Position paper of BIO Deutschland

Realising an industrial bioeconomy

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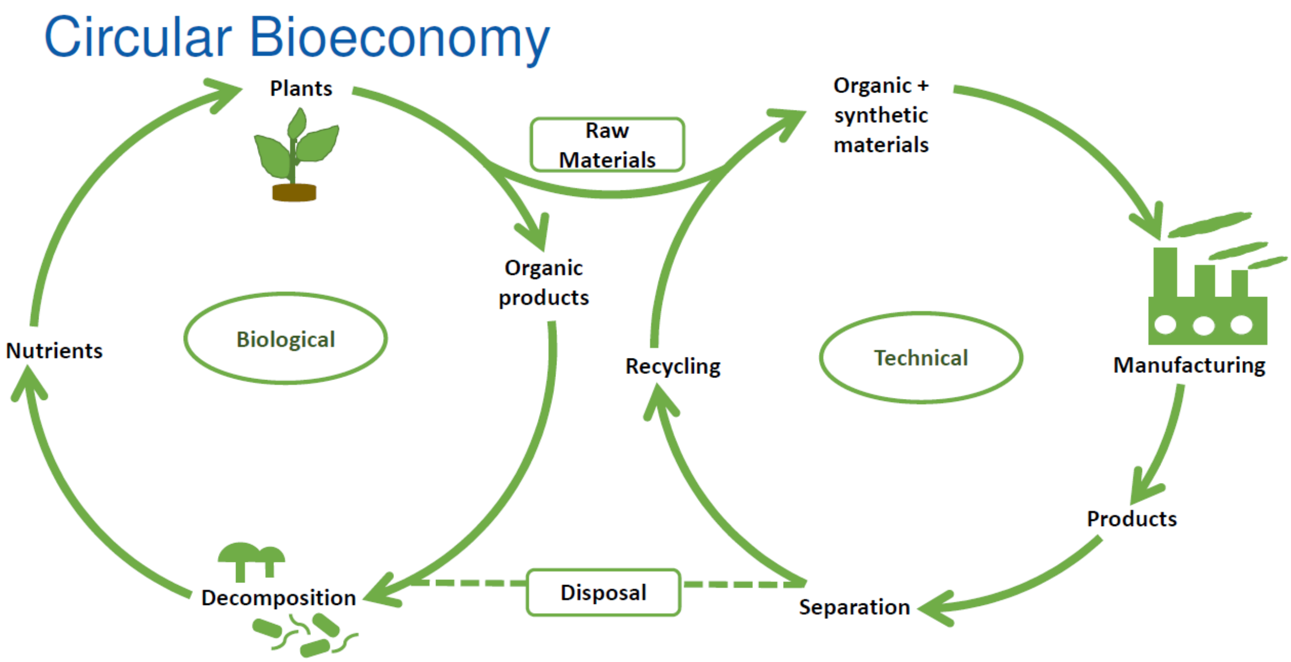
1. Introduction

Climate change, among other challenges, is forcing a rethink. We must do everything we can to sustain our livelihoods while keeping our economy strong. The bioeconomy is key to both these aims. While concepts such as circular economy and cascade utilisation focus on preserving the value of products, materials and resources in the economy for as long as possible and improving the environmental efficiency of processes, the bioeconomy encompasses the sustainable production of renewable biological resources and the conversion of these resources and waste streams into value-added products, such as food, feed, bio-based products and bioenergy.

Through the use of innovative technologies, it is possible to produce bio-based products in all sectors of the economy. A knowledge-based bioeconomy – especially one that supports the circular economy – can only be achieved with biotechnology.

As the diagram below illustrates, such a bioeconomy involves the technological usage of renewable biological resources – whether it's microorganisms, enzymes, cell cultures or whole organisms – in circular systems.



