Destination Bioeconomy
Research for a Biobased and Sustainable Economic Growth
Destination Bioeconomy

Research for a Biobased and Sustainable Economic Growth
Contents

Summary 2

   - High dependency on non-renewable resources 4
   - Climate change with a worldwide impact 4
   - Growing world population and ageing societies 4
   - Economic growth and sustainability 4

2. New Opportunities: Ecology and Economy under One Roof 5

3. Status Quo: Bioeconomy in Germany 6
   - First half of the National Research Strategy BioEconomy 6
   - National Policy Strategy on Bioeconomy 7
   - Institutionally embedded on federal and state (Länder) level 7

   - Systemic approach 9
   - Participative discourse 10
   - Intelligent innovation processes 10
   - Skilled personnel for the bioeconomy 10
   - Future prospects 11
Summary

The economic upturn of the past 200 years would not have been conceivable without fossil non-renewable resources such as coal and oil. They were the basis for continuous technological progress and have contributed towards Germany developing into one of the strongest economies of the world. However, the fossil-based economy increasingly reaches its limits.

The extraction of non-renewable resources comes with extensive ecological damage, and what is more, climate change calls for the reduction of carbon dioxide and other greenhouse gas emissions. At the same time – in connection with a growing world population – there is not only rising demand for food but also a growing demand for energy, infrastructure and healthcare services, amongst others. The world economy is growing; the question is: how does it grow sustainably?

Bioeconomy can make a significant contribution towards solving this question. It combines economy and ecology in an intelligent fashion and thus makes a biobased and sustainable economic growth possible. Bioeconomy stands for the knowledge-based creation and use of renewable resources to provide products, processes and services in all economic sectors within the framework of a future-oriented economic system (see the National Policy Strategy on Bioeconomy following the Bioeconomy Council).

Due to a wide availability of renewable resources, the implementation is not limited to industrial nations. In principle, it offers participation to all nations – beyond today’s borders of prosperity and system boundaries. Therefore bioeconomy is a concept which not only encompasses research and industrial policy but also energy, agricultural, forestry and fishery policies, climate and environmental policy as well as development policy.

Germany holds an internationally leading position in the establishment of a bioeconomy. At the end of 2010 – as one of the first nations – Germany published the interdepartmental “National Research Strategy BioEconomy 2030”, which is to span six years, and thus has set the course for a biobased change in industry and society. Under the auspices of the Federal Ministry of Education and Research (BMBF) this strategy was jointly drawn up with six further ministries and makes available a total of 2.4 billion euros of funds for research and development until the year 2016. In the summer of 2013, the Federal Cabinet passed the National Policy Strategy on Bioeconomy. Therein, the Federal Government describes goals, strategic approaches and measures to use the potential to generate added value and employment as part of a sustainable management and to support the structural change towards a biobased economy.

Industry has already recognised the significance of a bioeconomy from an early stage onwards. But the process is to gather even more speed. It is important to implement the bioeconomy in more and more products, processes and services. During the second half of the implementation of the National Research Strategy BioEconomy 2030, a basis will be created for the bioeconomy to overcome the status of pilot and demonstration projects in the long term, to find comprehensive industrial support and to thus make a significant contribution towards ensuring future growth and prosperity.

However, a sustainable economy can only be achieved as part of a transformation process of society as a whole, which involves society and takes into consideration all aspects of the structural change in industry. Therefore, the BMBF will increasingly follow the guidelines below in the second half of the National Research Strategy:

• We want to build up competences in Germany for a systemic observation of bioeconomy, which joins natural and technological sciences with findings from social and economic sciences. The results are to be used in the development of a coherent bioeconomy policy.

• We want to establish an open communication culture of responsibility and lead a participative discourse with research, industry, society and politics to jointly discuss bioeconomy as part of a transformation process of society as a whole and to develop the best biobased solutions.
• We want to incorporate bioeconomy more strongly into industry. For this purpose, central innovation hurdles need to be identified and building on that **intelligent innovation processes** must be established which provide sufficient freedom to develop biobased products, processes and services.

• We want to give impulses to meet the **future demand of a biobased economy for skilled workers**. It is to be assessed which requirements need to be defined in regard to qualification measures for young scientists and technicians in the bioeconomy – in the field of higher education as well as dual vocational education and training.

