

The Baden-Württemberg's government's sustainable bioeconomy strategy

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Dear readers,

a sustainable economy requires us to use our limited natural resources in a responsible manner. Fossil resources are finite and have an impact on the environment and the climate. The bioeconomy can help us solve many of the complex challenges associated with our need for and utilisation of raw materials. Unlike most other fields of research and technology, the knowledge and economic sectors in a bioeconomy aim to reconcile economic, environmental and social aspects. This is one of the reasons why they are among the fastest-growing economic sectors in Europe and the world.

The Baden-Württemberg government sees the huge potential in a sustainable and circular bioeconomy. Back in 2013, it launched the systemic research strategy “Die Bioökonomie im System aufstellen”. The concept of a bioeconomy has the potential to tackle climate change, ensure food supply and satisfy consumer as well as industrial requirements.

In June 2019, the Baden-Württemberg government decided to launch a cross-departmental regional strategy entitled “Sustainable Bioeconomy Baden-Württemberg” to put the knowledge that was generated into practice. Through this strategy, the Baden-Württemberg government is supporting the transition into a resource-efficient and circular economy based on renewable and biological resources.

The Baden-Württemberg government’s regional strategy has the following basic objectives:

1. Developing renewable and recyclable sources of raw materials, reducing greenhouse gas emissions, conserving natural resources and strengthening biodiversity using innovative biological concepts.
2. Making Baden-Württemberg an excellent role model for a sustainable and circular regional economy. The Baden-Württemberg government aims to achieve a climate-neutral economy while also focusing on innovative economic fields where value creation occurs largely in the regions themselves. Creating attractive and sustainable jobs in rural areas is an important part of the process.

Reliable and innovation-friendly framework conditions are expected to help industries and businesses within the regional economy exploit the potential of robust growth markets and innovative technologies. Examples include new production systems and conversion processes for biomass, innovations for various sections of the food value chain, and fine/specialty chemi-

cals produced using biotechnology or with the help of microorganisms. The Baden-Württemberg government is also focusing on the recycling of nutrients and raw materials through the high-value utilisation of by-products, residues, waste, wastewater and CO₂ as resources.

The Sustainable Bioeconomy Baden-Württemberg strategy was developed in close dialogue with the relevant stakeholders. As these stakeholders were involved early in the process, we have been able to broadly coordinate diverse topics, focal points and goals. Furthermore, we have had the chance to identify key research and development tasks as well as important conflicting goals. The strategy foresees the use of a wide range of technologies, without however specifying specific raw materials, processes, technologies or utilisation pathways. The strategy will be developed further and its progress monitored and assessed.

The Baden-Württemberg government is convinced that its Sustainable Bioeconomy Baden-Württemberg strategy will contribute to developing local expertise in a future sustainable and circular bioeconomy sector, as well as helping to raise the international visibility of stakeholders from science and industry in this sector in Baden-Württemberg and improving their international competitiveness. We would like to thank everyone who has participated in developing the strategy and will continue to support this process for the benefit of our state.



A handwritten signature in black ink, appearing to read 'Peter Hauk'.

Peter Hauk MdL
Minister for Rural Affairs and Consumer
Protection



A handwritten signature in black ink, appearing to read 'Franz Untersteller'.

Franz Untersteller MdL
Minister for the Environment, Climate
Protection and the Energy Sector

I. SUSTAINABLE BIOECONOMY STRATEGY FOR BADEN-WÜRTTEMBERG

1 INTRODUCTION

The way we currently organise our economy and our lives is based largely on the consumption of finite fossil raw materials, which is far from sustainable. The continued and, in some cases, increasing consumption of fossil resources accounts for many greenhouse gas emissions and progressive climate change. Carbon compounds such as plastics that are not recycled or safely disposed of are increasingly polluting the earth's ecosystems and endangering biodiversity and even our health as they enter the food chain. Dwindling resources threaten the supply of food, raw materials and energy to a constantly growing population.

Applying bioeconomic principles to society and the economy through a life sciences approach is seen as a potential way to move towards a sustainable and circular bioeconomy. In the definition given by the German government's Bioeconomy Council, the bioeconomy is understood to be an economy “which, through the knowledge-based generation and use of biological resources, provides processes and principles, products, methods and services in all economic sectors within the framework of a sustainable economic system”.

The transition to such an economic system requires political guidance to oversee the process. Governmental and economic incentives as well as social rethinking are needed.

With this in mind, political strategies aimed at implementing the bioeconomy in the EU and Germany were developed and presented in 2010, 2012 and 2013. However, regional and location-based conditions can only be dealt with effectively through regional strategies. Baden-Württemberg positioned itself very early on with the Baden-Württemberg government's “Die Bioökonomie im System aufstellen” strategy, developed in 2013 by a strategy circle at the Baden-Württemberg Ministry of Science, Research and the Arts.

Building on this research strategy, the governing parties agreed in the coalition agreement for the 16th legislative period (18th October 2005 to 27th October 2009) to “work together in an interdisciplinary way and in cooperation with the industry to analyse the potential and technological impacts of innovative biotechnological methods and processes used in a wide variety of applications, with the exception of the application of genetically modified organisms, and

promote the recovery of raw materials using biological processes. In addition, the parties called for bringing together all existing and planned activities under the Sustainable Bioeconomy Baden-Württemberg strategy.”

The Baden-Württemberg Ministry of the Environment, Climate Protection and the Energy Sector and the Baden-Württemberg Ministry of Rural Affairs and Consumer Protection, which are charged with developing a bioeconomy strategy in Baden-Württemberg, have laid out a political strategy aimed at paving the way for a sustainable, knowledge-based bioeconomy and its further development in Baden-Württemberg. The strategy also takes into account the results of the systemic research strategy as well as the recommendations for action developed by stakeholders from industry and society in a broad participatory process that looked at issues focussing on “Sustainable Bioeconomy for Rural Areas in Baden-Württemberg” and “Bioeconomy in Industrial and Urban Areas in Baden-Württemberg”.

All measures implemented must be financially sound in accordance with the constitutional requirements relating to a sustainable financial policy and applicable to public authorities. A sustainable financial policy requires a responsible and fair use of financial resources for both present and future generations. Space for redevelopment first needs to be created within existing programmes and the existing funding framework before current measures can be expanded or new ones implemented. Decisions regarding the provision of funds required for implementing the Sustainable Bioeconomy Baden-Württemberg strategy or reallocating existing funds will be made in future budget discussions; budgetary framework conditions will be taken into account.

