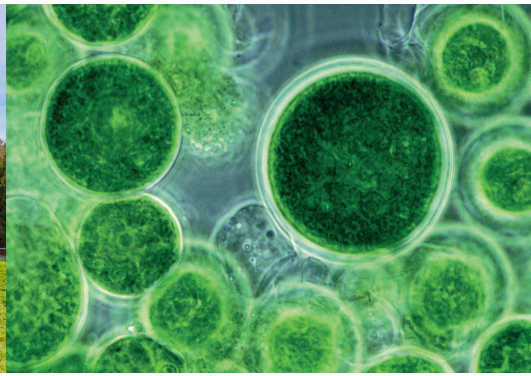
BIO ECONOMY RESEARCH

BADEN-WÜRTTEMBERG





COMPETENCE ATLAS

BIO ECONOMY RESEARCH
BADEN-WÜRTTEMBERG

Contents

Welcome Address
Theresia Bauer, MdL

The separation of economic success from the use of fossil fuels is unquestionably one of the great challenges of our time. This is particularly true for an economically strong high-tech state like Baden-Württemberg. Yet within this challenge, we see a great opportunity to strengthen the innovative power of Baden-Württemberg by developing new technologies and ideas that serve to help both our economy and our environment. Here is where the bioeconomy can play a big role, with its guiding principle of a circular economy that enables the best possible utilization and reuse of current resources and material streams. However, in order to be successful, researchers are required to align their goals with the complex questions and issues faced by the bioeconomy of the future.

Just as it is with other future oriented fields like digitalization and e-mobility, networking and cooperation is essential to bioeconomy related research. With the research program Bioeconomy Baden-Württemberg, the State Ministry of Science, Research and Arts is supporting inter- and transdisciplinary research groups, which bring together the extremely diverse bioeconomy expertise here in Baden-Württemberg.

This competence atlas shows the numerous ways in which the Baden-Württemberg research landscape is setup and how the program has been successful in bringing together all of the bioeconomy related research institutes – ranging from forestry, agricultural and plant sciences to process technology, economics and social sciences. By bringing this expertise together, Baden-Württemberg is showing that it can be a leader in developing the bioeconomy of tomorrow.

Theresia Bauer

Minister of Science, Research and the Arts

Editorial

Collaborations and knowledge exchange are key for the future-shaping sector Bioeconomy. This is true for interdisciplinary research as well as transdisciplinary and cross-sectoral implementation of Bioeconomy value chains and networks.

Through a jointly developed research strategy, Baden-Württembergs' universities and research institutes have positioned themselves at the forefront of Bioeconomy's multilateral research agenda, and bundled a broad number of relevant topics and expertise under the umbrella of the Bioeconomy Research Program Baden-Württemberg.

This Competence Atlas is a showcase of the manifold expertise of our research institutions, and will facilitate future interactions within the consortium and with external collaborators. It will be updated regularly to include new developments and partners.

Sustainable Bioeconomy has a regional and a global dimension. By continuing our role as a regional driver of sustainable Bioeconomy through research, innovation and capacity building, the members of the Bioeconomy Research cluster in Baden-Württemberg are competent and willing partners in international research, innovation projects and policy development.

We are hopeful that you will find information in this competence atlas useful and inspiring for future collaborations.

Prof. Dr. Thomas Hirth

Chairman of the Steering Committee

Dr. Annette Weidtmann

Head of the Coordination Office

History and Approach

Bioeconomy Research Program Baden-Württemberg

Research and development are fundamental for the structural change towards a Bioeconomy, in the sense of an enhanced utilization of biological resources within the framework of a sustainable economy.