BIO Deutschland is committed to efficiently implementing the bioeconomy in Germany and champions the interests of all companies active in the industrial biotechnology sector, in particular those of innovative small and medium-sized enterprises (SMEs). Industrial biotechnology is one of the central pillars in the transformation process towards a bio-based and sustainable economy, i.e. a bioeconomy.

2. Bioeconomy and climate protection

It appears that the COVID-19 crisis, in particular, is making more and more people aware of sustainability and climate protection. This is demonstrated by a survey conducted by the public opinion research organisation Civey, on the occasion of Science Year 2020 – Bioeconomy. According to the survey, 27% of all Germans believe the pandemic provides an opportunity for a rethink towards a more sustainable and climate friendly economy.

Investments in the industrial biotechnology are part of a strategic approach to climate protection. The transformation to a carbon-neutral Germany would not be possible without industrial biotechnology, which plays a central role in integrating innovations into markets while at the same time helping to reduce the burden on the environment. As a key technology, industrial biotechnology supports developments that lead to greater raw material, resource, material and energy efficiency, thus strengthening the circular economy. Industrial biotechnology also contributes to sustainable mobility.

In this way, industrial biotechnology opens up pathways to a climate and environmentally friendly industrial sector, as agreed at the national and international level.

- At the 21st Conference of the Parties to the UNFCCC (COP21) in Paris in November 2015, the Parties to the Convention made a binding commitment under international law to an ambitious package of climate protection measures and to ending the use of coal, oil and gas by the middle of the 21st century. The goal is to keep the increase in global average temperature to well below 2°C and pursue efforts to limit it to 1.5°C. The Climate Protection Plan 2050 outlines how Germany intends to implement the Paris Agreement. For example, the Climate Protection Plan 2050 reaffirms the overall target of reducing greenhouse gas emissions by at least 55% below 1990 levels by 2030.
- At the European level, the European Green Deal aims make Europe climate neutral by 2050, while also setting out a growth strategy that focuses on climate and environmental protection. This new green strategy for the environment, industry and the economy is intended to create a reliable framework for investment in the long term.

> It also seeks to make EU economy more competitive internationally and more resilient, especially against climate impacts. Innovations in key sectors such as industrial biotechnology are seen as crucial building blocks for success.

Industrial biotechnology and the bioeconomy are key to achieving these sustainability goals. Biotech entrepreneurs and companies are developing innovative technologies, processes and products, such as bioethanol from agricultural residues as well as bio-based chemicals and specialty chemicals that can reduce CO_2 emissions and waste generation. Industrial biotechnology thus also makes an important contribution to the circular economy, which aims to make the best possible use of products along the entire value chain. This includes keeping products in circulation for as long as possible and recycling them at the end of their life cycle.

With the help of industrial biotechnology, up to 2.5 billion metric tonnes of CO_2 can be saved annually worldwide by 2030. This is more than the total German emissions in the base year of 1990 (WWF, 2009).

Yet, due to the currently low oil prices and poor policy environment, innovations from the research and development (R&D) work of German companies have difficulty reaching the market. The fruits of this work are increasingly being harvested in other regions of the world where more favourable framework conditions and regulations exist. As a result, sustainability falls by the wayside and economic growth, jobs and additional tax revenues are generated outside Germany.

Clear direction setting policy decisions and a clear commitment to a knowledge-based bioeconomy are essential for the rapid and efficient implementation of the sustainability goals. By bundling the strategic activities for the transformation to a bio-based economy in a National Bioeconomy Strategy that is aligned with the United Nations Sustainable Development Goals (SDGs), Germany has taken an important and right step towards promoting the bioeconomy and sustainability.