2 OPPORTUNITIES AND DRIVERS OF A SUSTAINABLE BIOECONOMY

The bioeconomy is regarded as one of the primary drivers of innovation over the coming years. It can contribute to bringing about a systemic change in the way goods are produced, used and recycled or converted into energy at the end of their life cycle. It creates new approaches to food supply and the provision of products and energy. The bioeconomy thus not only opens up opportunities for addressing environmental and climatic issues, but also has great potential for creating attractive, environmentally friendly jobs in rural, urban and industrial areas.

The Baden-Württemberg government anticipates that a bioeconomy can offer long-term opportunities and potentials in Baden-Württemberg, notably in the following areas:

- **Ecology:** A sustainable bioeconomy contributes to climate protection, preserving ecosystems and biodiversity, the sustainable use of renewable resources and, ultimately, by respecting the region's ecological limitations, to Baden-Württemberg's sustainable development.
- **Economy and Society:** The sustainable bioeconomy can open up new opportunities for the economy. It can help protect jobs, generate investment and promote innovative food supply chains and new environmentally friendly products. At the same time, the bioeconomy has the potential to create added value in agriculture and forestry and rural areas in general.
- **Societal change:** The sustainable bioeconomy encourages us to transform the way we think, and move away from linear towards circular thinking and acting.

3 BASIC UNDERSTANDING OF THE SUSTAINABLE BIOECONOMY

The German government's Bioeconomy Council defines "bioeconomy" as the "knowledge-based production and utilisation of biological resources, biological processes and principles," to "provide goods, processes and services across all economic sectors within the framework of a sustainable economic system" (Bioeconomy Council, Further development of the "National Research Strategy BioEconomy 2030", 2016).

Drawing on this very technical definition, the Bioeconomy Council has reoriented its focus in its most recent statements. Accordingly, sustainable agricultural and food systems will remain

central topics in the future. In addition, the Bioeconomy Council will be focusing on the following current-interest topics: digitalization, biobased and sustainable cities, resource conservation, biobased circular economy and sustainable consumption (Bioeconomy Council, Thesen zur Gestaltung der Bioökonomiepolitik, 2018).

Today, the bioeconomy concept has developed into a political strategy approach for developing economic systems for resource and climate protection across all policy areas and levels around the world (OECD, G7, EU, individual states and countries), Ethical and social aspects have also been taken into account.

Against this background, the Baden-Württemberg government defines "bioeconomy" as the knowledge-based generation and utilisation of biological resources, processes and principles that are used to provide and utilise goods and services in all economic sectors within the framework of a sustainable economic and social system.

The definition of "bioeconomy" is kept deliberately broad. In addition to agriculture and forestry with their upstream and downstream sectors, the Baden-Württemberg government's definition also includes the environmental economy sector and all areas that apply life science knowledge.

The Baden-Württemberg government sees a sustainable bioeconomy as more than just a strategy to replace fossil raw materials. As the Baden-Württemberg government sees it, the objective of a sustainable bioeconomy is the intelligent management of natural resources and (regional) material flows for the provision of food and feed as well as materials and raw materials for producing goods and energy. Material flows need to be as circular as possible. In addition to plants as traditional renewable raw materials, the bioeconomy also includes other forms of life such as animals, fungi and microorganisms (biotechnology). It takes into account functional aspects of biology such as metabolic performance, biological systems and other system functions. Other resources of a bioeconomy are biological knowledge, system understanding and connecting biology with technology.

A "sustainable bioeconomy" for Baden-Württemberg is oriented towards and contributes to the Baden-Württemberg government's sustainability principles and goals as well as the United Nations' Sustainable Development Goals.

In its latest action plan, the European Commission also presented its ideas on understanding the ecological limitations of the bioeconomy and the need to take sustainability aspects into account as one of the three pillars of its bioeconomy policy (EU-COM 2018).

The aim is to integrate the requirements of the sustainability strategy as a quality feature into the individual steps of the value creation chain, making them an integral part of corporate quality management.

4 OBJECTIVES AND PRINCIPLES OF BADEN-WÜRTTEMBERG'S SUSTAINABLE BIOECONOMY STRATEGY

The goal of the Sustainable Bioeconomy Baden-Württemberg strategy is to provide economic players with ideas and inspirations aimed at establishing a sustainable economy in Baden-Württemberg based on biological resources. In accordance with the Baden-Württemberg government's sustainability goals, the strategy is expected to contribute to the region's sustainable development. The strategy therefore needs to be open to a wide range of technologies, without specifying raw materials, processes or utilisation pathways, and leaving space for further areas to be addressed once different situations have been evaluated. The basic conditions for a bioeconomy need to be designed in a positive way. Funding and support for certain initiatives will be provided to ensure that initial developments and transformation are carried out in a targeted manner.

Given this context, the Baden-Württemberg government's strategy is to pursue the following objectives:

Objective 1:

The Sustainable Bioeconomy Baden-Württemberg strategy will use innovative biological concepts to identify renewable or recyclable raw material sources. This is expected to considerably reduce the use of fossil raw materials and permanently reduce our dependence on energy and raw material imports.

Objective 2:

The Sustainable Bioeconomy Baden-Württemberg strategy will reduce greenhouse gas emissions in Baden-Württemberg and conserve natural resources and biodiversity.

Objective 3:

With the help of the Sustainable Bioeconomy Baden-Württemberg strategy, Baden-Württemberg will become a role model for the transition into a sustainable and circular economy.

Objective 4:

The Sustainable Bioeconomy Baden-Württemberg strategy will strengthen rural areas in Baden-Württemberg by increasing regional value creation through innovative bioeconomic solutions and by creating attractive, sustainable jobs.

In implementing these objectives, the Baden-Württemberg government sees the following principles as the framework for a sustainable bioeconomy:

- In general, food production takes priority for land use.
- Requirements for the preservation of biodiversity and natural environments are taken into account.
- Utilisation pathways with a higher economic, ecological and social value creation potential will always be preferred. After food production, these include specifically the material and energetic use of agricultural and forestry products that are not grown for the purpose of food production, such as perennial crops, biomass and its components that are not intended or needed for feeding humans and animals.
- The framework conditions of the principles of sustainability must be examined at an early stage for all developments, i.e. during planning and continuously during the course of development and market introduction.
- Wherever possible and appropriate, coupled, cascade and circular concepts should be applied. Priority should be given to the most efficient utilisation in line with the overarching objectives.
- Using biomass for energy production should be the very last step of as many material utilisation cycles as possible.