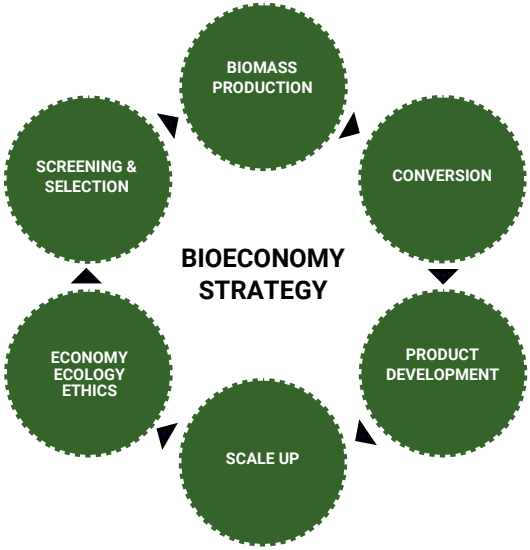
Therefore the Ministry of Science Research and Arts (MWK) of Baden-Württemberg initiated as one of the first regions a dedicated Bioeconomy research program. A strategy board of interdisciplinary experts selected focus areas in order to build upon specific strengths of the region. The systemic research strategy ***"Bioökonomie im System aufstellen"*** for Baden-Württemberg was published in 2013.

Implementation of the research strategy is supported by the MWK through funding research projects and structures within the Bioeconomy Research Program Baden-Württemberg since 2014. To date more than 60 subprojects have been selected in a peer review process and funded at 15 partner institutions. The interdisciplinary interaction is supported by the Coordination Office for Bioeconomy Research and the graduate school BBW ForWerts.

Baden-Württemberg's universities and research institutions collaborate in four focus areas concerning the use of biomass instead of fossil resources to develop a sustainable Bioeconomy, ensure global food security and contribute to climate and sustainable development goals:

- Sustainable and flexible value-added chains for biogas in Baden-Württemberg
- Lignocellulose as alternative resource platform for new materials and products
- Integrated use of microalgae for food and feed
- Modeling the Bioeconomy

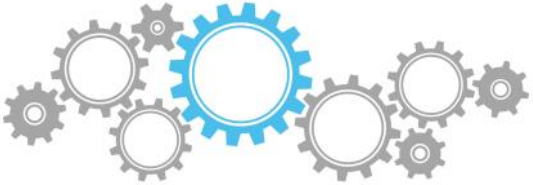
Within these focus areas a systemic approach is implemented to analyze entire value-added networks and develop sustainable bio-based products and processes. This includes sustainable biomass production and conversion, genotype selection, product development and the assessment of economic, ecologic, ethic, health, and social dimensions.



Coordination

Bioeconomy Research Program Baden-Württemberg

The dynamic and complex transformation towards a sustainable Bioeconomy requires knowledge and experience from many fields such as



- agriculture, forestry,
- natural sciences, engineering,
- food technology, nutrition science,
- social- and environmental sciences, economics,

and the intensive inter- and transdisciplinary dialogue therein. Existing expertise from leading universities and research institutions in Baden-Württemberg therefore have focused on the common goal of developing sustainable technologies and concepts for Bioeconomy. This systemic approach to Bioeconomy will contribute to global sustainability development goals (SDGs), including knowledge-based growth and jobs, renewability of resources, the resilience of ecosystems, circularity, mitigation of climate change, and efficiency and value orientation.

The future Bioeconomy will strongly depend on specially trained human resources to implement integrated Bioeconomy concepts in industry, politics, and science. As such, Baden-Württemberg is strongly investing in capacity building among young Bioeconomy experts as part of the Bioeconomy research strategy.

The **Coordination Office Bioeconomy Research Baden-Württemberg** located at the University of Hohenheim supports

- Strategy development,
- Interdisciplinary communication,
- Development of training programs,
- Knowledge-transfer and
- Project- and cluster development.

Through development of communication, dissemination and exploitation strategies the coordination office supports partners in the use of research results and the establishment of new partnerships.

The Coordination Office is your partner for questions concerning Bioeconomy Research in Baden-Württemberg, irrespective of whether you are from academia, industry, policy or civil society.

