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Focus Topic

The long path from paper to practice

On the status and perspectives of the bioeconomy in Germany

The term “energy transition” has been widely discussed in Germany for years, but very few Germans know anything about the term “bioeconomy”. However, both terms together denote an inextricably linked precondition for the path to a sustainable future. Reason enough to ask what the current state of the bioeconomy in Germany actually is, even if the volatility of its current status must be taken into account. After all, the bioeconomy is developing dynamically – recently spurred on by the Structural Development Act for former lignite mining regions and the climate protection programme, through which the federal government could provide considerable support to the bioeconomy.

This dynamic pace is necessary. If humanity is to survive climate change and achieve the climate protection targets agreed by the international community in Paris in 2015, it will no longer be allowed to use two-thirds of the fossil resources still contained on our planet. As quickly as possible – in the course of decades-long transformation – the international community will be tasked with converting the global economy, which today is primarily based on the incineration and processing of crude oil, natural gas and coal, not only to renewable energies, but also to renewable carbon sources. At the same time, it will need to implement a turnaround in energy policy, change its raw materials base and close material life cycles. All this would be impossible without biotechnology. It is only with the help of biotechnology that the vast majority of biomass reserves can be fermentatively developed and processed, enabling straw,

for example, to be turned into glucose and then into platform chemicals. Crude oil is still needed today for their production. It is only thanks to biotechnological expertise that microorganisms can produce valuable proteins, including enzymes that enable environmentally friendly syntheses or even the recycling of carbon dioxide. Add to this that the tools of biotechnology, microorganisms, are themselves biomass, i.e. renewable raw materials.

The production and use of biological resources is characteristic of the bioeconomy. It is guided by the sustainable development goals of the United Nations, some of which can only be achieved with the help of biotechnology. Biotechnology respects the limits of growth. Its primary purpose is to feed the world’s growing population. The bioeconomy necessitates the generation and application of biological knowledge that benefits all areas of the life sciences, including medical progress. This broad bioeconomic concept should not, however, cloud the view of what its main goal is: to help bid farewell to the age of fossil fuels in a timely manner and, as Iris Plöger of the Federation of German Industries (BDI) puts it, to change “the economy from consumption-based modes of production to methods based on recycling or reutilisation.” This change to sustainable production processes and products is not only ecologically necessary, but also opens up “a huge opportunity for the German and European economy,” says Dr Jürgen Eck, CEO of BRAIN AG. “The winners of the old economic system were and continue to primarily be those who own the fossil



The UN Climate Change Conference took place 30 November to 12 December 2015 in Paris. © Jmdigne

resources. The winners in the bioeconomy will be the owners of technologies.” This is exemplified by the Danish company Novozymes. Even without a raw material base, it has become the global market leader in the field of enzymes.

Appeal by the Bioeconomy Council

In principle, the German government is well aware of the bioeconomy’s importance: “The transition to an economy based on renewable resources is to be driven forward with the help of the bioeconomy,” was laid down in its coalition agreement in March 2018. “The bioeconomy is playing a more prominent role than ever before, not only in the coalition agreement and the high-tech strategy of the German government, but also in some strategies of the federal states,” says Dr Beate El-Chichakli. “What’s written on paper should gradually become visible in practice.” El-Chichakli heads the administrative office of the Bioeconomy Council, an advisory body that the German government first set up in 2009. However, the tenure of the previous Bioeconomy Council expired and a new one has not yet been granted. At their final meeting on 27 May 2019, the outgoing members of the Council adopted an appeal to the German government to “do more to promote change to a sustainable and bio-based economy than it has in the past.” In particular, it should treat bioeconomic policy as an inter-ministerial task, create incentives for sustainable investment and consumption decisions and assign an implementation plan to its new bioeconomic strategy in order to “translate its specifications into concrete measures with suitable timelines.”

By mid-October 2019, however, it was still uncertain when and in what form this new bioeconomic strategy would be adopted by the Cabinet. In July, the Federal Ministry of Education and Research (BMBF) and the Federal Ministry of Food and Agriculture (BMEL) presented a ministry draft for this strategy. At the same time, the Federal Ministry for Economic Affairs and Energy (BMWi) promoted its “Industrial Bioeconomy” dialogue platform. The Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU), in turn, asked the Institute for Applied Ecology to critically examine the extent to

which bioeconomic concepts can be regarded as sustainable at all. There was little sign of inter-ministerial determination.