Measures derived from these objectives should specifically be applied in cases when

- good incentives are unavailable at the national or EU level or when the regional conditions in Baden-Württemberg are not adequately presented
- structural changes and transformation processes are required
- sustainable developments and innovations can be initiated or specifically supported.

The Sustainable Bioeconomy Baden-Württemberg strategy does not aim to replace subject-specific policies, but rather to promote cross-departmental cooperation and interdisciplinary involvement of social actors. Biological resources should be increasingly integrated into the value chains of industry and energy products.

In addition to using biobased methods and biological processes, opportunities will be created to utilise organic waste and wastewater as raw material sources, and to efficiently and affordably exploit non-renewable, abiotic resources and recover them from industrial, consumer and energy products. The idea is to stimulate a shift in raw material utilisation based on the European Commission's "closing the loop" action plan for the circular economy. This envisages as many raw materials as possible being fed back into circular economies while taking into account environmental and economic criteria. The goal is to maintain high quality, high value materials (without downcycling).

For this to be successful:

- industry, science and society have to act together more closely, establishing links between value chains that did not exist before, and recycling products and substances as high-value products after their utilisation phase
- new value chains and networks must be developed across all economic sectors with new production and logistics processes and products
- the material flows between rural, urban and industrial areas need to be optimised to achieve a greater degree of inclusion of raw materials and nutrients across these three areas in the circular economy
- specialised jobs must be created to utilise regional biological resources and convert them locally into products
- legal obstacles to the envisaged bioeconomy system must be identified and it needs to be assessed as to how existing laws can be adapted to the new system, and whether the necessary development of existing laws can be initiated by the Baden-Württemberg government.

A sustainable bioeconomy based on locally exploiting regional biogenic material flows and converting them into products will increase the need for well-trained professionals in rural areas. Creating such jobs in rural areas is key to the implementation of the Baden-Württemberg's strategy.

Baden-Württemberg is already known globally as an economic and high-tech location for developing efficient, energy-saving and environmentally friendly technologies. With its Sustainable Bioeconomy strategy, the Baden-Württemberg government is also aiming to play a pioneering role in the sustainable development of the bioeconomy, both technologically and socio-politically, on a national and international level.

The adaptation of the latest biomass cultivation methods as well as innovative biobased materials and products along with biological raw material extraction and production processes can serve as models for the transition towards a climate-neutral, sustainable economy.

5 DEVELOPMENT OF BADEN-WÜRTTEMBERG'S SUSTAINABLE BIOECONOMY STRATEGY – SUSTAINABLE BIOECONOMY STRATEGY PLATFORM

Important foundations for Baden-Württemberg's Sustainable Bioeconomy strategy were developed in cooperation with social stakeholders - actors from primary production, trade, manufacturing, academia, social partners, non-governmental organisations and the financial and banking sectors participated in this process. The core content of the strategy platform comprised eight thematic working groups in two thematic branches. This participatory strategy process offered the opportunity to make a regional contribution to the development of the Baden-Württemberg government's Sustainable Bioeconomy strategy.

The dialogue processes comprised two branches:

- **Bioeconomy in rural areas**

Under the leadership of the Baden-Württemberg Ministry of Rural Affairs and Consumer Protection, this branch dealt with "Efficient and environmentally friendly production and sustainable provision of biomass through agriculture and forestry and their processing into high-quality traditional and innovative products as well as other marketing opportunities". One focus area was the exploitation of side streams and residues from biomass production and processing for coupled and cascade usage.

- **Bioeconomy in urban and industrial areas**

Under the leadership of the Baden-Württemberg Ministry of the Environment, Climate Protection and the Energy Sector, this branch incorporated into the overall system the utilisation of biowaste, other waste, wastewater and CO₂ and the possible applications of biological processes, procedures and principles in the industrial, commercial and municipal sectors. The overall goal was environmental, climate and resource conservation. To improve the focus, priority was given to the B2B area.

In the period from October 2017 to October 2018, over 100 experts got together to develop recommendations for action. In addition, issues that need to be clarified by scientific studies were identified. A board consisting of spokespeople from the working groups and representatives from the leading ministries accompanied and oversaw the work in the working groups and both branches.

BIOPRO Baden-Württemberg, a wholly-owned subsidiary of the Baden-Württemberg government, was given the task of leading and implementing the dialogue process in both branches. This process was funded by the Baden-Württemberg Ministry of the Environment, Climate Protection and the Energy Sector and the Baden-Württemberg Ministry of Rural Affairs and Consumer Protection. Technological, socio-economic and environmental aspects were taken into account to ensure comprehensive discussions about the bioeconomy and sustainability.

II. AREAS OF ACTION, STRATEGIC APPROACHES AND MEASURES

The Baden-Württemberg government has set clear priorities in the Sustainable Bioeconomy Baden-Württemberg strategy so that the region can take full advantage of the opportunities offered by a bioeconomy. The measures are described below (subdivided into six action areas).

6 BIOECONOMY IN REGIONAL POLITICS AND ADMINISTRATION

6.1 Action area: Supportive framework for a sustainable bioeconomy

Objective: Develop and instrumentalise a sustainable circular bioeconomy to promote Baden-Württemberg's sustainable development and identify potential obstacles and support options offered by regional policies and government.

6.1.1 Connecting sustainability and bioeconomy

The Baden-Württemberg government will primarily provide support measures that contribute to the sustainability objectives set out by the Baden-Württemberg government (e.g. a biowaste refinery can contribute to the sustainability objective by recycling more municipal waste). These contributions to sustainability need to be identifiable and measurable with appropriate indicators. These are not yet available for Baden-Württemberg and therefore need to be developed. In addition, quantifiable targets must still be identified in order to develop the bioeconomy in a positive way over the long term.

Measure 1 (objectives and indicators)

The Baden-Württemberg government will develop qualitative targets with quantifiable indicators for a sustainable bioeconomy in order to be able to effectively measure the contribution that a sustainable circular bioeconomy is making to existing sustainability objectives.

