# innovation space bioeconomy

The valuable use of
the BioBall programme in the Frankfurt
Rhine-Main metropolitan region

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*Bioeconomy is a crucial building block of a sustainable development (German Ministry for Education and Research 2017)*

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# content



La energía NOS transforma avaesen

ecci EDINBURGH CENTRE FOR CARBON INNOVATION

UNIVERSITY OF BIRMINGHAM

# foreword

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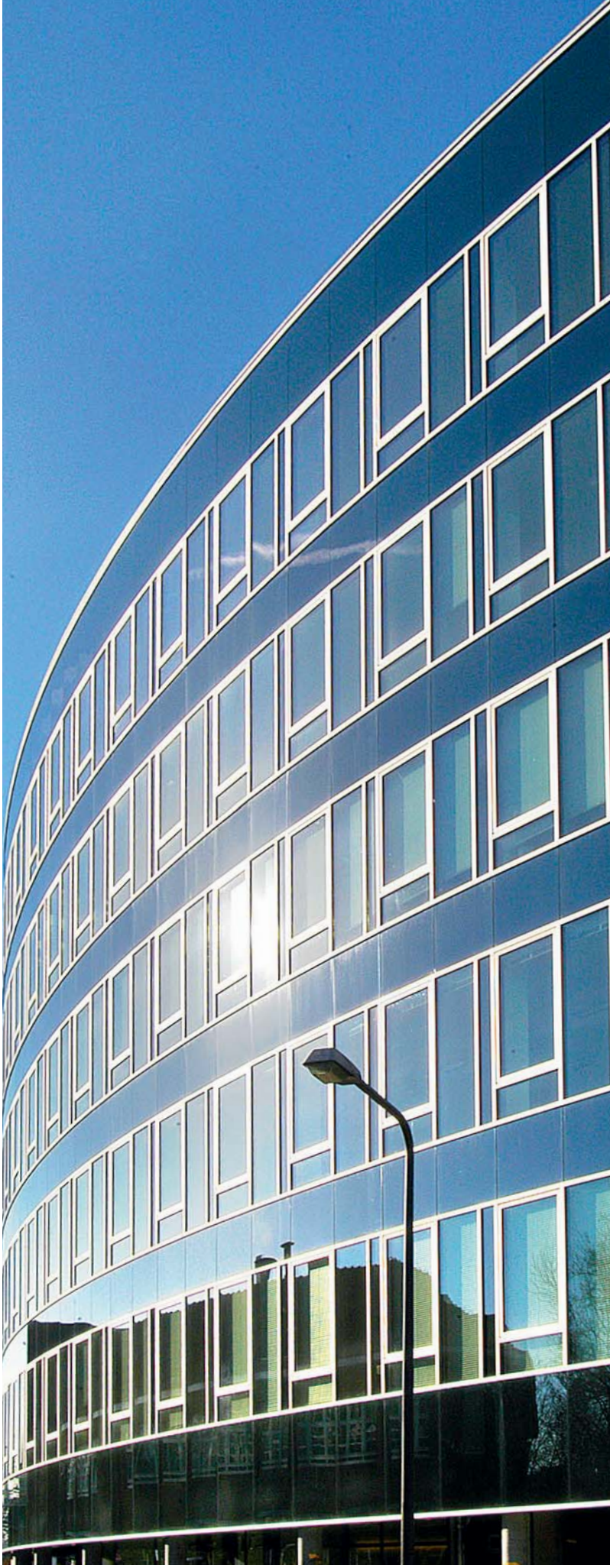
Ongoing debates on climate and environmental protection, as well as a growing world population, contribute to fossil-fuel-dependent economies reaching their limits. Bioeconomy is a new model for industry and a central stepping stone in a shift towards a more sustainable low carbon economy. It involves the usage of renewable biological resources to produce food, energy and industrial goods and also utilises the untapped potential stored within biological waste and residual material. With the new funding concept "Innovation Spaces Bioeconomy", the German Federal Ministry of Education and Research (BMBF) intends to accelerate the development of bioeconomic innovations in order for them to be drivers of structural change towards a sustainable bio-based economy.

With this case study, we describe how bioeconomy is promoted in the Frankfurt Rhine-Main metropolitan region through the innovation space BioBall („bioeconomy in the metropolitan region"). BioBall intends to strengthen bioeconomy in the metropolitan region by using biogenic wastes as raw materials, highlighting options for closing resource loops and fostering innovation between economic sectors and research, administration and politics. BioBall is managed by Provadis School of International Management and Technology with the support of DECHEMA (a non-profit professional society for chemical engineering and biotechnology in Germany).

Provadis is a private university based at an industrial park that has a history of more than 155 years and was once the headquarters of the largest chemical company in the world (Hoechst AG). At Provadis, we have more than ten years of experience in conceptualising and managing high-impact cluster initiatives: The Rhein-Main-Cluster Chemie & Pharma supports cross-company collaboration between large and small chemical industries in the region. Provadis' Centre for Industry and Sustainability manages a regional cluster of change in order to foster innovation networks that tackle climate change. We define ourselves as a "think and do tank" for a sustainable industry and act as a platform organisation that fosters collaboration between companies, academia and public authorities on a regional and international level.

This case study was developed as a knowledge and innovation exchange with the EIT Climate-KIC project ConnectedClusters – an alliance of four city regions (Frankfurt, Birmingham, Valencia and Edinburgh) – which is committed to sharing, replicating and scaling what works in developing innovation ecosystems in order to deliver effective climate action. Our partners stem from three European innovation clusters: Energy Capital (EC) in Birmingham, the Asociación Valenciana de Empresas del Sector de la Energía (AVAESEN) in Valencia and the Edinburgh Centre for Carbon Innovation (ECCI).

With this brochure we want to identify innovation opportunities and an innovation space for a more sustainable economy. We also want to share our insights in developing high-impact clusters and support international collaboration between European stakeholders.



# 1 climate protection needs feedstock change

Governments at federal, state and local level, as well as business associations and the general public have agreed to follow the Paris Climate Agreement in the interests of climate protection. This international agreement calls for a 95 % reduction in greenhouse gas emissions by 2050. Since carbon dioxide from coal, natural gas and oil accounts for the largest share of these emissions, the use of these fossil raw materials must be gradually reduced until they are virtually eliminated by 2050. The energy, fuel, chemical and pharmaceutical industries are directly affected. This is an enormous challenge for Germany and for the entire global economy. It affects not only raw materials and their supply chains but also the multi-stage processing of raw materials, from intermediates up to the final consumer product. BioBall, the initiative presented in this study, aims to accelerate the transition into a bioeconomy under the specific conditions of the industrialised and densely populated metropolitan region of Frankfurt Rhine-Main. This is expressed in the acronym BioBall, which is derived from the German term „Bioökonomie im Ballungsraum".