Between ivory tower and summit meeting

Nevertheless, Dr Christian Patermann, the doyen of the European bioeconomy, believes that the status of the bioeconomy is not so bad in Germany. Fourteen years ago, he and his colleagues in the EU Directorate-General for Research in Brussels launched the concept of a knowledge-based bioeconomy. Its implementation was initiated during the in 2007 under the 7th Research Framework Programme. “There are now 800 institutions in Germany conducting bioeconomic research,” confirms Beate El-Chichakli. “Germany is playing a pioneering role in research funding, and is setting the topics. These are innovative, open to new technologies and encourage new approaches.” Things look rather different when it comes to the private sector. “None of the large industrial companies has yet placed a focus on the bioeconomy or communicated this externally in the way that some Scandinavian companies are doing, for example. Start-ups and smaller companies in the bioeconomy have rarely managed to grow significantly through successful investments and thus contribute to the renewal of the German industry and enterprise base.” For Christian Patermann, this is a cause for concern. In countries such as Finland, France, Ireland, Italy and the Netherlands, the development of the bioeconomy is driven by the private sector. “In Germany, it is mainly scientists who are focusing on the bioeconomy,” he says. Germany runs the risk of “getting lost in an ivory tower”.

And this is even though Germany has been a very strong advocate of bioeconomic concepts. In 2015, the first Global Bioeconomy Summit took place in Berlin, organised by the Bioeconomy Council and financed by the BMBF. Already at that time, it brought together some 700 bioeconomy experts from 80 countries. Since then, Berlin has become a centre of networking and global agenda-setting for the international bioeconomy community. The summit will take place for the third time in 2020. That same year, the BMBF will dedicate its Science Year to the bioeconomy, funding projects that commu-

nicate the topic to society. But is the political will to shape the bioeconomy strong enough?

Three sources of renewable carbon

Michael Carus, who has been analysing bio-based approaches in his Nova Institute for 25 years, doubts this: "The bioeconomy is not getting off the ground because it is not being pushed politically." Currently, only bio-based fine chemicals such as medicines, cosmetics and detergents, which have superior properties to fossil-based products, are competitive on their own, as are cellulose fibres made of wood, which are very popular in the textile industry. Technically, it would be possible to convert the entire chemical and plastics industry to biogenic resources. However, this would first require policy interventions, such as quota regulations or taxes on fossil carbon. "The problem of the bioeconomy is not supply, but demand," says Carus. "How do I create demand for bio-based products? That should be at the core of a policy that really wants to implement something."

This sounds too much like a planned economy, says Dr Manfred Kircher, the long-standing director of the Industrial Biotechnology 2020 cluster, who today operates a bioeconomy consulting firm. He believes that the preferential treatment of bio-based products in public procurement will not lead to the desired results: "Bio-based products should become more efficient in order to hold their own against the competition." In view of the strength of the German chemicals industry with its fossil-based composite systems, which have been established for many decades, it is a very ambitious goal to produce the same products competitively from renewable raw materials, says Jürgen Eck. "We should be thinking more along the lines of additive bioeconomic value creation, i.e. products with bio-based manufacturing methods that are unrivalled on the market, such as new ingredients for healthier diets or functional biomaterials with new properties." Perhaps it was a mistake to spend so much time on the question of whether sufficient biomass is available. For even if Germany were still dependent on raw material imports, this would not limit the potential of the bioeconomy.

Biomass alone cannot pave the way for a bioeconomy, says Michael Carus. He advocates a strategy of "renewable carbon". In addition to renewable biomass, this could be obtained from two other sources. As a second option, from the recycling of plastics and other organic chemical products. And thirdly, from industrially and naturally produced carbon dioxide, i.e. CO₂ from the technosphere (from industrial and biogas plants) and from the atmosphere (where it can be extracted directly from the air). In the case of hydrogen, which is electrolytically produced from renewable energies with the aid of electricity, this CO₂ can be biotechnologically converted into methane. This can then be used as a platform chemical for organic syntheses or fed into the natural gas grid, enabling excess electricity to be stored. A pilot plant run by the biogas systems manufacturer Viessmann in Allendorf, a town in northern Hesse, shows how well this principle works.

