeconomy strategies approach food security in different ways. In most cases, biotechnology is regarded as a promising way to increase yields, improve food safety and the nutritional quality of foods. These aspects are frequently considered sufficient to make a contribution to food security, with little attention given to changes in consumption patterns and efficiency in the use of resources. Yet, in a few strategies, the increased demand for non-food biomass is explicitly named as a potential threat to food security. In India, for example, policy on support for biofuels is conscious of potential land-use conflicts.

The increased use of land and other natural resources as well as the widespread modification of plants for human benefit mean a significant intervention in living organisms with likely impacts on (natural) biodiversity and the functioning of ecosystems. However, most strategies highlight potential benefits to humans and the environment to the greatest possible extent, while making only brief mention of safety risks linked to the modification of biological organisms.

Bioeconomy-related actions and strategies (selection)

Argentina	National Plan "Argentina Innovadora 2020" (2012)
Austria	Bioeconomy Background Paper (2013)
Australia	Bioenergy – Strategic Plan 2012–2015
Brazil	Biotechnology Development Policy (2007)
Canada	Blueprint beyond Moose and Mountains (2011)
Denmark	Agreement on Green Growth (2009)
EU Commission	A Bioeconomy for Europe (2012)
Finland	Finnish Bioeconomy Strategy – Sustainable Growth from Bioeconomy (2014)
Germany	National Policy Strategy on Bioeconomy (2013) National Research Strategy BioEconomy 2030 (2010)
Great Britain	UK Bioenergy Strategy (2011)
India	National Biotechnology Development Strategy (2007/2014)
Ireland	Delivering our Green Potential (2012)
Japan	Biomass Industrialization Strategy (2013) Biomass Utilization Plan (2009)
Malaysia	National Biotechnology Policy (2005) Bioeconomy Initiative and National Biomass Strategy 2020 (2011)
Netherlands	Bio-based Economy 2010–2015
Russia	Bioindustry and Bioresources – BioTech 2030 (2012)
South Africa	South Africa – the Bioeconomy Strategy (2013)
Sweden	Research and Innovation Strategy for Bio-based Economy (2011)
USA	National Bioeconomy Blueprint (2012)