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Biogas – Sustainable and flexible value-added chains in Baden-Württemberg

Given the existing infrastructure of numerous biogas plants in Baden-Württemberg, a main objective of biogas research is to guarantee more efficient, cost effective and sustainable biogas production. This includes the use of biogas to compensate fluctuations in renewable energy systems, the material use of biogas and the utilization of alternative residual and waste materials. Additionally, our research considers the economic, ecological and social implications of biogas production. Projects funded in this cluster focus on:

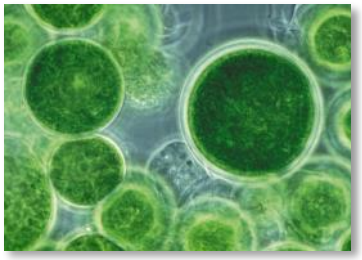
- New and optimized technologies for biomass production, conversion and use
- Potential of biogas production in context of new German legislation (EEG 2014)
- Modeling of food- and non-food markets including other regenerative and bioenergy production

Lignocellulose – Alternative resource platform for new materials and products

New technologies facilitate the use of wood and other plant-derived lignocellulosic biomass in the production of bio-based products such as plastics and detergents. A portion of crude oil that is currently used for similar production could therefore be replaced. Also bio-based conversion routes give access to new compounds with promising properties. The additional possibility of recovering energy from side products through complete utilization of biomass and increasing economic yield is also considered through systemic analyses of value chains. Our research covers:

- Biomass from agriculture and forestry including selection, breeding, cultivation and harvest
- Maintenance of biodiversity, ecosystem processes and metabolic cycles
- Efficient conversion and preparation techniques
- Development of new processes and products derived from cellulose and lignin
- Systemic analysis of value chains

Microalgae – Integrated use for food and feed



Microalgae are small, photosynthetic organisms that live in lakes, streams and oceans. They can be cultivated in photobioreactors or open ponds irrespective of arable land availability and therefore could become interesting biomass sources in future. Due to their specific composition, microalgae possess a large potential for use in human and animal nutrition, for example they are a promising source of proteins, lipids and carotenoids. We study:

- Resource saving production of proteins and essential fatty acids in microalgae
- Optimized cultivation, harvesting and processing techniques
- Functionality in food technology
- Nutrition physiology
- Sustainability assessment, consumer acceptance and economic modeling

Competence network modeling the Bioeconomy

The transformation from a fossil-based to a bio-based economy will increase the demand for forest and agricultural biomass. This will result in higher competition between the different uses of biomass (food, feed, fuel and fibre). The competence network aims to analyse, compare and evaluate the direct and indirect economic and ecologic impacts of potential biomass value chains. Technological and economic simulation models at various aggregation levels are adapted, combined and applied through:

- Modeling of energy systems and biomass conversion plants
- Models for ecological impact and life cycle analysis
- Farm, agricultural sector and economic models

Interdisciplinary training for young scientists

The graduate program BBW ForWerts was established to provide young academics with interdisciplinary competencies. As future ambassadors for Bioeconomy, graduates from BBW ForWerts will take on the task of connecting the ever-increasing knowledge base of natural sciences with societal demands and economic implementation. In this way they will identify and address the challenges of society's transition towards sustainable development. The graduate program is embedded within the Bioeconomy Research Program Baden-Württemberg, and offers interdisciplinary training for young scientists involved in the research projects.

BBW ForWerts graduate students participate in

- summer schools,
- workshops,
- method courses and excursions,

in order to gain an overview of other research areas as well as in-depth insight into their own research fields.

Strong emphasis is placed on soft-skills, including effective communication of knowledge to different societal stakeholders. Networking with fellow students, industrial partners and research institutions as well as entrepreneurship education are also crucial parts of the BBW ForWerts graduate program.

Since its founding in July 2014, the graduate program has grown to more than 50 doctoral students from currently ten different countries. Each student is associated with one of the 15 partner institutions in Baden-Württemberg. From its start, the three-year training course has included international partners. Among the doctoral candidates are scholarship holders funded from China (China Scholarship Council) and Brazil (National Council for Scientific and Technological Development).