Difficult for investors to understand

However, the pressure placed on the economy to move to-

wards the bioeconomy also comes from investors. "Fossil-based supply chains are increasingly seen as a risk in the financial sector," says Manfred Kircher. For example, Allianz Group, which manages an investment portfolio of more than two trillion euros for insurance customers and third parties, has already started withdrawing from coal-based business models. It is foreseeable that this investor withdrawal will one day also affect crude oil. "If the financial sector pulls the plug, it's much more crucial than if the United States pulls out of the climate agreement." On paper, this might make sense, Christian Patermann replies. However, investors and entrepreneurs tend to be cautious when confronted with the variety of terms used in the bioeconomy, especially as investments in the bioeconomy are more complex, riskier, more long-term and more difficult to broker than in other innovation fields. "We need certified experts in Germany who can credibly explain bioeconomic opportunities and risks to both investors and entrepreneurs. This would be particularly important for many SME entrepreneurs and hidden champions who want to set up bioeconomic value chains."

The blessings of federalism

In this regard, more and more support is raining down on Germany's regions. As uncoordinated as federal policies might appear with regard to the bioeconomy, some landscapes – often aided by federal funding – are truly blossoming bioeconomically and are beginning to bring science and business together to create fruitful networks. Baden-Württemberg, for instance, launched a statewide strategy in June that Patermann considers "one of the most modern, effective and practice-oriented regional strategies in the world." Bavaria, the only federal state with its own bioeconomy council, has scientifically upgraded its KoNaRo – Centre of Excellence for Renewable Resources in Straubing. In North Rhine-Westphalia, a project to transform the Rhenish lignite mining district into a model bioeconomy region got underway in August. In Saxony and Saxony-Anhalt, the Leading-Edge Cluster BioEconomy is flourishing. The heart of the cluster is Leuna, a hub for the chemicals industry, which is also showing promise in attracting bioeconomy companies. In spring of this year, the BMBF also decided to support four thematically organised "Bioeconomy Innovation Areas" which are devoted to using marine organisms sustainably (Kiel), recovering raw materials from waste (Frankfurt), producing textiles from renewable raw materials (Aachen) and developing new food systems (Karlsruhe).

Bio-based value creation in an urban area

"Bioökonomie im Ballungsraum" (BioBall) is the official name of the innovation area in the Frankfurt Rhine-Main metropolitan region. This economically thriving region, which has a population of 5.7 million, amasses huge amounts of carbon-based byproducts and wastes. It is estimated that the region annually generates at least 900,000 tonnes of organic waste, 146,000 tonnes of dry sewage sludge, 125,000 tonnes of methane and carbon dioxide from fermentation processes, and 90,000 tonnes of lignin from paper production. Up until now these byproducts have not been exploited commercially at all, or only partially exploited commercially through composting and incineration. The actors within the innovation area – in addition to researchers, this includes mainly representatives from private and

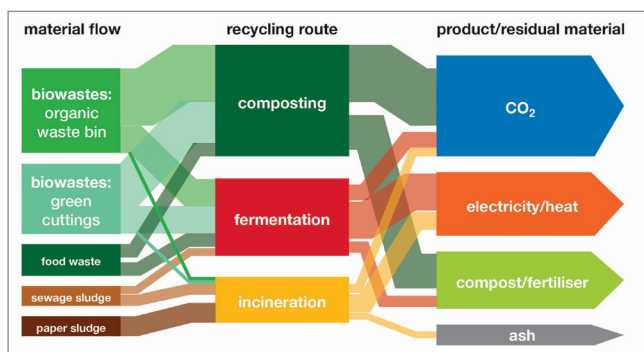


Fig. 1: Current use of biogenic waste, residues and carbon emissions, graphic based on Bioball