6.1.2 Baden-Württemberg Sustainable Bioeconomy Council

Implementing and further developing Baden-Württemberg's Sustainable Bioeconomy strategy requires experts in different disciplines to share their knowledge. This requirement was taken into account by the board of experts involved in drafting the strategy and will continue to shape future transformation processes in Baden-Württemberg. To this end, the Baden-Württemberg government will set up an advisory council to pool existing expertise and advise the government on the implementation and further development of the strategy. This framework

will provide space for exchanging thoughts on the opportunities and risks for ecosystems, biodiversity, climate protection and land use.

Measure 2 (Sustainable Bioeconomy Council)
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The Baden-Württemberg government will establish the Baden-Württemberg Sustainable Bioeconomy Council to provide support for the implementation and further development of the Sustainable Bioeconomy Baden-Württemberg strategy.
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6.1.3 Legal framework

The development of a sustainable and circular bioeconomy will be subject to the positive and negative effects of regulations and rules from different legal areas as well as strategic approaches on a national and European level. Due to the innovative nature of biological production in many areas, some aspects of the bioeconomy have either not been sufficiently considered in many regulations or may even have an unintentional inhibitory effect. For example, to protect against the outbreak of certain animal infectious diseases such as mad cow disease (BSE) and to ensure compliance with the hygiene requirements governing primary feed materials, livestock feed (including insects intended for the production of animal feed) are strictly regulated. This is currently hampering the development of an insect biotechnology for chemical raw materials based on biowaste (the natural food source for certain insects). As such, stakeholders must be given support to help them comply with the diverse and often complicated regulations that can have direct or indirect effects on the bioeconomy. In cooperation with the German Federal Government and the EU, experimental approaches such as “regulative innovation zones” or “clearing houses” can serve as reference points for specific optimisations and promote a sustainable bioeconomy.

Measure 3 (legal) framework

Baden-Württemberg will use the “regulatory innovation frame” approach to assess which conditions might inhibit or promote the development and dissemination of a sustainable circular bioeconomy in Baden-Württemberg and how these basic conditions can be further developed in a targeted manner.

The implementation of biological innovations in companies and municipalities generally depends on the relevant approval procedures. In future, existing forms of consultation provided by the relevant approval bodies will have to be expanded to encompass a broader range of qualified people.

Measure 4 (consulting companies/clearing houses)
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Baden-Württemberg will analyse optimal ways for companies and municipalities to access consultation on the legal framework, authorisation processes and application procedures when implementing biological innovations into their production and business processes.

6.1.4 Cooperation at federal level and representation of regional bioeconomy areas at the federal and EU level

Measure 5 (supra-regional participation)
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Baden-Württemberg will take a regional approach to developing the sustainable bioeconomy. It will also be actively involved in exchanges with other regions with regard to taking into consideration and implementing regional policies in efforts to introduce and further develop supra-regional initiatives at the federal and EU level. Interlocutors include German federal government/regional councils, conferences of ministers and the German Bundesrat (Federal Council) as well as the German Federal Government and the EU.

6.1.5 Public procurement in Baden-Württemberg

Public procurement serves as a role model. Greater focus will be placed on integrating sustainable bioeconomy products and services within public procurement.

Measure 6 (public procurement)

This measure involves assessing how aspects of the sustainable circular bioeconomy can be integrated into public procurement.

6.1.6 Idea competitions for innovative bioeconomy solutions

Baden-Württemberg is a leading location for research and innovation, where talented individuals come up with innovative solutions and products. This potential will be linked to the development of a sustainable circular bioeconomy in Baden-Württemberg and used to solve current challenges. For this purpose, idea competitions addressing current issues will be launched, with examples including biobased sustainable packaging alternatives, targeted at initiating transformation in the packaging industry and trade sectors.

Measure 7 (idea competitions)

Baden-Württemberg will announce and open applications for idea competitions addressing current issues, with the aim of introducing innovative bioeconomy solutions and products.
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7 THEMATIC AREAS OF ACTION

7.1 Action area: Sustainable bioeconomy in rural areas

Objective: Securing the supply of raw materials for a sustainable circular bioeconomy and exploiting future-oriented opportunities for creating added value and employment in rural areas.

Strategic approaches and measures

With their natural resources and expertise, rural areas serve as more than mere suppliers of raw materials for industrial processes. They can add impetus to the development of a sustainable bioeconomy by implementing decentralised bioeconomy approaches. Of particular note is the potential offered by the bioeconomy to create new sectors in peripheral regions outside metropolitan areas. These can make a significant contribution to increasing value creation and creating attractive, knowledge-based job opportunities. The aim is to carry out a majority of the steps within the value chain in rural areas and thus have a positive effect on the total value added as well as employment in rural areas.

This action area is focused on promoting the efficient, sustainable use of available natural resources while also considering the preservation of biodiversity as well as the conservation of soil and forest functions. Individual regions need to maintain their capacity to supply raw materials of sufficient quantity and quality for use in traditional and bioeconomy markets while ensuring that ecological boundaries are respected. As far as forest areas are concerned, it is crucial to preserve and create suitable local, natural, healthy, productive and stable forests across all forest ownership types so that future generations have space and opportunities for further action.

7.1.1 Sustainable generation and supply of biological resources

Maintaining a diversity of species and genetic variability within different plant types, along with special cultivation systems and methods, is the cornerstone for sustainable agricultural and forestry plant production as a raw material basis for the bioeconomy. Soil, water and nutrient resources are essential for the bioeconomy and must be intelligently and sustainably managed so that the future requirements and needs of society can be satisfied without overburdening our ecosystem capacities or threatening biodiversity. In this context, integrated and organic farming each offer their own respective advantages and should therefore be developed into a beneficial mix. While organic farming is limited in terms of yields, it offers additional social benefits within a systems approach. Regardless of natural performance, the regional value creation potential of cultivation systems in agriculture and sustainable, natural forestry need to be exploited in the best way possible. Integrated as well as segregated approaches for land-use

systems suited to the local area need to be used. Key focus areas include genetic variety, biodiversity, valuable substances and the functionality provided by (crop) plants, ecosystem services, the reduction of greenhouse gas emissions and CO₂ storage as well as resistance, regenerative ability and the multi-functionality of land-use systems.

Measure 8 (land use systems of the future)
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The Baden-Württemberg government will promote applied research and development on the efficient generation and supply of regional biomass, taking into account sustainability, the preservation of biodiversity and climate change mitigation as well as any new requirements, demands and markets.