Carbon-free alternatives such as hydropower, geothermal energy, solar and wind energy are, in principle, available for the energy sector and, to some extent, also for the mobility sector. Air traffic, for example, will depend on carbonaceous fuels for the foreseeable future, as only they have the necessary energy density. Also, the chemical and pharmaceutical industries, which supply us with many of our everyday products such as detergents, adhesives, paints, skin care products, plastics and active pharmaceutical ingredients, depend on carbon. In organic chemistry, carbon is indispensable and therefore irreplaceable. As a renewable alternative to fossil carbon sources, vegetable biomass from agricultural, forestry and aquatic sources is an obvious choice. Possible sources include sugar, potato starch, rapeseed oil, straw, wood and algae. These raw materials offer an alternative to fossil carbon and energy sources because they provide access to the entire spectrum of energy forms such as heat, electricity and fuel as well as chemical and pharmaceutical products. Biogenic raw materials are carbon-neutral because plants use photosynthesis to bind carbon dioxide from the atmosphere, which is released during the processing of their biomass and during the use of bio-based products. This natural carbon cycle of photosynthesis therefore means that the carbon dioxide balance of bio-based products is neutral if only biomass and emission-free energies are used. The accumulation of carbon dioxide in the atmosphere is thus avoided. An economy based on this principle is called a bioeconomy.

The Paris Climate Agreement gives us 30 years to implement this change from fossil to renewable raw materials. This corresponds to more than one generation and therefore does not seem so urgent at first. However, given the scale of the task of adapting major parts of the economy and infrastructure to a bioeconomy, three decades are indeed short and it is therefore urgent to tackle change vigorously.

*The desired change in raw materials from fossil to biogenic resources must however under no circumstances rely on first-generation biogenic raw materials (that may be used for food or animal feed). Rather, this change can only be achieved sustainably if it is based on second to fourth generation biogenic raw materials. These include the non-edible parts of agricultural biomass (e.g. straw, berry pomace), organic residues and waste flows (e.g. municipal green waste, lignin from the paper industry) up to gaseous carbon sources such as synthesis gas (CO, $H_2$, $CO_2$ or $CH_4$).*

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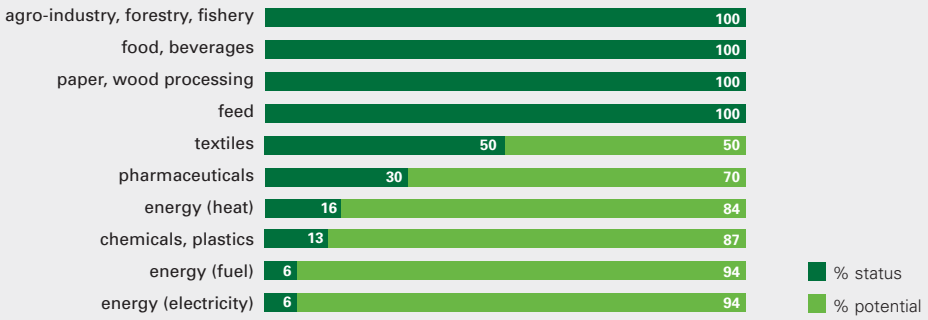
# bioeconomy is the alternative

The industrial processing of biomass is not new in itself. It has a long tradition – especially in the areas of nutrition, the timber industry and the paper industry. These sectors are therefore referred to as traditional bioeconomy. Although the textile, pharmaceutical, chemical and energy industries already use bio-based raw materials, their share is still low overall (Fig. **A**) or, to put it another way, it has enormous growth potential. Converting these industries to bio-based raw materials is also the vision of the modern bioeconomy.

In fact, the products of these industries, which are still dominated by fossil raw materials, can, in principle, be produced from renewable biological raw materials. Although the solution for the change in raw materials is on the table, it also leads to a serious dilemma. The biomass that is produced worldwide today is almost completely used by traditional users in the food and timber industries. Although agriculture and forestry still have reserves and can supply additional quantities of sugar beet, sugar cane, rape, soya and wood (primary biomass), the usable areas are naturally limited, and the dwindling biodiversity is increasingly showing us the limits of biological systems.

At the same time, it is foreseeable that the demand for food will continue to increase as the world's population increases.

## A more sectors are going to expand into the bioeconomy




**A THE GROWTH POTENTIAL OF BIO-BASED PRODUCTS IN MODERN BIOECONOMY SECTORS**

The industrial valorisation of sugar and vegetable oil derived from food biomass will continue as well as grow, but it must be complemented by utilising more non-food materials. Thus, there is no alternative but to make greater use of by-products from the processing of primary biomass, such as straw. The various by-products of the industrial processing of biomass also have potential. The production of biodiesel, for example, produces large quantities of glycerine, which is fed as a raw material into processes for other chemical products and thus used as a material. A by-product, for which no further material use is possible, can still be fermented to biogas and used to generate heat and electricity, i.e. for energy production. Such a cascade from material to energetic use enables the almost complete utilisation of all components of biomass. In this way, the efficiency of raw materials can be improved. This indicator describes the proportion of a raw material that is converted into valuable products. The higher it is, the lower the proportion of production waste. Cascade use can also include carbon dioxide emissions from biomass processing, as carbon dioxide can also serve as a carbon source for fuels and chemicals. This prevents carbon dioxide from entering the atmosphere at all. Cascade use thus relieves the strain on natural resources, keeps agricultural land free for food and reduces carbon dioxide emissions.

Source: A Kircher, M. (2020) Bioökonomie im Selbststudium: Unternehmensstrategie und Wirtschaftlichkeit. Springer Spektrum.