In Germany and all other industrial countries coal, oil and natural gas have made a historically unparalleled economic upturn possible over the past two hundred years. Without fossil non-renewable resources the industrial revolution would not have been as successful. Never have as many people profited from modern, industrial progress. All the same, the current fossil-based economic systems are reaching their limits.

High dependency on non-renewable resources

For the 21st century world a dependency on coal, oil and natural gas is posing a growing problem. Easily accessible places of extraction are becoming rare; especially the extraction of oil is increasingly linked with high use of energy and ever larger negative environmental effects. This leads to higher costs and increasing dependencies between resource-poor and resource-rich countries. Access to oil and natural gas is of crucial importance above all to industrial and newly industrialised countries but more and more also to developing countries. Newly emerging economies such as China and India, who together have to meet the needs of three billion people, provide for additional demand. The dependency on imports alone is enough motivation to look for alternatives.

Climate change with a worldwide impact

It is undisputed amongst experts that the current economic habits and our patterns of consumption are responsible for a large part of the greenhouse gas emissions and the current global climate issues. According to the assessment of the Intergovernmental Panel on Climate Change (IPCC), chances of getting to grips with global warming still existed if significant efforts and deciding changes were made within the next years. The need for action is also palpable in the heart of Europe. It is no longer just faraway islands and oceans which are affected. On average, it has become 1.2 degrees warmer in Germany since 1882.

Growing world population and ageing societies

But not just the external conditions are changing; societies themselves are subject to continuous change. The world population, for instance, is steadily increasing. For the year 2050, more than nine billion people are predicted on Earth. How can nine billion people be fed? Added to this is the demographic change: Especially industrial nations are confronted with an ever ageing society. This does not only pose a huge challenge to the social and health services but also to the economy.

Economic growth and sustainability

Since the industrial revolution, natural and technological sciences have made a significant contribution towards economic growth and prosperity. Especially countries lacking raw materials, such as Germany, are dependent on utilising research and technology for new products, services and an innovation-driven economic growth.

What counts now is to use Germany’s innovation power for the necessary change in the economy towards sustainability. The tremendous gains in productivity of the past two centuries as well as a large part of the technological developments so far were based on the easy availability of non-renewable resources. An equally large impact is expected from the advances in the knowledge of life sciences. New insights from the past twenty to thirty years have in part revolutionized the understanding of biological processes. This knowledge holds enormous potential for further sustainable development of the economy. Entirely new paths open up especially with a view to alternatives to non-renewable resources but also in terms of the use of biological processes in the industrial process technology.

The central questions of the 21st century are not whether climate change is coming, how strongly the world population is growing and to which extent the emission of fossil carbon has to be lowered, but how economy and society will be able to best meet these developments and how research and innovation funding contributes towards this. Is it possible to bring ecology and economy together? Are sustainability and economic growth, environmental protection and prosperity contradictions or can they go hand in hand? How can a comprehensive structural change towards a biobased and sustainable economy be implemented together with all social interest groups?
2. New Opportunities: Ecology and Economy under One Roof

Against the background of a finite planet and increasing demands, the efficient use of renewable resources is the order of the day. The use of renewable resources, however, is not a new idea. Whether for food, clothing or health – many renewable resources have been incorporated into products and economic processes. Many industrial processes use smallest biological resources such as microorganisms or enzymes.

Some of these processes are centuries old – such as, for instance, beer and cheese production. Others have only developed during the course of the advances in molecular biology during the 1980s – such as the production of novel cancer medication with bacteria or cells in the pharmaceutical industry. And yet others have been developed in recent times – like the processes for the production of bioplastics. In any case, biobased economic activities are not limited to the industrial sector. The value of renewable resources is recognised in many economic sectors, and the use of biobased products, methods and processes increases.