Measure 9 (analysis of potentials)

Scenarios will be developed outlining future regional biomass demand in Baden-Württemberg and analysed in terms of environmental and sustainability aspects in order to estimate sustainable biomass potential.

7.1.2 Food systems and food of the future

Demographic change, an increase in nutrition-related illnesses and changing lifestyles and conditions are important societal and scientific challenges that must be overcome through the development of a sustainable circular bioeconomy. Baden-Württemberg is promoting healthy and balanced nutrition as well as the reduction of food waste through its “Nutrition Strategy for Baden-Württemberg”. In addition, the food and nutrition sectors are important economic sectors in the bioeconomy with a large degree of innovative power and high potential for value creation. They are especially important for Baden-Württemberg due to the region’s prominent food industry. This is because quality and the individual added value of a product can have a positive impact on purchasing decisions. At the same time, the sales of value-adding regional foods can boost incomes for family-run farms.

Specific objectives:

- innovative, demand-oriented nutrition concepts of the future,
- healthy, regional foods of the highest quality,
- reducing environmental pollution and waste (from producer through to the consumer),
- innovative solutions and products that contribute to economic growth, especially of small and medium-sized enterprise (SMEs in the commercial sector),
- improving the competitiveness of Baden-Württemberg’s food industry.

Measure 10 (food systems and food of the future)
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Baden-Württemberg is specifically promoting applied research and development on consumer-oriented product and process innovations along the value-creation chain for food. The focus of these efforts includes technical and digital innovations in the area of traceability systems for the origin, hygiene, safety and shelf life of food as well as the process-related improvement of food processing.
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7.1.3 Digitalization in agriculture and forestry

Digital options in the areas of agriculture and forestry offer enormous opportunities for promoting efficient and effective biomass generation as well as bioeconomic value creation chains. These digital options, from areas such as sensor technology, networks and robotics, enable the implementation of real-time systems and the fusion and analysis of information (smart production and conversion), which can provide even greater production and decision-making support for consumers when paired with the Internet of Things, cloud computing, big data, artificial intelligence applications and blockchain technologies (digital production and conversion).

Moreover, these digital options ensure that bioeconomic value-creation chains become even more transparent and allow for traceability. This is supported by more intensive networking between value-creation chains, which also promotes more efficient and effective logistics within these value chains. This is especially relevant for biomass-based value chains since biomass is a perishable good and not easily transported. Digital options enable biomasses to be produced and processed in a more environmentally friendly way that is more acceptable to society. This not only has logistical advantages but is also down to biomass production methods that are friendlier to the environment and nature due to the decreased use of chemical pesticides. These characteristics might also be relevant for international competitiveness.

Furthermore, an attribute that should not be underestimated is the fact the digital options make jobs within bioeconomic value-creation chains more attractive. This may help overcome a potential shortage of experts and future employees.

Research and technological infrastructure and education and training facilities for bioeconomy and technology will also need to be put in place.

Measure 11 (digitalization in agriculture and forestry)

Within the scope of the “Agriculture and Forestry 4.0 - sustainably digital” projects, Baden-Württemberg intends to take full advantage of dynamic developments and innovations in digitalization to boost resource efficiency across the entire process chain and promote innovative applications and business models. This approach is oriented towards specific operational and business structures present in Baden-Württemberg. A link to digitized material flow management will also be established.

7.1.4 Intelligent raw material and material flow management

A constant supply of consistently high-quality raw materials is essential in most industrial sectors. This poses a challenge for biobased process chains. One reason for this is that raw materials from agriculture are produced seasonally in certain harvest cycles. It is therefore essential to implement clearly defined utilisation concepts that allow for and ensure a continuous supply of biogenic raw products and materials for process industries in the required amounts and quality levels. This requires developing suitable concepts for harvests, decentralised processing, logistics and warehousing, minimizing post-harvest losses and ensuring that the quality of the biomass is maintained during storage and processing. It also requires interface management, involving stakeholders, setting quality requirements, checking cost efficiency and agreeing on standardised quality parameters.

Measure 12 (intelligent raw material and material flow management)

Baden-Württemberg will support innovation initiatives that contribute to the efficient mobilisation of regional biogenic raw materials based on the availability of residual materials, side streams and biowaste from primary production and processing and to intelligently organise their supply through the use innovative digital and biological channels.

Measure 13 (information platform for knowledge and biogenic raw materials in rural areas)

Baden-Württemberg will develop a concept for a digital information platform aimed at facilitating knowledge exchange as well as the supply and demand of raw materials from agriculture and forestry. The aim is to make biogenic resources and materials, needed for industrial uses that have thus far been under-utilised, and usable as a basic material for high-quality value creation.

7.1.5 Promoting the intelligent use of biological resources

Newer chemical, thermal and biotechnology-based conversion processes enable the production of new materials and biobased platform chemicals that could replace fossil resources and offer

new, superior characteristics. However, a number of these processes are still limited to the scale of laboratory or pilot projects. Demonstration facilities and concepts for implementation are needed so that further testing, evaluation and optimization can be undertaken. The broad integration of engineering and production processes, within integrated biorefinery concepts, for example, calls for links to be established among experts in different areas and cooperation to occur between actors across new networks.

Effectively implementing circular economy concepts, coupled usage and successful market introduction of new materials and products requires cooperation between the research and development areas and consumers as well as connections between economic sectors and industries.

Measure 14 (pilot/demonstration facilities)

For the purpose of demonstrating feasibility and further developing the comprehensive processing of biological resources into innovative products, the Baden-Württemberg government will support the creation of pilot and demonstration facilities. These facilities will serve as role models for future decentralised, modular biofactories in rural areas. Existing funding guidelines will be extended for this purpose. The focus here remains on lignocellulosic crops, side streams and residual materials along the agricultural and forestry value chains as well as valuable ingredients and functionalities offered by plants.
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Baden-Württemberg's forests and sustainably managed renewable raw material in the form of wood offer ideal conditions for the material use of timber. Timber construction companies located in Baden-Württemberg are a major driver of innovative developments and generate ideas for the rest of Europe. The increasing use of wood as a raw material, in construction for example, can help replace CO₂-intensive resources such as steel and cement. When sustainably harvested and efficiently used in products with long life cycles, wood can make a significant contribution to reducing CO₂ in the atmosphere.