# 3 transformation into a bioeconomy is a challenge

Transforming into a modern bioeconomy is challenging in many respects. The main task is to bring bio-based products to market competitively. Therefore, cost, quality and the carbon footprint of fossil products are yardsticks. As far as a carbon footprint is concerned, bio-based products have a fundamental advantage. The quality of many bio-based products is also superior. In most cases, however, the same performance spectrum is offered compared to conventional products. In this case, only lower costs can create a competitive advantage. However, the production costs of bio-based products are a critical factor because they are usually higher than fossil-based alternatives and therefore inevitably lead to higher selling prices. The causes lie in the complexity of biogenic raw materials and the generally more complex processing and logistics involved. In addition, processing is considerably less developed than it is with oil refineries and chemical syntheses, which have been optimised for more than 100 years. The need to invest in new plants is also a challenge that should not be underestimated.

It is therefore necessary to make raw materials available at a low cost, in the required quantity and of the required quality. It is also necessary to develop technical processes, trim them down in terms of costs and transfer them to industrial plants. Compared to fossil raw materials, biomass has a considerably lower carbon and energy density, which makes transport over long distances uneconomical and therefore requires processing as close as possible to the point of origin, i.e. in agricultural areas. In general, it is therefore to be expected that a comparatively close-meshed infrastructure will be economically viable for such plants so that the change in the bioeconomy will also have a major influence on the future development of rural and urban areas. As already mentioned, the principle of cascade use must be applied, i.e. to primary biomass. Its complex constituents and

by-products of production, including carbon dioxide, must be used as completely as possible in terms of materials and energy. The cascade use itself exerts a further influence on the infrastructure of the bioeconomy because it couples different material flows not only within a company but also over long distances between industrial sites. This coupling, in turn, can involve industries that have had little or no contact with each other in the fossil-based economy of the past. In the German chemical industry, for example, bio-based raw materials from agriculture and forestry have a share of 13 % so far. In the course of raw material change, this share will grow significantly and thus also intensify the interfaces between the participating industries. The same can be assumed for the fuel sector, as well as heat and power generation. Electricity generation has a dual function. On the one hand, bio-based raw materials are used directly or in the course of cascade use to generate electricity; on the other hand, the use of carbon dioxide consumes electricity. Processes for synthetic fuels (PtL; power to liquid) and chemicals also consume electricity.

The transition to a bioeconomy will thus create new business relationships between many sectors and thus integrate agriculture, forestry, chemicals, energy, textiles, construction, waste management, etc. into new supply and value chains. The potential of this can only be utilised if the key players in companies, politics, administration and, not least, research are willing and motivated to change. It is they who are responsible for working together in sometimes unusual constellations: in technical-scientific research, in the development of business models and in investment in plants and infrastructure. And it is they who lead the change to success in the bioeconomy.

# 4 accepting the challenge of transformation

So, what needs to be done to accelerate the realisation of a bioeconomy in Germany? The Federal Ministry of Education and Research (BMBF) also asked itself this question. In 2016, it invited industries and research institutions to develop concepts that promote cooperation between stakeholders and that support the development of necessary innovations with the „Innovation Spaces Bioeconomy" funding measure. The aim is to create so-called innovation spaces that encourage actors to initiate creative research and development projects on new products, processes and services in the bioeconomy. At the same time, the innovation space should support the actors in penetrating the market more strongly than before with the project results and thus achieving a more comprehensive industrial and social significance for bioeconomy.
It is clear that there can be no standard model for such an innovation space. Its design depends significantly on the respective regional starting position because such an innovation space should ideally build on the capacities and competencies available in a region. It must be asked which sectors can be further developed in an established region or which products and markets are promising. An innovation space can be based on a raw material potential, on existing processing capacities or on a certain technical competence. An important factor is the scientific quality in relevant disciplines that is necessary for research and development projects. Last but not least, it is advantageous to be able to build on existing networks and an established culture of cooperation between economic sectors, as well as with research, administration and politics.

In the case of the BioBall innovation space, the Frankfurt Rhine-Main metropolitan region was analysed.

*Within the Frankurt Rhine-Main area the following biogenic waste and residuals accumulate:*

- *900,000 t biowaste, of which 200,000 t is food waste*
- *146,000 t sewage (dry mass)*
- *125,000 t biogas ($CH_4$ / $CO_2$) from fermentation*
- *90,000 t lignin from paper production*

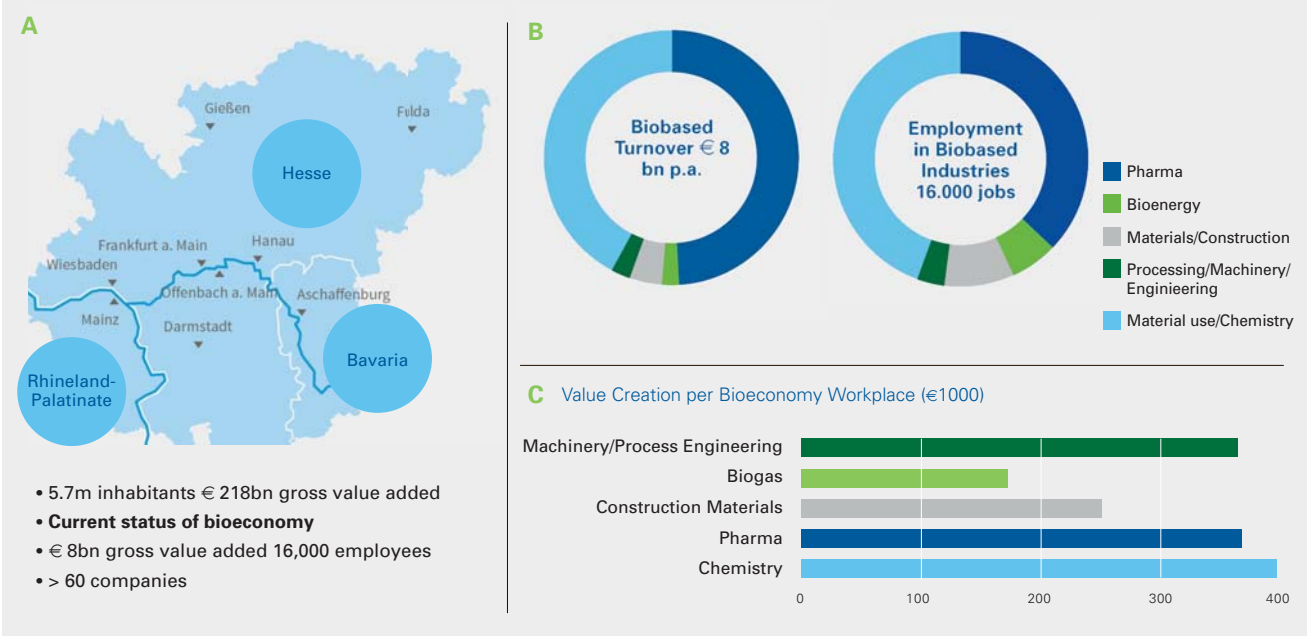
# 5 the frankfurt rhine-main metropolitan region – building an innovation space on solid ground

This metropolitan region comprises mainly southern Hesse, as well as parts of Bavaria and Rhineland-Palatinate.