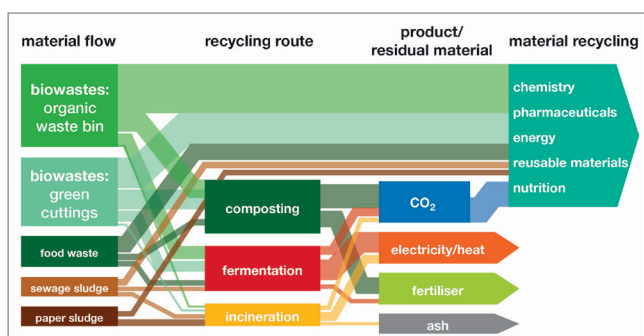


Fig. 2: Future use of biogenic waste, residues and carbon emissions, graphic based on Bioball

municipal companies and from the municipal administration – now want to use these biogenic material flows in a cascading way; in other words, they want to use them to the greatest extent possible for material purposes first and only at a later stage for energetic purposes. BioBall will begin with four flagship projects focused, respectively, on: extracting fine chemicals from fermentable waste; recovering varnish raw materials from woody waste; making fuel cells and organic intermediates out of park and garden waste (the city of Frankfurt alone produces 9,000 tonnes of green garden waste annually); and producing antibiotically active animal feed from food industry waste. Companies and scientific institutions across Germany are eligible to participate in BioBall.

An industrial region goes green

Despite its roots in Saxony and Saxony-Anhalt, the Leading-Edge Cluster BioEconomy is similarly open to cross-regional partnerships. One of the main objectives of the cluster is to maximize value creation of wood through coupled production and cascade utilisation in order to generate chemicals, new materials and energy.

On the academic side of the cluster, the ScienceCampus Halle – Plant-based Bioeconomy plays a major role. Other important players are the German Biomass Research Center (DBFZ) and the Helmholtz-Centre for Environmental Research (UFZ), both based in Leipzig. The private companies involved in the cluster are mostly concentrated in Leuna. There, the Fraunhofer Center for Chemical-Biotechnological Processes (CBP) has demonstrated in a pilot plant how a lignocellulose

biorefinery can process beech and poplar wood chips into cellulose and a mixture of hemicellulose and lignin, and then, in a next step, produce not only commercially exploitable byproducts such as acetic acid and furfural, but also sugar monomers and lignin. Members of the cluster are conducting research into the further processing and refining of sugar monomers into platform chemicals and of lignin into materials. However, it has not yet been possible to transform the successfully tested research-scale biorefinery into an economically viable operation.

A campus in the heart of the breadbasket

The lignocellulose biorefinery that the chemicals company Clariant put into pilot operation in Straubing in 2012 appears to offer better prospects. It aims to process 4,500 tonnes of straw into 1,000 tonnes of final products such as bioethanol and into synthetic building blocks for making bio-based plastics, whereby the process energy of the plant is derived from the burning of the accumulated lignin. In September 2018, Clariant broke ground on a plant in Romania that plans to use this method to produce 50,000 tonnes of bioethanol annually. A year later, Clariant licensed the underlying technology to the Poland-based Orlen Group and furthermore confirmed that this technology can also be used to process miscanthus (China reed). Straubing has since time immemorial been known as the breadbasket of Bavaria, making it an ideal location for bioeconomic value creation. A technology and support centre for renewable resources has been located there since as early as 1973. Straubing is a Danube port, which is advantageous in terms of accessing international trade networks. A BioCubator, located near the port, provides bioeconomy start-ups with favourable conditions. In 2017, Straubing was afforded the status of a university city by the Bavarian Parliament. It has since been home to the Campus Straubing for Biotechnology and Sustainability of the Technical University of Munich (TUM).

From lignite mining district to bioeconomy district

A highly productive agricultural area like the one in the Gäuboden near Straubing can also be found in the fertile plains of the Rheinisches Revier between Cologne and Aachen. Lignite open-pit mining has recently left its mark on the district too. The district is highly industrialised, as are the cities that surround it. The sugar beet industry (whose processes have a great deal in common with a biorefinery), the food processing industry, the paper industry and the chemicals industry have the greatest bioeconomic relevance. In addition, the district has excellent research institutions, including Forschungszentrum Jülich at its heart. Forschungszentrum Jülich established the Bioeconomy Science Center (BioSC) with the universities of Aachen, Dusseldorf and Bonn. The greatest challenge facing the Rheinisches Revier now is managing policymakers' decision to move away from lignite subsidies, and the structural changes that come with that move. The hope is that, in the process, the Rheinisches Revier will work with all of the stakeholders in the district to become a model bioeconomy region. Efforts to make this "BioRevier" a reality began this summer. For example, planners want to take open-pit mining sites that have been out of commission for decades and use them to produce renewable resources. Simultaneously digitalising agriculture will increase productivity. "PhenoRob – Robotics and Phenotyping

for Sustainable Crop Production” is a Cluster of Excellence at the University of Bonn that will contribute to these efforts. Researchers there aim to test innovative approaches to microbial strain and process development and create new value chains between agriculture and the chemicals industry, for example. The government of North Rhine-Westphalia is preparing a new bioeconomy strategy in parallel.