But it is not enough to change the raw material basis from fossil to renewable and to use biomass for industrial uses. It also does not suffice to integrate biological knowledge via individual innovations into existing process technology. To master the challenges of the 21st century a structural change of the entire society must be achieved which combines economic growth with ecological compatibility and takes social interests into consideration. The economy must pay tribute to the growing demands on the way in which goods are produced. These are based on the protection of the environment, climate, nature and animals as well as the adherence to social standards. They are linked to further challenges, since the availability of renewable resources and the climatic conditions are very different geographically. From this, new production centres, new flows of goods and thus possibly new competitive situations and conflicts result, which need to be considered as part of the international cooperation. The transformation process in economy and society can therefore only be made holistically.

Bioeconomy relies on renewable resources as well as biobased process solutions which resort to the entire bandwidth of biological resources all the way to microorganisms, cells and individual biological components. The guiding principle of the bioeconomy is the development of a circular economy which allows the best possible use in the sense of resource efficiency and sustainability as well as multiple use of raw materials and material flows – even across sectors. What is more, the cultivation, production and use of renewable resources is to be carried out responsibly, fairly and according to internationally agreed sustainability standards whilst thus laying the foundation for future economic growth. It provides the chance to develop innovation-driven, biobased solution approaches for current and future challenges: with a view to world nutrition, resource scarcity and environmental protection as well as to economic growth and prosperity. Due to widely available renewable resources, the implementation of a modern bioeconomy is not just limited to industrial nations. In principal, it offers all nations participation – beyond today’s borders of prosperity and system boundaries in a new division of labour. Areas of agricultural production experience new growth due to the creation of local processing and finishing capacities, industrial areas must find new suppliers for important base materials.

Bioeconomy is a concept which encompasses research, industry and energy policy as well as agricultural, forestry and fishery policies, climate and environmental policy and development policy.
3. Status Quo: Bioeconomy in Germany

Germany holds an internationally leading position in bioeconomy. At the end of 2010, Germany – as one of the first nations – published the inter-departmental “National Research Strategy Bio-Economy 2030”, which is to span six years, and thus has set the course for a biobased change in industry and society.

Under the auspices of the Federal Ministry of Education and Research (BMBF) this strategy was jointly drawn up with six further ministries (by the then Federal Ministries of Food, Agriculture and Consumer Protection, for Economic Affairs and Technology, for the Environment, Nature Conservation and Nuclear Safety, for Economic Cooperation and Development, of Health and of the Interior) and makes available a total of 2.4 billion euros of funds for research and development until the year 2016. This strategy established five central fields of action:

- securing global nutrition,
- ensuring sustainable agricultural production,
- producing healthy and safe foods,
- using renewable resources for industry and
- developing biomass-based energy carriers.

At the same time, important guiding principles were established – for example: Food security always comes before other uses of biomass. Through an intelligent linking of value-added chains, competition between the different biomass utilisation paths is to be diffused, i.e. by combined and cascade utilisation. A resource-, nature-, climate- and animal-friendly as well as ethically acceptable production must be one assessment standard for the bioeconomy.

First half of the National Research Strategy BioEconomy

Under the roof of the research strategy varied funding instruments were used and measures initiated by the participating ministries during the first three years of its run time.

The Federal Ministry of Food and Agriculture (BMEL) has, amongst other things, advanced the industrial application of renewable resources, the use of innovations in the sectors food, agriculture and consumer as well as the promotion of organic farming. The Federal Ministry for Economic Cooperation and Development (BMZ) has made an important contribution towards a German participation in international agricultural research. The funding of research projects on the energetic use of biomass has been handled by the Federal Ministry for Economic Affairs and Energy since the last parliamentary election.

Considerable efforts of the BMBF were aimed at giving new research impulses towards more sustainability in the agricultural sector: Therefore, for example, the protection and preservation of the soil as one of the most important resources in agriculture was moved to the centre of attention of a funding initiative and new, climate-friendly and climate-adjusted research and development approaches for the increase of productivity in plant breeding as well as sustainable strategies in food production were pursued. What is more, the aspect of global responsibility was addressed more strongly and specifically promoted in research cooperations with developing and newly industrialised countries. In the long term, German know-how together with the BMZ’s activities thus contribute towards also building up a sustainable agriculture internationally.

A further important building block within the National Research Strategy is the support of the industry’s research and development efforts, especially in small and medium-sized businesses. With the help of targeted funding measures on a national and European level, promising bioeconomy projects could be launched which mobilised significant private investments. At the same time, new cooperations between academia and industry could be initiated along the entire value-added chain, which contributed towards an increased consideration of renewable resources as well as resource-efficient concepts in industrial production processes.