It produces almost 8 % of Germany's gross national product, with the chemical and pharmaceutical industries in particular occupying a very strong position, accounting for around 30 % of gross value added in the manufacturing sector. Agriculture, on the other hand, accounts for a small share of only 2 %. Bio-based processes and products generate a turnover of 8 billion EUR in Hesse and create employment for 16,000 people. Core areas are bio-based chemicals, pharmaceuticals, bioenergy and construction materials. Mechanical and plant engineering – which specialises in bio-based processes – and the corresponding process providers are also indispensable for the bioeconomy and strong in the region.

The companies already active in the bioeconomy generate a total turnover of 56 billion EUR, including the turnover achieved with fossil-based products. Such strong companies in the metropolitan region can be expected to generate the economic strength needed to carry out research and development projects and utilise the results.

An analysis of today's bio-based value creation per job in Hesse has shown that in the modern bioeconomy of the metropolitan region, the chemical and pharmaceutical industries and machinery/process engineering generate the highest results. Construction materials and energy follow much further behind (Fig. **B**), which is understandable due to the generally small number of processing steps in these areas. In view of the many production and value-added stages required to manufacture a pharmaceutical and chemical end product, it is not surprising that these sectors create attractive value.




**A THE FRANKFURT RHINE-MAIN METROPOLITAN REGION B TURNOVER OF BIO-BASED PRODUCTS AND ASSOCIATED JOBS C VALUE ADDED PER JOB IN SELECTED SECTORS**

There is a need for biogenic raw materials in the above-mentioned sectors of the modern bioeconomy, as well as in the traditional bio-based sectors of the food and feed industry, the fermentation industry and paper production and the production of construction materials for the building sector. Raw materials are both imported and produced in the region by agriculture and forestry. Processing results in the production of a wide variety of solid, liquid and gaseous by-products, some of which are of considerable volume. It is not only the manufacturing industry that causes biogenic material flows of varying quality. The region is densely populated, and 5.7 million inhabitants generate bio-based municipal waste, which is collected separately from the „brown bin". The municipalities also produce biowaste by maintaining green and sports facilities. Municipal waste management is another important player in the recycling of industrial by-products and municipal waste. It recycles waste from organic bins, garden and park waste, food waste, waste from the food industry and/or liquid fertiliser into compost and biogas, i.e. products from short process chains with low added value and low job potential. However, there are also examples of systematic cascade use of all raw material fractions and material flows in the region. In these cascades, material and energy recovery are combined in such a way that added value can be achieved at every stage of the cascade and jobs can thus be created.

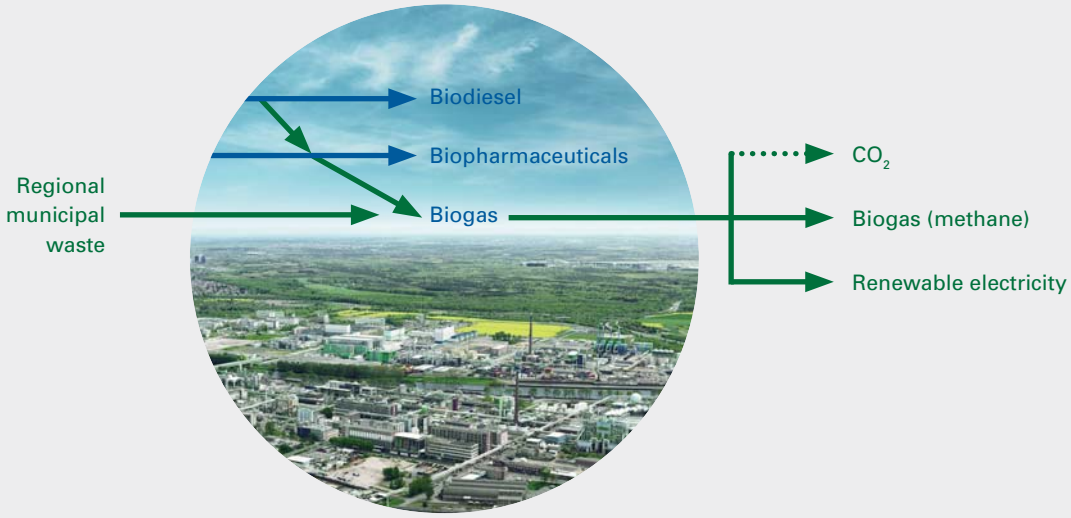
Sources: A GeoBasic-DE / BKG 2016 B Kircher, M., Michels, J. (2015): Studie zur wirtschaftlichen Bedeutung der wissensbasierten Bioökonomie in Hessen. Hessen Trade & Invest. Wiesbaden. C Kircher, M., Michels, J. (2015): Studie zur wirtschaftlichen Bedeutung der wissensbasierten Bioökonomie in Hessen. Hessen Trade & Invest. Wiesbaden.

## EXAMPLE 1: CASCADING IN THE FRANKFURT HÖCHST INDUSTRIAL PARK

In the Frankfurt-Höchst industrial park, the by-products of bio-based processes from various companies are coupled in a cascade. The production of biodiesel from rapeseed oil produces a by-product that is introduced into a pharmaceutical production process. By-products of this pharmaceutical production are then transferred to the biogas plant at the site, which is also supplied with food waste from the surrounding area. The resulting biogas is converted into electricity at the site or, after purification, fed into the municipal natural gas network (Fig. D). The utilisation of carbon dioxide is a technically possible option, but it has not yet been realised. Amongst others, the Provadis School of International Management and Technology is currently researching – in the context of two programmes (ICO2Chem and MIKE) – how gas, and in particular carbon dioxide, can be used to close the loop even further. However, this example shows how companies in the agricultural, fuel, pharmaceutical and energy sectors can already link their material flows for mutual benefit in an industrial park.