3. Bioeconomy – the biological transformation of industry

The transformation to a sustainable economy – a bioeconomy – requires fundamentally new approaches and the innovative power of entrepreneurship. Also called “white” biotechnology, industrial biotechnology uses tailor-made microorganisms that detect toxins, fix CO_2 and produce biofuels, biomaterials, vitamins and food supplements. With the help of industrial biotechnology, it is possible for the first time to decouple the required economic output from resource consumption and environmental pollution. This is achieved through massive increases in efficiency, the substitution of fossil resources and energy, and the development of interlinked cascade systems, e.g. in biorefineries. In recent years, it has also become apparent that digitalisation is creating further opportunities for making biological systems and processes usable for humans. Biological systems are therefore becoming a model for sustainable innovations.

According to IPCC estimates, about 1 billion tonnes of organic waste are generated worldwide every year (IPCC, 2002). In the EU27, the figure is 233 million metric tonnes, including 12 million metric tonnes of organic and green waste in Germany. Sewage sludge alone accounts for 65 million tonnes in the EU27 and 2 million tonnes in Germany (Eurostat, 2010; Federal Statistical Office, 2012). Industrial biotechnology enables these wastes to be used not only as energy, but also as valuable raw materials for industrial processes and products.

In addition to the chemical industry, there are numerous other user industries that use white biotechnology products and processes. Impetus is being provided by the food, animal feed, textile, paper, pulp, pharmaceutical, agricultural, cosmetics, environmental and energy industries. The chemical industry already uses 16% renewable raw materials, and this percentage is increasing steadily thanks to industrial biotechnology processes. Similar to today’s petroleum refineries, biorefineries will in the future produce the required range of products from biomass. This will make biorefineries not only the key to converting the economy to renewable and recycled raw materials, but also an essential component of the energy transition.

Compared to the petroleum-based economy, the bioeconomy is often more decentralised and is already a significant economic factor in the EU. In 2017, the EU27 bioeconomy generated €614 billion in value added with an estimated turnover of €2.2 trillion while employing around 17.5 million people.

This represents about 9% of the EU27 labour force and 4.7% of the EU's Gross Domestic Product.[1] The bioeconomy's importance will increase in the coming years, as the transformation from a petroleum-based market economy to a knowledge-based market economy founded on the use of renewable and regenerative raw materials offers great potential for innovative technologies and more sustainable products while promising to create an economic system that is fit for the future.

4. Application areas of industrial biotechnology and how they relate to the UN SDGs

The United Nations Sustainable Development Goals (SDGs) provide an important framework for action on sustainable economic and social development. Many of these SDGs are linked to the production, use and distribution of biomass.

Due to its cross-cutting nature, industrial biotechnology is relevant for the achievement of many SDGs. On one hand, it gives rise to the creation of new sectors, for example in the fields of bioplastics and waste management. On the other hand, the technological possibilities offered by the bioeconomy will inject new dynamism into existing sectors in agribusiness, the food industry, and mechanical and automotive engineering. In the future, the biologisation of the economy will both create new industries and give new impetus to existing industries.

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[1] Ronzon, T., Piotrowski, S., Tamosiunas, S., Lara, D., Carus, M. and M`barek, R., Developments of economic growth and employment in bioeconomy sectors across the EU, SUSTAINABILITY, ISSN 2071-1050 (online), 12 (11), 2020, p. 4507, JRC120390

In the following, we will present some possible applications of industrial biotechnology in the context of how they relate to the United Nations Sustainability Development Goals.

4.1. Biorefineries

Industrial biotechnology enables the tapping of plant-based raw materials such as starch, sugar and vegetable oil. Above all, however, new methods and processes enable the efficient use of residual materials such as straw, leaves and wood, as well as biowaste from agricultural production and households.

The use of living, reproducing cells in bioreactors also makes it possible to tap new sources of raw materials. Similar to today's petroleum refineries, biorefineries can produce chemicals, materials and fuels from biogenic residues via cascade systems.

Biorefineries that convert plant-based raw materials into intermediates and end products can contribute achieving the following SDGs:

Good Health and Well-Being (SDG 3), *Clean Water and Sanitation* (SDG 6), *Affordable and Clean Energy* (SDG 7), *Decent Work and Economic Growth* (SDG 8), *Industry, Innovation, and Infrastructure* (SDG 9), *Sustainable Cities and Communities* (SDG 11), *Responsible Consumption and Production* (SDG 12), *Climate Action* (SDG 13).