Encouraged by the strategy process Biotechnology 2020+, entirely new forms of cooperation between life sciences and engineering sciences were established to get visionary ideas for tomorrow’s biobased production off the ground.
First pilot and demonstration plants show that an intelligent combined and cascade utilisation of renewable resources as well as recycling and waste material is not only feasible but also creates the basis for sustainable, eco-efficient and globally competitive products, processes and services. Moreover, with their Bio-Refineries Roadmap, the BMEL and BMBF give an overview of the most important technologies and their paths to the realisation of a material and energetic use of renewable resources and at the same time identify main hurdles and any need for action in regard to research policy.

National Policy Strategy on Bioeconomy

In the summer of 2013, the Federal Cabinet passed the National Policy Strategy on Bioeconomy. Therein, the Federal Government describes goals, strategic approaches and measures to use the potential to generate added value and employment as part of a sustainable management and to support the structural change towards a biobased economy. The inter-ministerially effective strategy drawn up under the auspices of the BMEL has set itself a coherent policy as a target. Recommendations for action were developed for all fields of policy which are relevant for an internationally competitive, sustainable bioeconomy. Not only were the measures for research and innovation policy laid out, but explicitly also those for industry, energy and agricultural policy, for climate and environmental policy as well as for development policy. Respective government activities will be agreed and promoted as part of an inter-ministerial bioeconomy workgroup which was constituted in 2013.

Institutionally embedded on federal and state (Länder) level

In Germany, the bioeconomy has also increasingly embedded itself institutionally. The “Bioeconomy Council”, for instance, counsels the Federal Government on the implementation of the National Research Strategy as well as the Policy Strategy. The body consists of experts from various specialist disciplines in academia and industry, outlines recommendations on the further development of research priorities and supports the civil society dialogue with all groups of society.

Bioeconomy Council

As independent advisory board for the Federal Government, the Bioeconomy Council was first established in 2009 with the Federal Ministry of Education and Research (BMBF) and the Federal Ministry of Food and Agriculture (BMEL). In the second working period of the Bioeconomy Council, which has been active since 2012, the 17 members – with their specialist knowledge – cover the subject of bioeconomy in its entirety, look for new paths for sustainable solutions and put their insights in a global context. The council holds an open dialogue with society. It furthermore makes recommendations on how training and further education as well as research and development can be optimally funded. The council orientates its activities along long-term goals as well as current political requirements.

More information can be found on: www.biooekonomierat.de
The bioeconomy has been gathering speed worldwide. Numerous nations have passed bioeconomy strategies in the meantime. These include the USA, Canada and Russia as well as the United Kingdom, Finland and Sweden but also Brazil, Argentina and South Africa. Similar to Germany, they see the bioeconomy as a promising concept on the renewal of the economy and as an important pillar of innovation policy. Dependent on the technological strength or the availability of renewable resources, different focal points are placed on fields such as innovation, bioenergy or similar. Many of these countries are partners in research cooperations, which may develop into future economic partnerships.

To better link the existent activities in Europe, the EU Commission has published a European Bioeconomy Strategy; and the bioeconomy has been given high priority in the new EU framework programme for research and innovation Horizon 2020.

Current funding measures by the BMBF at a glance

**Primary Production**
- Innovative Plant Breeding within the Cultivation System
- Plant Biotechnology of the Future
- Securing the Global Food Supply – GlobE
- German Plant Phenotyping Network (DPPN)

**Conversion / Processing**
- Industrial Biotechnology Innovation Initiative
- Biotechnology 2020+
- Leading-Edge Cluster BioEconomy
- Founding Push Biotechnology (GO-Bio)
- KMU-innovativ: Biotechnologie – BioChance
- Competition for Ideas: New Products for the Bioeconomy

**Consumers / Society**
- SUSTainable FOOD production and consumption – SUSFOOD

**Environmental Resources**
- Soil as a Sustainable Resource for the Bioeconomy - BonaRes

**Residues and Waste Materials**
- Bioeconomy International
- ERA-Nets

Figure: Different stages of the bioeconomic added value are interlinked within a value creation network: Starting with environmental resources (soil, air, water and biodiversity) to the (primary) production of biomass (agriculture, forestry and wood industry, fishery, aquaculture and microbial cultivation) and to diverse industrial conversion and processing steps all the way to the use for food, animal feed, material industry products as well as bioenergy. The intelligent combined and cascade utilisation of recycling and waste materials or biomass which is not required by the food and feed industry, is crucial for a sustainable and resource-efficient circular economy in the bioeconomy. Current funding measures of the BMBF (see bullet points) are woven into the value creation network and some reach across several stages.