Industrial Site Frankfurt-Höchst

D

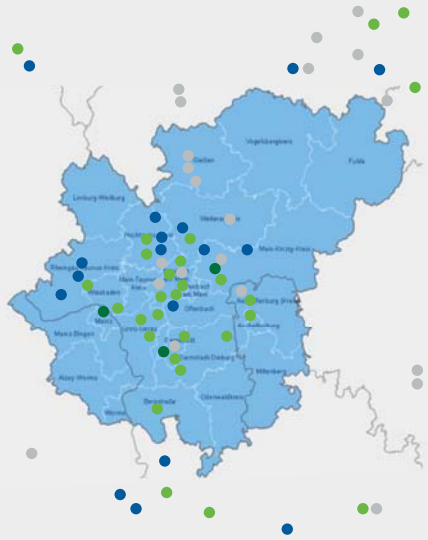



## EXAMPLE 2: IMPLEMENTING A PRODUCTION CYCLE BASED ON DOMESTIC BIOMASS

In the second example, a medium-sized company successfully applies the cascading principle. Biowert Industrie GmbH – based in the Odenwald region – processes grass cultivated in the region, i.e. all components of the plant's raw material. The grass fibres are introduced into composite materials such as decking boards. The liquid part – the grass press juice – goes into a biogas plant and generates the electricity and heat required by the company for drying the fibres. The remains from the biogas fermentation are used as fertiliser for the meadows. The process water is also extracted from the grass. Biowert thus implements the model of a production cycle based on domestic biomass.

D Picture: © Infraserv GmbH & Co. Höchst KG

E



**Our innovation space:**

- inspires stakeholders in science, the economy and municipalities
- facilitates targeted communication
- initiates consortia for innovation
- organises technology transfer
- operates beyond the metropolitan region

- **companies:** Creago, VPC, Storck KG, Bse Engineering, CordenBiochem, BNP Paribas, right. based on science UG, FES, CMBlue, Mainova, RMD, Fraport, Infraserv Logistics, Food and Energy Campus, EAD, Envirochemie, Döhler GmbH, Merck, BRAIN, Herbstreith & Fox , UPM, Herbstreith & Fox , Mann+Hummel
- **scientific institutions:** U Lüneburg, Ifn FTZ, U Kassel, U Marburg, MPI terr. Mikrobiologie, U Gießen, TH Mittelhessen, FhG IME, ISOE, U Frankfurt, Senkenberg, DECHEMA FI, FhG IWKS, TU Darmstadt, U Würzburg, FhG ISC, TU München
- **municipalities:** Stadt Hanau, Stadt Frankfurt, Stadt Mainz, Stadt Darmstadt,
- **communication platforms:** CLIB2021, HoE, Biotechnika, EIT Climate-KIC, Hessen Chemie, HTAI, Sirius Venture, Dechema, Springer Nature, BioPro, BioKompass, Federchimica Assobiotec Innovationsmittler

**E SCIENTIFIC INSTITUTIONS, COMPANIES, MUNICIPALITIES AND COMMUNICATION PLATFORMS IN THE FRANKFURT RHINE-MAIN METROPOLITAN REGION AND OTHER COOPERATION PARTNERS**

## 5.1. research excellence

The existing economy and raw material base are not the only important factors for the successful development of an innovation space for a bioeconomy in the metropolitan region. With its high-ranking research, education and communication facilities, this region brings with it further prerequisites that are crucial for an innovation space. The Philipps University in Marburg is a leader in microbiology. In Giessen, the Fraunhofer Centre for Insect Biotechnology and Bioresources has achieved a leading position. The Goethe University in Frankfurt is also internationally renowned for its biotechnological processes. And the engineering sciences are well established at the Technical University of Darmstadt. Here, the innovation space can draw in particular on competence in „material flow management", i.e. through the recording of the volumes of raw materials, by-products and waste – including the analysis of sustainability through life cycle analyses. Interdisciplinary research and educational projects in the field of industry and sustainability are the unique selling propositions of the Provadis School for International Management and Technology in Frankfurt. The universities and technical colleges mentioned above also offer training and further education in all areas of bioeconomy, together with other institutes outside the region. The region therefore has an extraordinarily qualified academic basis. It should be emphasised that the metropolitan region is, of course, not limited to regional scientific competence alone. It also draws knowledge from national and international networks. Overall, the metropolitan region has a high density of scientific institutions, companies, municipalities and communication platforms that have recognised the potential of the bioeconomy and are participating in the innovation space.

E BioBall innovation space. Source: adapted from Provadis Hcohschule 2019

## 5.2. existing networks and successful collaboration

Another prerequisite for an innovation space is an open culture of communication and innovation. An innovation space cannot be successful without actors who are experienced in discussing tasks and possible solutions based on mutual trust, despite the fact that their companies or institutions may be competitors. The metropolitan region of Frankfurt Rhine-Main in particular is known as a networking hub. In Frankfurt, for example, DECHEMA is the traditional network for chemical engineering and biotechnology in Germany, which combines the technical-scientific exchange of experts from different disciplines and organisations into specialist committees. The Rhein-Main-Cluster Chemie & Pharma is also active in Frankfurt. It is a platform for the chemical and pharmaceutical companies in the metropolitan region, which are located in a regional density that is unique in Germany. These specialist and industry-specific communication platforms offer an excellent basis for an innovation space that is geared towards the development of a bioeconomy that overlaps with industries.

## 5.3. political will and support

One last necessary success factor for a regional bioeconomy remains to be mentioned – namely, support from the political and administrative levels of the metropolitan region itself. At state level, the Hessian Ministry of Economics, Energy, Transport and Housing commissioned a study on the potential of the bioeconomy in Hesse in 2017, which confirmed the promising status and growth potential of the Hessian bioeconomy. Representatives of industry and politics subsequently published a joint position paper on the further development of the bioeconomy. Business and politics must be prepared to support the vision of the bioeconomy. In fact, the region can also demonstrate successful initiatives here. At the municipal level, for example, Frankfurt is active. The city was one of three finalists in the competition for the European Green Capital Award 2014/2015, and the measures initiated in relation to the award continue as a Green City process. In Frankfurt, Darmstadt, Hanau, Mainz and Wiesbaden, interdepartmental discussions were held in order to arouse interest in the innovation space, get to know already existing initiatives, maintain further contacts and gain partners. These discussions were held between initiators, environmental agencies, municipal business development agencies, local industrial companies and other municipal agencies and companies, e.g. green space agencies, supply and disposal companies, waste management companies and operators of industrial parks. These talks showed a high willingness for interdepartmental and cross-regional cooperation. Cities and rural districts have a key function in building up an infrastructure for networking small and medium-sized enterprises in the medium and long term, e.g. in the field of supply and disposal. In the innovation space, towns and municipalities therefore see themselves as playing a role in shaping the structural change in economic and environmental policy and contributing to the innovation culture in the region.