The Baden-Württemberg government is embracing this development through its timber construction offensive and its hardwood technical centre, thus paving the way for new ideas and approaches.

Measure 15 (promoting the material use of wood)

Baden-Württemberg is launching a timber construction offensive and establishing a technical centre for hardwood to promote the increased use of wood as a material.

7.1.6 Further development of the biogas plant inventory

The biogas plants in Baden-Württemberg account for around 8 percent of gross electricity generation (as of 2018) and make a reliable contribution to our renewable energy supplies. Over half of this is produced by the 950 agricultural biogas plants found in Baden-Württemberg. With the expiry of the guaranteed EEG (Erneuerbare Energien Gesetz, engl. Renewable Energy Sources Act) bonus, a major decline in biogas plants is expected for 2021, leading to a fall in biogas production capacities in Baden-Württemberg. At the same time, land for biomass production will become available, meaning that the relevant stakeholders must identify which areas (food, feed, fibre or fuel) offer the most effective use in a sustainable bioeconomy. The following are some examples of initiatives that will be pursued and supported::

- Developing practical strategies for maintaining and increasing farm manure fermentation capacities as a contribution to mitigating climate change
- Developing and assessing scenarios that supply bioenergy for various end uses (heating, mobility, electricity)
- Developing innovative utilisation concepts for residual substances / fermentation products from biogas facilities
- Creating conversion concepts and technologies that can use diverse raw materials for decentralised small-scale production of products such as basic chemicals, fibre and manure

Measure 16 (Further development of the biogas plant inventory)

Baden-Württemberg will develop a concept for the future-oriented, economically efficient and environmentally friendly expansion of its biogas plants following the expiry of the guaranteed EEG bonuses. The objective is to help existing biogas plants become essential elements in bioeconomy-based value-creation chains on a broad scale by promoting efforts such as the diversification of input materials and product palettes, making energy supplies more flexible and boosting energy efficiency.
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7.1.6 Regulatory and funding policies for rural areas

Innovations in rural areas have the potential to contribute to the creation of a sustainable bio-based economy in Baden-Württemberg. Success in this area depends on numerous factors, such as common agricultural policies, energy and climate policies, tax regulations and market and price developments, to name just a few. The competitive disadvantages of sustainable bio-economic methods and products that exist under current market conditions can be mitigated in part by intelligent regulatory and funding instruments. The first step involves analysing how to put in place effective incentives for investing in innovative production systems and processes.

This could entail investment subsidies or remuneration for ecosystem services, CO₂ storage, resilience when faced with the effects of climate change, environmentally friendly cultivation methods on moorland, integration into the circular economy or increasing the recyclability and sustainability of biobased products and materials.

Measure 17 (regulatory and funding policies for rural areas)

Baden-Württemberg will specifically extend its regulatory and funding instruments for rural areas for the bioeconomy. Idea competitions for start-ups, pioneering projects and flagship initiatives will be launched to promote bioeconomic innovations in rural areas and funding guidelines will be created or modified, if needed. The main focus will be innovative production systems, recyclable biobased products and materials and innovative business models along the agricultural and forestry value chains and their implementation in rural areas.

7.2 Action area: A sustainable bioeconomy in industrial and urban areas

Objective: Supporting the development and dissemination of dedicated biological innovations in the area of raw materials, methods, products and services to promote the sustainable development of the economy, municipalities and companies.

7.2.1 Biofactory pilot/demonstration facilities

Biological processes and methods can be used to recover useful raw materials in waste and wastewater. This will contribute to the creation of a true circular economy. Based on application-oriented research and pilot projects, Baden-Württemberg will support researchers and businesses in exploiting intelligent biorefineries, smart fermentation processes, biocatalysis and biological metal recovery as innovative forms of raw material supplies. This will include the establishment of biofactories as living labs and pilot facilities.

The “Bioeconomy in urban and industrial areas” branch will focus on the following fields of technology:

Separation and enrichment processes in intelligent biorefineries based on:

- industrial and municipal wastewater
- biological waste
- waste, residual substances and byproducts from industry.

Substance synthesis and CO₂ recycling via smart fermentation and biocatalysts with:

- for example microalgae, bacteria and fungi
- bioinspired technology (e.g. the use of enzymes, artificial photosynthesis).

Measure 18 (pilot/demonstration facilities)

Baden-Württemberg will specifically promote the research and development of pilot and demonstration facilities with the objective of turning biologically inspired methods into a model for a sustainable bioeconomy in modular biofactories.

7.2.2 Technology development for extracting and recovering inorganic raw materials

Biological metal extraction processes (biomining) such as the hyperaccumulation of metals by plants, bacterial processes (bioleaching, biooxidation, bioabsorption, etc.) and enzyme-based approaches are able to tap metalliferous deposits that have low levels of precious metals (such as in mine dumps) as well as secondary raw material sources such as electronic scrap or slag

that are increasingly accumulating in urban and industrial areas. The Baden-Württemberg government regards this as an important approach for securing future supplies of crucial high-tech raw materials, for which concentrated natural deposits are not (no longer) found in Baden-Württemberg. In addition, these approaches can be turned into an instrument for soil remediation.

Measure 19 (technologies for inorganic material extraction)

Baden-Württemberg is increasingly promoting innovative technological developments and pilot measures aimed at raw material extraction and the preservation of resources by way of biological processes (biomining), thus making a contribution to the supply of critical raw materials and the circular use of valuable metals.

7.2.3 CO₂ recycling (with biotechnical/bio-inspired technologies)

Biological systems use the special chemical / physical characteristics of carbon for energy and material cycles, which are mainly driven by solar energy. Humans merely copy this as a linear process by inputting more and more fossil carbon sources and emitting CO₂ - with known consequences for the world's climate. Today's economic output in the form of energy generation and synthesis processes is therefore based on the chemistry of carbon. Focus will now have to be placed on CO₂ recycling and circular management to maintain this.

Measure 20 (bio-CO ₂ recycling)
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Baden-Württemberg will establish a development priority for biotechnological / bio-inspired CO ₂ recycling in cooperation with applied researchers and the industry, which will contribute to achieving the 2030/2050 climate protection targets.
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7.2.4 Bioplastics

Many open questions remain about bioplastics and biodegradable plastics including their suitability for recycling, biodegradability and overall environmental assessment. Initiatives at the EU level and from industry and commerce require political accompaniment and framework conditions for steering the topic of biobased plastics into an ecologically meaningful direction.