The first three years of the National Research Strategy have shown: The realisation of a biobased and sustainable economy strongly depends on managing to involve all participants: researchers, producers of renewable resources, industrial users and society.

The transformation process has to be aimed at sustainability and must be sped up. More new sustainable and biobased products and production processes must be developed and brought to market. Processes which have been successfully tried out in pilot and demonstration plants must be transferred to a broad industrial use. Within the next three years of the National Research Strategy, the BMBF will increasingly pursue the following guidelines:

- We want to build up competences in Germany for a systemic observation of the bioeconomy, which joins natural and technological sciences with findings from social and economic sciences. The results are to be used in the development of a coherent bioeconomy policy.

- We want to establish an open communication culture of responsibility and lead a participative discourse with research, industry, society and politics to jointly discuss bioeconomy as part of a transformation process of society as a whole and to develop the best biobased solutions.

- We want to incorporate bioeconomy more strongly into industry. For this purpose, central innovation hurdles need to be identified and building on that intelligent innovation processes must be established which provide sufficient freedom to develop biobased products, processes and services.

- We want to give impulses to meet the future demand of a biobased economy for skilled workers. It is to be assessed which requirements need to be defined in regard to qualification measures for young scientists and technicians in the bioeconomy – in the field of higher education as well as dual vocational education and training.

Systemic approach

The development of a biobased and sustainable economy is influenced by many factors. Scientific technical innovations play as much a role as a driving force as does the interplay between economy, environment, technology and society. What is more, there are goals connected to the bioeconomy which may well be in competition with each other. Therefore, systemic research approaches are of central importance for a further development of the bioeconomy hub Germany.

The new funding priority “Bioeconomy as Societal Change” is to be set up for this purpose. It ties in with the questions which are also worked on in the BMBF framework programme “Research for Sustainability” within the funding priority “Social-Ecological Research”, but places a particular focus on innovation processes as well as the practical implementation of a biobased and sustainable economy – as all initiatives of the National Research Strategy BioEconomy 2030 do.

Activities in social, political and economic sciences are as much in the focus as are interdisciplinary cooperations with natural and technological sciences.

The goal should not only be to analyse the technological developments but also to look at the aspects of supply and demand, changing lifestyles and patterns of consumption as well as political and normative questions. Such a consideration of the bioeconomy which takes into account society as a whole can identify different scenarios, develop suitable assessment criteria to set priorities and give decision makers the chance to weigh up risks and opportunities.

The bioeconomy cannot be planned out at the green table, but has to be carefully guided based on real observations and scientific scenarios. To achieve this, four modules are to be established step by step in the new funding priority:

- Accompanying research to technological innovations in bioeconomy

- Development of a societal monitoring on bioeconomy
• Securing young academics through junior research groups

• Funding interdisciplinary research groups on social and economic scientific questions

The foundation of the bioeconomy is the sustainable production of biomass in agriculture, forestry and fisheries. In future, we must succeed in observing agriculture and food production as a whole – that is in an economic as well as societal and ecological context. Healthy and fertile soil is as essential to "Agricultural Systems of the Future" as are sustainable plant production and livestock farming. For sustainable plant production, for example, modern plant cultivation and innovative growth regimes must be aligned. Equally, sustainable livestock farming must take into consideration both market-oriented livestock production and animal welfare alike. Material flows as well as environmental and location factors must be included in the development of future-oriented agricultural systems as much as relevant aspects of food production and consumer behaviour and insights from adjacent scientific and economic sectors.