# 6 a bioeconomy needs a vision, a mission and a strategy

In order to further advance change in the metropolitan region, a space is needed that brings the actors of the future bioeconomy in contact with each other, inspires them and enables them to change. A major obstacle here is that the actors are still essentially networked along the conventional value chains. For example, clusters organised in the metropolitan region provide a platform for the traditionally closely linked chemical and pharmaceutical industries. But bioeconomy also includes other industrial sectors that will need to reorganise and coordinate their value chains differently in the future. The decision-makers in these sectors – the municipal economy, public administration, politics and civil society in general – must not only agree that it is necessary to implement changes. They must also be willing and motivated to shape change together. This requires a common vision of the future economy and a mission that lays out what the actors intend to contribute to its realisation, as well as a strategy as to how they want to achieve the mission and its goals.

On a fundamental level, the vision of the bioeconomy is widely accepted. And at the political level, creating a bioeconomy is a high priority area. In 2010, the German government published the National Research Strategy BioEconomy 2030 and established the Bioeconomy Council – a high-level advisory board. And in its coalition agreement of 2018, the German government cites bioeconomy and a communication platform dedicated to it as independent fields of action: „The transformation to an economy based on renewable resources is to be further promoted with the help of the bioeconomy. To this end, we will initiate a dialogue at an early stage between industry and social actors on the requirements for a changed raw material base within the framework of a platform". The three federal states, over which the metropolitan region extends, share the vision of the bioeconomy and corresponding municipal initiatives in the metropolitan region that has already been mentioned. Business associations such as the German Chemical Industry Association (VCI), which is based in the metropolitan region, refer to biorefineries, i.e. plants for the processing of biogenic raw materials, as the „chemical industry of the future". Despite this broad consensus, this vision still needs to be promoted, partly because the term bioeconomy still needs to be explained, and partly because some actors have not yet recognised the need for change.

The vision must define a mission in which the actors agree on what they intend to contribute to the vision. Among the diverse raw materials, product groups and sectors of the bioeconomy, a focus must be set which must be developed jointly.

In the next step, a strategy gets derived from the agreed upon mission and a binding joint decision gets made. The basic procedure must be agreed and both qualitative and quantitative goals set.

For the successful implementation of the strategy, it is crucial to continuously sensitise the various actors in the metropolitan region to the opportunities offered by the bioeconomy and to motivate them to become actively involved. It is important not to confine the approach to representatives of the established value chains but to focus on future options and to bring those actors who would not meet in existing, established networks into contact. However, developing a network that has only been modified in this way is not enough. The network must be characterised by a culture of change that understands this change in the bioeconomy not as an attack on proven structures and technologies but as a business option with new partners. It is precisely in such new partnerships that the innovation potential for new technologies, products and business models lies. The implementation of the strategy therefore also has the task of enabling the actors to innovate. It is important to communicate economic, ecological, technical and scientific information in such a way that the actors can evaluate the opportunities, the risks and the approaches to solutions. A non-binding network becomes an inspiring innovation space only when cooperation is characterised by a culture of change, where actors share a common vision and agree upon a mission and a strategy together.

# 7 “innovation space” and “innovation alliance”

In concrete terms, an innovation space consists of all actors who share a vision of the bioeconomy and wish to participate in its realisation. An innovation space is deliberately designed to be open and diverse, in order to, on the one hand, receive suggestions from very different perspectives and, on the other hand, develop the acceptance of the expected new value chains at an early stage. In the innovation space, people with varied backgrounds come together, each bringing with them a network from their environment, industry or scientific discipline. For such a network to have an inspiring effect, it must develop a climate of trust, openness and spontaneity.

The BioBall innovation space is working towards creating the technical and scientific prerequisites for improving the competitiveness of bio-based raw materials and products. To this end, several independent research and development consortia from companies and scientific institutions will be initiated. A considerable synergy potential is to be expected for the technologies developed in the various projects. In order to raise this potential, the consortia have formed the innovation alliance, which reports its results and experiences to the innovation space and thus encourages actors from the industry and science sectors to cooperate all the way to the economic implementation of the research results. BioBall is therefore a long-term innovation space that has set itself ambitious qualitative goals for the next 20 years:

- The innovation space should inspire all players
- The process of change in society as a whole should progress in the direction of a bioeconomy
- Sustainability should be established as a competitive factor
- The value-adding material use of biogenic material flows should be achieved
- The Frankfurt Rhine-Main metropolitan region should be an internationally visible lighthouse of the bioeconomy
- The climate target should be achieved

*The innovation space brings together actors from private and municipal business, science and public administration who would otherwise not meet. This is where innovation for the bioeconomy is created.*

# 8 the bioball innovation space: a best-practice example

The acronym BioBall derives from Bioökonomie im Ballungsraum (bioeconomy in the conurbation) as the BioBall innovation space was formed in the Frankfurt Rhine-Main metropolitan region. Its actors are representatives of private and municipal companies from a wide range of sectors. These include private and public research and teaching in a variety of scientific disciplines, public administration, politics, and interested citizens in the Frankfurt Rhine-Main metropolitan region. They pursue the vision of the bioeconomy according to the understanding of the German Bioeconomics Council, which defined the bioeconomy "as the production and utilisation of biological resources (including knowledge) to provide products, processes and services in all sectors of trade and industry within the framework of a sustainable economy". The innovation space thus sees itself as a driver of structural change towards a sustainable, bio-based economy – under the specific conditions of a densely populated and industrialised metropolitan region.

In order to pursue this vision, the BioBall innovation space initiates research and development projects that lead to an increased material use of biogenic by-products and waste in the Frankfurt Rhine-Main metropolitan region and thus open up new utilisation paths and value chains. In particular, bio-based side and waste streams of the private and municipal economy are to be developed as raw materials for food, chemical, pharmaceutical and energy products. Through this, bio-based material cycles can be closed and at the same time a higher added value can be achieved. From a purely technical point of view, the concept of using by-products and waste as raw materials is not new. What is new, however, is the development and implementation of this recycling process for the concrete material flows of a metropolitan region. To this end, municipal and private material flows must be coupled and utilised according to the cascade utilisation principle. The mission of the BioBall innovation space therefore also includes developing a new form of cooperation between academia and industry, municipal companies and municipal administration.