Measure 21 (plastics for packaging)

Baden-Württemberg will address the issue of <i>plastics in the sustainable bioeconomy</i> . The Baden-Württemberg government plans to initiate a broader dialogue between research and industry. The mechanical engineering, chemical and trade sectors will be particularly encouraged to initiate transformation, especially in the packaging industry.

Measure 22 (developing recycling methods for bioplastics)

Baden-Württemberg will address the issue of *plastics in the sustainable bioeconomy* as well as the use of biobased alternatives by working with municipalities, public waste removal providers and private waste removal businesses to assess how to identify and implement recycling methods specifically for bioplastics.

7.2.5 Regional funding programmes for industrial and urban areas

The transformation towards a sustainable and circular bioeconomy within companies goes hand in hand with changes in the companies' core processes. This makes transformation highly complex and calls for a cautious approach. Analysing existing potentials and possibilities for implementation requires expanding know-how and making additional investments into the core business from the outset. Companies will therefore be given access to direct and long-term support for initiatives related to the bioeconomy.

Measure 23 (funding programmes for companies)

Baden-Württemberg will set up a funding programme for companies to open up space for a sustainable bioeconomy within the current economy. This will involve providing financial support and consulting via so-called bioeconomy scouts.

Baden-Württemberg will fund incentives for in-company bioeconomy investments and technological developments in areas that promote the bioeconomy, in addition to expanding funding mechanisms already in place. A contact point providing companies with subject-related funding advice will be set up within existing structures.

7.2.6 Collective innovation processes through sectoral dialogue

An important element in promoting the implementation of a sustainable bioeconomy in companies is the exchange of ideas and experience between companies. This involves, for example, sharing contact information for technical experts and encouraging cooperations. However, concepts cannot simply be copied from one company to another, as production processes and infrastructure in different companies, even within the same sector, are never exactly the same. Nevertheless, dialogue within and between sectors can be a source of inspiration. One idea for the future is to establish dialogue forums for various sectors, such as the automobile, machine and facility engineering, environmental technology, chemical and pharmaceutical and textile sectors.

Measure 24 (industry dialogue)

Baden-Württemberg will build on existing networks to develop concepts for initiating and reinforcing the exchange of knowledge and experience in the field of a sustainable bioeconomy within a given industry.

7.2.7 Collective innovation processes from cross-industry innovations

While exchanges at company level within a given industry certainly makes sense for disseminating established approaches, disruptive innovations can be better stimulated through collective innovation processes via cross-industry exchange. Such inter- and trans-disciplinary networking can promote technology exchanges in areas that would not be obvious at first glance (for example digitalization and newspapers → e-paper). Integrating external research and development is an important factor in cross-industry innovations.

Measure 25 (cross-industry innovations)

The Baden-Württemberg government will set up innovation challenges to advance cross-industry exchanges and promote technology transfers.
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8 INTERDISCIPLINARY AREAS OF ACTION

8.1 Action area: Networking among areas, actors and clusters

Objective: Supporting the development and dissemination of a sustainable circular bioeconomy by bringing together material flows and stakeholders in rural, industrial and urban areas.

8.1.1 Supporting thematic initiatives

Thematic initiatives (for example clusters and consortia) form the networks that can integrate and exchange knowledge and experience, facilities, materials, by-products and residues or waste along value chains within and between different areas.

Measure 26 (thematic initiatives)

Baden-Württemberg will implement regional subject-specific initiatives for networking between diverse stakeholders across geographical areas and support networking among rural, industrial and urban areas as well.
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A comprehensive platform will facilitate and even enable interdisciplinary, area- and cross-sectoral networking and information exchanges between the aforementioned actors, initiatives, competitions and networks / clusters.

8.1.2 From a research and innovation hub to leading region

Through the implementation of Baden-Württemberg's systemic research strategy ("Bioökonomie im System aufstellen"), the relevant universities and research institutions, with the support of the Baden-Württemberg Ministry of Science, Research and the Arts, have been able to develop structures, generate new knowledge and create a successful concept for knowledge and technology transfers within the scope of the Bioeconomy Baden-Württemberg research programme (2014-2020). This has led to the creation of promising successor projects funded with national as well as international resources.

It is in this context that Baden-Württemberg was cited in a European Commission study as one of the six top ranking European regions on the bioeconomy maturity index. The plan now is to maintain and increase Baden-Württemberg's visibility and pioneering role as a research, innovation, education and economic location for a sustainable bioeconomy. The focus will be on interdisciplinary research and education on the bioeconomy, as well as knowledge and technology transfer, which can be boosted by effective support for third-party funding applications

at the regional, national and EU levels and increased international networking. As many experts from Baden-Württemberg as possible must be involved in the implementation of the Baden-Württemberg government's broad-based approach to the sustainable bioeconomy, with the overarching strategy guided by Baden-Württemberg's Bioeconomy Council.

Measure 27 (bioeconomy research, innovation and education cluster)
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Building on established network structures of the Baden-Württemberg Bioeconomy research programme, the Baden-Württemberg government will provide support for and further develop the creation of a bioeconomy research, innovation and education cluster.

8.1.3 Platform for advising and bringing together clusters and initiatives

In today's world, networking and communication occur primarily through digital channels. Various actors, topic-specific initiatives, competitions and networks / clusters will form an overarching platform that facilitates and even enables networking across disciplines, initiatives, geographic areas and sectors along with exchanges and access to information. This will also facilitate networking in the real world. Specifically, this calls for the sharing of competent service and advice, such as support for large-scale cooperative R&D applications, professional advice for submitting applications to bioeconomy-related and interdisciplinary third-party funding calls (e.g. FNR, BLE, BMBF, BBI-JU, EU) as well as general funding programmes and questions about legal compliance.

Measure 28 (digital portal: Sustainable Bioeconomy Baden-Württemberg)

Baden-Württemberg is creating a digital platform to connect actors with existing offers and services, provide consulting information and expand the platform across all three areas (rural, urban and industrial), taking it beyond the current level of development. Specifically, exclusive and public forums will promote exchanges, publish tenders and competitions, provide networked advice on available funding and identify opportunities for participation in professional groups and initiatives. In addition, this platform will help entrepreneurs to find partners (e.g. via a chatroom, internal areas for thematic initiatives, funding recipients, etc.).
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8.1.4 The International Bioeconomy Congress Baden-Württemberg

The development of a future-oriented and sustainable bioeconomy requires regional action coupled with global thinking. The international "Bioeconomy Congress Baden-Württemberg", established as part of the Baden-Württemberg Bioeconomy research programme initiated by the Baden-Württemberg Ministry of Science, Research and the Arts, already serves as a platform for promoting international exchange and networking. In the future, it will also continue

contributing to boosting Baden-Württemberg's visibility as a leading hub for research, innovation, education and business.