4.2. Bioplastics

Only with the help of industrial biotechnology can bioplastics develop into a real competitor to bulk plastics made from petroleum, such as polyethylene, polypropylene or polyvinyl chloride. The consumer-oriented market for bioplastics made from starch, cellulose or lactic acid is already growing steadily, and new sources of raw materials are being tapped. The main advantage of bio-based plastics lies in the avoidance of fossil resources, such as petroleum and natural gas, and in the minimisation of CO_2 emissions during the production process. In addition, biotechnological processes take place under comparatively mild reaction conditions and low temperatures. Progress is also being made in developing biodegradable plastics.

Bioplastics are not a substitute for conventional plastics, but are a complement to this existing range of plastics, providing specialty products that offer new properties and application possibilities. For example, they are an optimal solution for organic waste bags, compostable fruit and vegetable bags, or agricultural films that can be ploughed under after the harvest. Used correctly, bioplastics can help to reduce food waste, return nutrients to the soil through increased compost volumes, and avoid the accumulation of plastic in the soil.

The use of bioplastics can contribute to achieving the following SDGs:

Clean Water and Sanitation (SDG 6), *Affordable and Clean Energy* (SDG 7), *Decent Work and Economic Growth* (SDG 8), *Industry, Innovation, and Infrastructure* (SDG 9), *Sustainable Cities and Communities* (SDG 11), *Responsible Consumption and Production* (SDG 12), *Climate Action* (SDG 13), *Life on Land* (SDG 15).

4.3. CO_2 becomes a raw material

Biotechnological processes have the potential to supplement or even replace conventional chemical production processes. Fermentation processes, for example, make it possible to convert carbon dioxide from flue gas plants into alcohol and other chemicals. Through highly selective material conversion, biotechnology enables the production of chemicals with fewer production steps, lower raw material consumption and greater energy efficiency. Greenhouse gas emissions are reduced or avoided, and ideally greenhouse gases themselves become raw materials.

Biotechnological processes for recycling CO2 can thus contribute to achieving the following SDGs:

Good Health and Well-Being (SDG 3), *Affordable and Clean Energy* (SDG 7), *Decent Work and Economic Growth* (SDG 8), *Industry, Innovation, and Infrastructure* (SDG 9), *Climate Action* (SDG 13), *Life on Land* (DSG 15).

4.4. Food and agriculture

In the food industry, many of the enzymes used are produced with the aid of genetically modified microorganisms. Such enzymes are used in food production, for example to modify starch, to optimise fats and proteins, or to stabilise foams and act as a "glue" to stick meat parts together to produce cooked ham. The growing importance of plant-based protein sources or meat made from cell cultures for food production will permanently change the way we eat in the future. In this area, too, white biotechnology plays a key role alongside food technology.

Other innovative approaches can also be found within fungal biotechnology. Through the targeted cultivation of fungal mycelium – the "roots" of mushrooms – it is possible to produce vegan foods using agriculture industry residues in short periods of time and with low water consumption.

In animal nutrition, the biotechnologically optimised enzyme phytase can reduce the ecological impact of increased animal production. Unlike ruminants, pigs and poultry are unable to tap the vital nutrient phosphorus contained in plant-based foods. By adding phytase to the feed, the supplementary feeding of phosphate can be eliminated. At the same time, phosphate pollution of the environment decreases by an average of 30% when manure is used as fertiliser. The use of probiotic microbial strains enables healthier animal husbandry without antibiotics.

The use of such strains enables plants to better access nutrients such as phosphate, to ward off pests or to promote plant growth through targeted stimulation. Suitable microbial strains are already being sown with plants, e.g. as seed coating, and enable significant increases in yield while simultaneously reducing CO_2 emissions.