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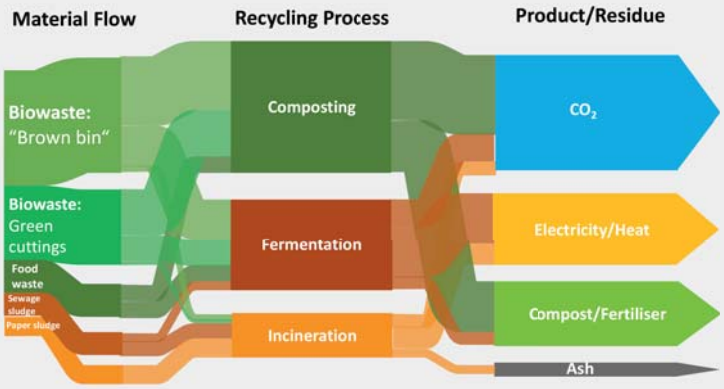



> 1M Tonnes p.a. in the Frankfurt Rhine-Main Metropolitan Region

**F CURRENT USE OF BIOGENIC WASTE, RESIDUALS, AND $CO_2$ EMISSIONS**

To develop this strategy, the volume and use of by-products and waste in the metropolitan region were first analysed. Every year, 900,000 tonnes of biowaste – 200,000 tonnes of which is food waste – are disposed of. 146,000 tonnes of sewage sludge are produced in the wastewater treatment plants. 125,000 tonnes of biogas, which on average contains 40 % carbon dioxide, are produced from industrial by-products and food waste, and 90,000 tonnes of lignin are produced as residual material in the region's paper industry. The innovation space will concentrate on the recycling of these material flows. So far, these materials have been recycled with little or no added value or have been disposed of at a high cost.

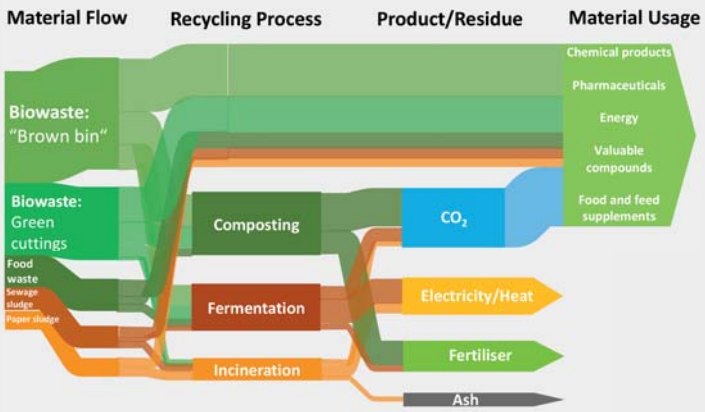
Biowaste is composted by default or goes to biogas plants. Sewage sludge is used as fertiliser on agricultural land. However, this sensible application will decrease because the limit values for certain impurities in sewage sludge will be reduced. Sludge that does not meet the specifications will be incinerated according to state-of-the-art processes. Only a very small part of the carbon dioxide emission is captured and used – for example, in beverage applications. The vast majority is released into the atmosphere unused. The BioBall innovation space wants to use these materials and gases on an industrial scale as carbon sources for the production of valuable chemical products, pharmaceuticals, food and feed supplements (Fig. F). The aim is not only to close the carbon cycles of the metropolitan region and reduce carbon dioxide emissions but also to create value and employment in a sustainable way.

Source: F Provadis Hochschule 2018

In order to ensure that the projects contribute to the qualitative objectives of the innovation space, quantitative ecological and economic targets were agreed upon. An estimation of the achievement of these targets is considerably uncertain for research projects whose industrial implementation will take several years. It is therefore more important to deal intensively with the contribution of the project to the objectives and to present the achievement of the objectives plausibly:

- Projects should have the ecological potential to support the achievement of the 2°C target of the Paris Climate Convention if applied comprehensively.
- Three years after their market launch, the products realised by a project should enable a profit margin (EBIT) of at least 16 %.
- The targeted products should have achieved a market penetration of 10 % ten to fifteen years after the start of the project.
- In order for projects to address relevant raw materials, the carbon source to be recycled should be available in at least four biogenic material flows in the Frankfurt Rhine-Main metropolitan region, which together offer an accumulated volume of 500,000 tonnes per year.
- In the interest of economic usability, the research results of the innovation alliance should be transferable to at least four other regions.

G Our vision until 2040




## G FUTURE USE OF BIOGENIC WASTE, RESIDUAL MATERIALS AND CARBON EMISSIONS

BioBall e. V. was founded in 2019 to develop and manage the innovation space. The task of the association is to:

- moderate the innovation space in such a way that technical-scientific research projects are initiated and that all actors are „taken along" and actively participate in the comprehensive economic, ecological and social transformation,
- examine project proposals in terms of their contribution to the qualitative objectives of the innovation space and the quantitative performance parameters for research projects,
- present the innovation space to the outside world,
- recognise, at an early stage, changed framework conditions and innovations that can have an influence on the strategy,
- control the achievement of qualitative goals,
- communicate the results in the innovation space and beyond.

Even if the innovation space concentrates on problems within the Frankfurt Rhine-Main metropolitan region, it will develop significance beyond this region. Germany alone has eleven comparable metropolitan regions, including the directly neighbouring Rhine-Ruhr and Rhine-Neckar regions with similarly important chemical industries. At the European level, Flanders and South Holland are comparable metropolitan regions. It is therefore an important task of the innovation space to communicate its model and its results to comparable metropolitan regions and to utilise them economically there. BioBall therefore aims to establish itself as a leading metropolitan bioeconomy and offer a model with an impact beyond the region.

Source: G Provadis Hochschule

# 9 the bioball innovation space: activities

BioBall e. V. offers, for the actors of the innovation space, communication formats that address the technical possibilities of the use of regional material flows and its economic and ecological potential. The aim is to ensure that the exchange in these platforms initiates a continuous pipeline of ideas for technical-scientific processes and product developments. Finally, these ideas will be implemented in concrete projects by consortia of private and municipal industries, universities and public and private research institutions. The tasks for these projects should come from the metropolitan region; however, the project consortia themselves expressly invite players from industry and science from all over Germany.