Measure 29 (international bioeconomy congress)

Baden-Württemberg will continue to organise the international Baden-Württemberg Bioeconomy Congress and expand the topics addressed as well as the target audience through panels and presentations focused on real-life practices. These include primary production, industry, sustainability, environmental and climate protection and implementation within waste removal companies and within municipalities. The aim here is to promote networking and cooperation among actors, and knowledge exchange about the sustainable bioeconomy among researchers, businesses, policy-makers and local and regional authorities.

8.2 Action area: Educating and training professionals

Objective: Developing the potential for value creation and employment offered by a sustainable and circular bioeconomy in Baden-Württemberg through qualified professionals with interdisciplinary skills.

Strategic approaches and measures

Knowledge about the sustainable bioeconomy will be promoted within existing circles of experts at the same time as raising awareness among professionals from other disciplines, local and regional authorities and the general public. The issue of the sustainable bioeconomy will also be promoted in schools, universities and among apprentices who will shape the working world of the future.

8.2.1 Instruction, education and professional training for professionals

A key factor in developing and implementing a sustainable bioeconomy in Baden-Württemberg is the skilled professionals who generate disruptive innovations (“game changers”) and technological developments. Imparting the necessary background knowledge and creating a keen awareness of the topic plays an important role here as well. For this reason, the Baden-Württemberg government intends to combine and integrate two topics – “Experts for a sustainable bioeconomy” and “Education for sustainable development (ESD)” - for school, professional and university education and training.

Possible approaches are:

- assessing a possible expansion of school curricula
- promoting projects at technical schools, schools, universities and for trainees
- introducing bioeconomy modules at colleges and universities across various areas of study.

Measure 30 (education and training)

ESD structures will be used to disseminate and strengthen bioeconomy knowledge and awareness with the aim of promoting sustainable development in Baden-Württemberg.
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8.2.2 Professional training for public employees and companies

Professionals and experts in Baden-Württemberg’s government, municipalities and companies need to be given a way to build knowledge about biological processes and approaches and legal and funding-related frameworks in order to develop the potential for added value and employment offered by a sustainable circular bioeconomy.

Measure 31 (professional education for public employees)

Together with Baden-Württemberg's educational institutions, education authorities and associations, appropriate educational options will be developed and offered to government and municipal employees.

Measure 32 (professional education for public waste disposal authorities)

Sponsored by the Baden-Württemberg government, the Competence Centre for Biowaste at the State Institute for the Environment, Measurements and Conservation in Baden Württemberg is developing consulting services for public waste disposal authorities.

Measure 33 (professional education at companies)

Together with the Baden-Württemberg's educational institutions, education authorities and associations, appropriate educational options will be developed and offered to employees working in industry, forestry and agriculture.

8.3 Action area: Information and dialogue about the sustainable bioeconomy

Objective: To expand information about the bioeconomy and strengthen social dialogue to generate new ideas and initiatives for sustainably implementing and further developing a sustainable circular bioeconomy.

Strategic approaches and measures

The processes and products associated with the bioeconomy affect almost all areas of life. The interests and needs of consumers therefore have to be taken into account when identifying innovation potential. One of the unavoidable challenges when establishing a bioeconomy therefore includes achieving broad social consensus. Engaging in broad, knowledge-based dialogue about conflicting goals is particularly important in an economic area associated with multiple policy fields and interests.

8.3.1 Dialogue for implementing and further developing a sustainable bioeconomy in Baden-Württemberg

The methods, processes and products of a circular bioeconomy can make a significant contribution to sustainable development in Baden-Württemberg and to achieving the objectives of Baden-Württemberg's sustainability strategy. This strategy must be open to different potential paths and technologies and continuously developed in accordance with local and regional conditions. It is vital to maintain an ongoing exchange of knowledge and ideas about opportunities and consequences for the economy and society as well as for rural areas, ecosystems, biodiversity, climate change mitigation, land use.

Measure 34 (participatory dialogue)
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As part of the implementation and further development of its strategy, Baden-Württemberg will continue engaging in participatory dialogue with the scientific and economic sector as well as society as a whole with the aim of establishing an innovation-friendly and citizen-oriented social and economic environment conducive to the sustainable development of a circular bioeconomy.

8.3.2 Information initiatives

Targeted information and communication contribute to transparently identifying and formulating the social requirements for sustainably developing a bioeconomy. They all create spaces for innovations related to the bioeconomy as well as interest in biobased products.

Measure 35 (information initiatives)

Baden-Württemberg will support the creation of appropriate information material and concepts aimed at promoting sustainable development in the region. The purpose of this is to make the advantages of a sustainable circular bioeconomy accessible to everyone including the general public, to integrate consumers and to raise awareness of the bioeconomy as a future-oriented concept among agriculture and forestry enterprises, the manufacturing sector, industry and service providers. Information will be shared via appropriate print media, digital platforms, trade fairs, expert conferences, lectures and educational institutions.
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8.3.3 The Bioeconomy Experience Space

The products and processes of a sustainable circular bioeconomy will need to be presented in a transparent and public way in order to convey why it is needed, its objectives and individual and social advantages for the general public.

Measure 36 (Bioeconomy Experience Space)
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Baden-Württemberg will make the overall concept of a sustainable bioeconomy “accessible” to the general public through a “Bioeconomy Experience Space” with information and practical examples.

8.3.4 Competence Centre for Biowaste

This competence centre will be a point of contact and support for efforts to develop a sustainable bioeconomy. It will be aimed at satisfying the increasing demand for consultation regarding the establishment of innovative bioeconomy-based exploitation practices in research, municipalities and the economy as a whole, and especially public waste disposal authorities and private waste disposal companies. The centre will share information through project-related individual consultations, by providing support for pioneering projects and new media channels planned for the future.

Measure 37 (further develop the Competence Centre for Biowaste)

The “Competence Centre for Biowaste” will be developed within the framework of a sustainable bioeconomy.
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