An exemplary strategy at the state level

In the process, it might also look to Baden-Württemberg's bioeconomy strategy for inspiration. There the University of Hohenheim is a beacon for bioeconomics teaching and research in Germany. Christian Patermann praises the mix of strategic thinking and practical courses of action that this strategy provides, along with the funding it provides for specific periods of time. He says this makes it more accountable than other strategies. The strategy is aligned with the EU's 2018 strategy when it comes to including urban spaces in the bioeconomy and explicitly naming the potential benefits of digitalisation. In addition, it calls for bioeconomics teaching and training, even for non-academic actors, and goes beyond biological resources to recognise carbon dioxide as a potential commodity. The strategy also aims to use bio-based methods to close critical raw and recyclable materials cycles. With BioXtractor, BRAIN AG has developed a pilot project with this very goal just over Baden-Württemberg's border with Hesse. The project uses certain types of bacteria that are commonly found in mines to extract significant quantities of precious metals from things like electronic waste and waste incineration ash. BRAIN's CEO Jürgen Eck also points to a process that converts carbon dioxide

companies during approval processes and to provide bioeconomy scouts who would assist them as advisors. Advisors of this kind are important. There is little in the way of hard facts to assess the state of the bioeconomy in Germany, says Beate El-Chichakli. All recent comparisons have ultimately only provided anecdotal evidence, she says, because no reliable data is available to serve as a foundation. Finland lists bioeconomic products in its foreign trade balance, but Christian Patermann says Germany doesn't even have generally accepted terminology for bioeconomic products or bioeconomic services. In February 2019, the German federal government responded to a minor interpellation by the FDP parliamentary group saying the government only has a limited quantity of solid, official statistical data on the bioeconomy.

Still, Manfred Kircher can extrapolate from different sources that Germany's bioeconomy is already generating revenues of around 360 billion euros. Some 59 billion euros of that comes from the biomass-producing industries (agriculture, forestry and fisheries), while the remaining 297 billion euros comes from industries that process biomass (paper, chemicals and pharmaceuticals, wood processing, textiles and biofuels). Some of these industries have significant growth potential in bio-based products.

As Christian Patermann explains, “The bioeconomy is part of the overall economy, so the economics minister should be doing everything in his power to open markets in that area for German companies, instead of leaving its development to the research and agriculture ministry.” BIO Deutschland made a similar demand in its statement regarding the ministry draft for the new German bioeconomy strategy. It claims Peter Altmaier was of the same mind when he created the Industrial Bioeconomy dialogue platform. When he and Research Minister Anja Karliczek presented the joint agenda “From Biology to Innovation” last autumn, he added that, “If there is one ministry that is predestined to advance this topic, it is the Ministry for Economic Affairs.” The German Presidency of the Council of the European Union laid the foundation for a knowledge-based bioeconomy in Europa in 2007 too. Why not use Germany's next Council Presidency in the second half of 2020 – in concert with the Federal Ministry of Education and Research's Science Year and the third Global Bioeconomy Summit – to finish the house built upon that foundation? 

Joachim Pietzsch

(The author is the editor of the textbook Bioeconomics for Beginners.)



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from bioethanol production to dicarboxylic acids with the help of microorganisms. The dicarboxylic acids can then be used to produce valuable organic compounds. “We're learning more and more about how to better close carbon dioxide cycles,” says Eck. His company developed the process in cooperation with Südzucker AG as part of the strategic alliance ZeroCarbPF, which was funded by the BMBF. A pilot plant for the technology is now being built at CropEnergies in the town of Zeitz in Saxony-Anhalt.

Before the upcoming Council Presidency

Patermann was also impressed by highly practical aspects of Baden-Württemberg's strategy, such as its promise to support