The technical-scientific projects are open to new technologies and are intended to combine biotechnological, chemical, thermal or mechanical methods. For example, four projects will be launched that use methods from chemical extraction, insect biotechnology, biotechnology, synthetic biology and electrochemistry to demonstrate the scientific spectrum of the innovation space. In one of the projects, raw materials will be extracted from food processing residues for further processing into paints and coatings. Insects reared on biowaste will lead to an antimicrobial feed. Based on wood-like waste, organic electrodes for fuel cells are to be developed and carbon dioxide is to be developed as a carbon source for chemicals by means of microbial electrosynthesis.

Whether, and to what extent, the projects achieve the quantitative goals mentioned above, and which conclusions can be derived from the experiences of the projects, will be investigated in an accompanying project for all projects. There, obstacles and drivers of the bioeconomy in the metropolitan region will be analysed, taking into account economic, legislative and scientific factors. Finally, based on macroeconomic and ecological assessments, methods for local authorities to evaluate their specific bioeconomy potential will be offered.

The BioBall innovation space also addresses training so that the economy has the necessary specialists available to implement the targeted procedures. The participating universities already cover the entire range of disciplines required for educating in bio-

economics. The students are taught how different biorefinery concepts are developed and applied in industrial practice. The course content should enable the participants to understand and evaluate complex industrial concepts for the material and energetic use of bio-based raw materials. This also includes subject areas and courses of study that supplement the technical-scientific education (biotechnology, chemistry, mechanical engineering, process engineering) with regard to economic issues, biodiversity, urban and regional planning or life cycle analysis, material flow management and resource management. It is part of the culture of innovation that BioBall strives for that the exchange between all actors also leads to suggestions for teaching.

*BioBall e. V. offers, for the actors of the innovation space, communication formats that address the technical possibilities of the use of regional material flows and its economic and ecological potential. The aim is to ensure that the exchange within these platforms initiates a continuous pipeline of ideas for technical-scientific processes and product developments.*

# 10 the bioball innovation space: timeline and next steps

Finally, the timeline of BioBall's development to date and the steps planned for the future are presented.

In 2016, the BMBF published the call for proposals „Innovation Spaces Bioeconomy" and invited innovation intermediaries to submit initial sketches of ideas. Out of 38 that submitted ideas, 14, including BioBall, were invited to develop a concept by August 2018. In the Frankfurt Rhine-Main metropolitan region, actors from science and education, private and municipal industry, politics, public administration and innovation mediation formed several working groups that developed the network and conceived the vision, mission, strategy and organisation of the BioBall innovation space. In April 2019, the BMBF selected a total of 4 innovation spaces from the 14 submitted concepts (Table I). They provided each innovation space with a public funding budget of up to 20 million EUR for technical and scientific research and development projects for the period 2019-2024. To foster collaboration between industry and research, an innovative funding scheme is being applied, in which the total funding budget can only be utilised when industrial co-funding (1 EUR from industry generates 1.5 EUR funding) will be obtained.

- BioBall e.V. (Bioökonomie im Ballungsraum e.V.) was founded in 2019 and the office started its work **in November 2019**.
- **In 2020**, the first research projects and the accompanying project will be launched. Thus, the innovation alliance, which comprises all research and development projects, will begin to develop out of the innovation space.
- **From 2020 onwards**, further research and development projects will follow, which will be initiated from the innovation space.
- **From 2021 onwards**, the innovation space will be consolidated by involving further actors. In addition, networking with similar metropolitan regions in Germany and Europe will be intensified. This will provide a basis for the economic utilisation of the project's results beyond the Frankfurt Rhine-Main metropolitan region.

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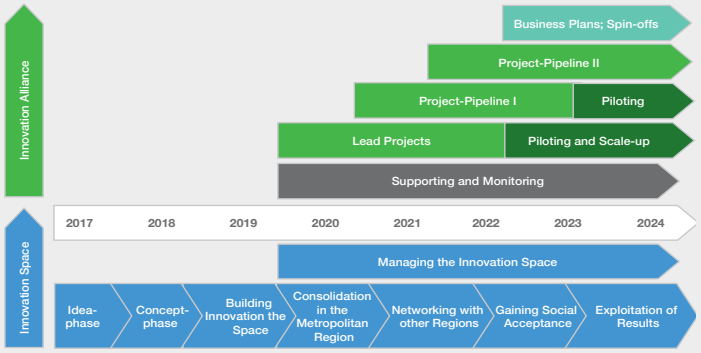


BioBall has a long-term vision. The current funding phase is only the beginning

I

| | Innovation Space | Coordination |
|---|---|---|
| **BamS** | Bioeconomy on marine sites (Bioökonomie auf marinen Standorten) | Kiel University (hristia Albrechts-Universität zu Kiel) |
| **BioBall** | Bioeconomy in metropolitan regions (Bioökonomie im Ballungsraum) | Provadis School of International Management and Technology AG |
| **BioTexFuture** | Production of bio-based textiles based on sustainable raw material cycles (Herstellung biobasierter Textilien auf Basis nachhaltiger Rohstoffkreisläufe) | RWTH Aachen University (Rheinisch-Westfälische Technische Hochschule Aachen) |
| **NewFoodSystems** | Development of new land- and resource-saving food production systems with consumer involvement (Entwicklung neuer flächen- und ressourcenschonender Systeme der Lebensmittelproduktion unter Einbindung von Konsumenten) | Federal Research Institute of Nutrition and Food (Max Rubner-Institut Bundesforschungsinstitut für Ernährung und Lebensmitte) |

**H DEVELOPMENT STEPS AND SCHEDULE OF THE BIOBALL INNOVATION SPACE I THE FOUR BMBF-FUNDED INNOVATION SPACES OF A BIOECONOMY**

- **From 2022 onwards**, the first research results will be piloted on an industrial level. The first business plans for new companies and spin-offs are expected from 2023. The funding phase will end in 2024 and the innovation space will continue to develop under its own steam.

**With this concept, BioBall offers all actors in academia, private and municipal business, municipal administration and society a long-term innovation space moderated by innovation mediators, for which the initial funding is only the catalyser for the future development of the "Innovation Space Bioeconomy" in the metropolitan region.**

Source: H Provadis Hochschule

*Creating an innovation space for bioeconomy needs new approaches on how to use biogenic waste as raw materials and an active exchange between research, administration and industries.*

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