Looking to the future, the use of new precise molecular biological methods in crops will help to enable a more sustainable production of food, feed and biologically produced raw materials in the plant-based bioeconomy. In addition to agronomic traits, the focus is particularly on improved food and feed quality.

The use of biotechnological processes in food and agriculture can contribute to achieving the following SDGs:

Zero Hunger (SDG 2), *Good Health and Well-Being* (SDG 3), *Clean Water and Sanitation* (SDG 6), *Affordable and Clean Energy* (SDG 7), *Decent Work and Economic Growth* (SDG 8), *Industry, Innovation, and Infrastructure* (SDG 9), *Sustainable Cities and Communities* (SDG 11), *Responsible Consumption and Production* (SDG 12), *Climate Action* (SDG 13), *Life on Land* (SDG 14).

4.5. Innovative materials and lightweight construction

The combination of natural fibres and (bio)plastics makes it possible to produce new materials that reduce the consumption of finite resources and at the same time achieve improved properties such as lightness and stability. One of the key factors behind this dynamic development is the mass production of bio-based carbon fibres. These comparatively lightweight materials can be used to reduce the energy consumption of vehicles and aircraft.

The use of innovative materials can contribute to achieving the following SDGs:

Affordable and Clean Energy (SDG 7), *Decent Work and Economic Growth* (SDG 8), *Industry, Innovation, and Infrastructure* (SDG 9), *Sustainable Cities and Communities* (SDG 11), *Responsible Consumption and Production* (SDG 12), *Climate Action* (SDG 13).

4.6. Mobility

A key factor in decarbonising the transport sector is reducing the dependence on oil. In addition to alternative drive technologies, fuels made from biogenic residues are a promising way to achieve this aim. Today, it is already possible to produce 1 tonne of cellulosic ethanol from 4.5 tonnes of straw. In Germany alone, the German Biomass Research Center estimates that between 8 and 13 million tonnes of straw could be tapped for sustainable fuel production.

When biomass energy sources are burned, as much CO_2 is released as was previously fixed from the air during the growth phase. Since only emissions that were and are promptly bound by biomass are produced, biomass offers a considerable advantage over fossil fuels in that only minor additional emissions are caused. In 2016, the use of biofuels in the transport sector reduced CO_2-equivalent emissions by about 6 million tonnes.[2] It also helps to avoid risks associated with fossil oil and gas production, as sustainably produced and used biomass will not result in environmentally damaging consequences.

Advanced biofuels can contribute to achieving the following SDGs:

Affordable and Clean Energy (SDG 7), *Decent Work and Economic Growth* (SDG 8), *Industry, Innovation, and Infrastructure* (SDG 9), *Sustainable Cities and Communities* (SDG 11), *Responsible Consumption and Production* (SDG 12), *Climate Action* (SDG 13).

4.7. Paper and pulp

Enzymes such as amylases, cellulases, proteases, lipases and xylanases are also used in paper and pulp production. These make processes more efficient and help save raw materials, energy and time. For example, paper can be recycled and reused by using amylases to remove printer ink, thus reducing the production of new paper. This, in turn, reduces the amount of CO_2 emitted per ton of paper produced. In addition, enzymes that enable environmentally friendly and chlorine-free bleaching are considered one of the fastest growing markets for industrial enzymes.

The use of biotechnologically produced enzymes in paper and pulp manufacturing can contribute to achieving the following SDGs:

Clean Water and Sanitation (SDG 6), *Decent Work and Economic Growth* (SDG 8), *Industry, Innovation, and Infrastructure* (SDG 9), *Sustainable Cities and Communities* (SDG 11), *Responsible Consumption and Production* (SDG 12), *Climate Action* (SDG 13), *Life on Land* (SDG 15).