Participative discourse

But the holistic understanding of bioeconomy encompasses not only systemic research approaches; the interests of all societal protagonists must be taken into consideration. A fact-based discussion between research, industry, politics and other societal groups should be made possible. Public dialogue events with experts on the bioeconomy could be a suitable communication forum to give interested laymen the opportunity to obtain knowledge of current scientific insights from the bioeconomy sector and to introduce their own ideas, wishes and requirements. Such and other involvement formats within the participative discourse should be increasingly promoted in future.

Intelligent innovation processes

Holistic approaches within the bioeconomy can only be developed if all relevant players in the innovation chain find together on platforms and in networks and if competences and knowledge are shared as well as used in a national and international context. These players include small and medium-sized businesses as well as large scale industry, universities and non-university research facilities, but also users and consumers, investors and patent exploitation companies, certification authorities and interest groups. New and innovative products and system solutions with a high potential to increase added value can only get to market quickly and efficiently if critical points in the innovation process have been identified early on and are tackled in a targeted fashion. For this purpose, a new type of funding instrument is to be designed and tested.

These "Innovation Alliances" are to be fashioned upon the principle of self-organising networks. A thematic focus is to manifest itself through the formation of an association of appropriate players as well as in the planning of relevant research and development projects. The most important goal of these novel associations will be to intelligently dovetail fundamental and application-oriented research activities, to align these in good time towards the requirements necessary for an industrial production and to introduce bioeconomic innovations into as many economic sectors as possible. In such a broad innovation association academic partners are given a protected space for an exchange with the industry. It in turn receives early insights into scientific and technological possibilities and ideas. Participating consumer groups, certification authorities and investors can voice their requirements and include them in the innovation process at an early stage. On this basis, commercially interesting and relevant innovations can effectively find their way into society through the interplay of the participants.

Skilled personnel for the bioeconomy

Excellent skilled personnel are the prerequisite for innovative research, growth and secure employment in a biobased and sustainable economy. Personnel in production and processing plants which are to process different biological basic materials into a multitude of new products are faced with new types of challenges. Optimised material flows are to be taken into account under sustainability aspects and economic considerations. This knowledge must be integrated into vocational training and extended vocational training.
But young academics and scientists must also increasingly be involved in bioeconomic research projects and led towards an application-oriented, entrepreneurial thinking. In the coming three years of the National Research Strategy, the BMBF will therefore pay particular attention to young postdocs and doctoral students. On top of this, every two years there will be the award ceremony for the research prize “Next Generation Biotechnological Processes”. With this prize, researchers are to be specifically supported in the utilisation of their scientific breakthroughs for the development of novel biotechnological production processes.

Further measures for academic education and further training in research facilities and at universities will be integrated into the diverse research activities in bioeconomy. For this purpose, the funding instruments offer opportunities in form of personnel exchanges between academia and industry or in the form of “industry doctoral students”. At the same time, it is planned to increasingly involve extracurricular learning centres in bioeconomy projects as well as to highlight the variety of technical professions in the bioeconomy.

**Future prospects**

The runtime of the National Research Strategy Bio-Economy 2030 extends to the year 2016/2017. As before, the strategy provides the political framework for further development of the research and innovation centre Germany and sets the cornerstones for further expansion of a biobased and sustainable economy. Whether the strategic goals and focal points of the research strategy have actually contributed towards the desired change in the economic system will be analysed at the end of the runtime through an external evaluation. The insights gained through this, the experiences from the research funding and the suggestions from the participative discourse on bioeconomy will supply the basis for a future funding programme for the protection of a sustainable and biobased growth in Germany.
This publication is distributed free of charge by the German Federal Ministry of Education and Research as part of its public relations work. It is not intended for commercial sale. It may not be used by political parties, candidates or electoral assistants during an election campaign. This applies to parliamentary, state assembly and local government elections as well as to elections to the European Parliament.

In particular the distribution of this publication at election events and at the information stands of political parties, as well as the insertion, printing or affixing of party political information, are regarded as improper use. The distribution of this publication to third parties as a form of campaign publicity is also prohibited.

Regardless of how recipients came into possession of this publication and how many copies of it they may have, it may not be used in a manner that may be considered as showing the partisanship of the Federal Government in favour of individual political groups, even if not within the context of an upcoming election.