4.8. Textiles

In the textile industry, large quantities of water, energy and chemicals are used to manufacture finished textile products from materials such as cotton. Raw materials like these must be bleached, washed and dried before they can be processed further. This involves the use of chemicals at high temperatures. Enzymes perform this work in a more environmentally friendly way and at low temperatures. When textiles become soiled, enzymes such as proteases and lipases are used to clean them. These enzymes are found in detergents and help to remove protein residues and grease stains – also at low temperatures.

The production of protein-based materials, such as spider silk, can be achieved through biotechnological processes using renewable raw materials. The underlying silk proteins – produced by fermentation and purification processes, spun into protein fibres using spinning processes, and converted into textile fabrics by modern looms – are bio-based and biodegradable materials with mechanical, high performance properties.

In the production and care of textiles, biotechnological processes can contribute to achieving the following SDGs

Clean Water and Sanitation (SDG 6), *Decent Work and Economic Growth* (SDG 8), *Industry, Innovation, and Infrastructure* (SDG 9), *Sustainable Cities and Communities* (SDG 11), *Responsible Consumption and Production* (SDG 12), *Climate Action* (SDG 13).

4.9. Health

In keeping with a One Health approach, the presentation of industrial ("white") biotechnology applications must also include ("red") medical-pharmaceutical biotechnology. Vitamins and antibiotics are among the most important biotechnologically produced products. Ascorbic acid (vitamin C), riboflavin (vitamin B2) and cobalamin (vitamin B12) are now manufactured almost exclusively using industrial biotechnology. The synthesis of riboflavin via a multi-step chemical process has been completely replaced by biotechnological methods.

These methods reduce the environmental impact by 40%. They also lower CO_2 emissions by 30% and raw material consumption by 60%. Waste is avoided, so there is even no need for cost-intensive purification of

[2] BMWI, Renewable Energy Sources in Figures, 2016

the end product. The new technology is also increasingly being used in the production of other important medicines.

The use of industrial biotechnology in the healthcare industry contributes to achieving the following SDGs:

Good Health and Well-Being (SDG 3), *Decent Work and Economic Growth* (SDG 8), *Industry, Innovation, and Infrastructure* (SDG 9), *Sustainable Cities and Communities* (SDG 11), *Responsible Consumption and Production* (SDG 12), *Climate Action* (SDG 13), *Life on Land* (SDG 14).

This position paper was prepared by BIO Deutschland's Working Group on the Industrial Bioeconomy.

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Prof. Dr Christine Lang and **Dr Jörg Riesmeier** chair the Working Group on the Industrial Bioeconomy, which is comprised of representatives from Bayer Pharma AG, Berlin Partner for Business and Technology GmbH, BIOCOM AG, Blucon Biotech GmbH, BRAIN AG, Clariant Produkte (Deutschland) GmbH, Enzymicals AG, EurA Consult's network "biomastec", Fraunhofer Research and Development Center for Marine and Cellular Biotechnology, and Novozymes Berlin GmbH.

As the sector association of the biotechnology industry, BIO Deutschland has set itself the objective of supporting and promoting the development of an innovative economic sector based on modern biosciences. The association currently has over 340 members. Oliver Schacht, Ph.D., is Chairman of the Board of BIO Deutschland.

BIO Deutschland's supporting members and partners are AGC Biologics, Avia, Baker Tilly, Bayer, BioSpring, Boehringer Ingelheim, Centogene, Clariant, CMS Hasche Sigle, Deutsche Bank, EBD Group, Ernst & Young, Evotec, Exyte Central Europe, Isenbruck, Bösl, Hörschler, Janssen-Cilag, KPMG, Merck, Miltenyi Biotec, MorphoSys, Novartis, Pfizer, Phenex Pharmaceuticals, PricewaterhouseCoopers, QIAGEN, Roche Diagnostics, Sanofi Aventis Deutschland, SAP, Thermo Fisher Scientific, TVM Capital and Vertex Pharmaceuticals.

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