The graduate program is funded by the Ministry of Science, Research and Arts (MWK) of the German federal state Baden-Württemberg. The BBW ForWerts Administration Office is located at the University of Heidelberg.

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Partner Institutions (1)

Bioeconomy Research Program Baden-Württemberg

Karlsruher Institute of Technology (KIT) (1)

- Institute for Applied Biosciences
- Institute of Catalysis Research and Technology (IKFT)
- Institute for Industrial Production
- Institute of Process Engineering in Life Science
- Institute of Pulsed Power and Microwave Technology
- Institute of Technology Assessment and System Analysis (ITAS)
- Engler-Bunte-Institute KIT, Fuel Chemistry and Technology
- Engler-Bunte-Institute KIT, Water Chemistry and Water Technology

University of Freiburg (2)

- Chair of Geobotany
- Chair of Molecular Genetics of Prokaryotes
- Chair of Forest Biomaterials
- Chair of Forestry and Environmental Policy
- Industrial Ecology Group
- Chair of Hydrology
- Chair of Remote Sensing and Landscape Information Systems
- Chair of Silviculture
- Chair of Soil Science

University of Heidelberg (3)

- Centre for Organismal Studies

University of Hohenheim (4)

- Institute of Agricultural Engineering
- State Institute of Agricultural Engineering and Bioenergy
- Institute of Animal Science
- Institute of Crop Science, Biobased Products and Energy Crops
- Institute of Farm Management
- Institute of Food Science and Biotechnology
- Institute of Nutritional Medicine

Partner Institutions (2)

Bioeconomy Research Program Baden-Württemberg

University of Applied Forest Sciences Rottenburg (5)

- Institute of Applied Research

University of Stuttgart (6)

- Institute of Biochemical Engineering
- Institute of Interfacial Process Engineering and Plasma Technology
- Institute of Energy Economics and Rational Energy Use
- Institute for Acoustics and Building Physics
- Dept. Life Cycle Engineering GaBi
- Institute for Sanitary Engineering, Water Quality and Solid Waste Management

University of Tübingen (7)

- International Centre for Ethics in the Sciences and Humanities (IZEW)
- Institute of Microbiology

University of Ulm (8)

- Competence Centre for Translational Peptide Research

BIOPRO Baden-Württemberg GmbH (9)

Centre for European Economic Research GmbH (ZEW) (10)

Dialogik gGmbH (11)

Forest Research Institute Baden-Württemberg (12)

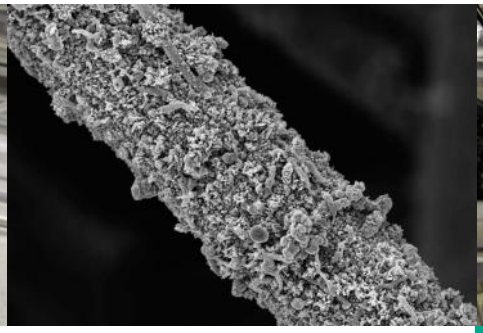
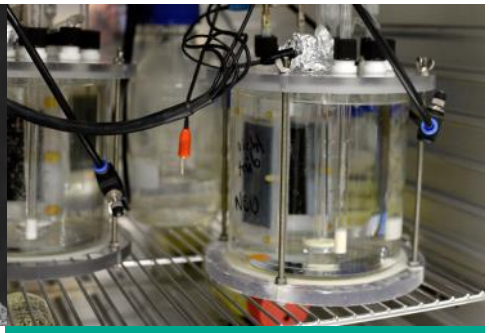
Fraunhofer Institute for Chemical Technology (ICT) (13)

Max Rubner-Institut - Federal Research Institute of Nutrition and Food (14)

State Research Institute and Education Center for Viticulture and Oenology and Fruit-growing, Weinsberg (LVWO) (15)

Karlsruhe Institute of Technology

Institute for Applied Biosciences

The Division **Applied Biology** at the **Institute for Applied Biosciences** focuses on the biotechnological production of platform chemicals using renewable carbon sources, carbon dioxide or waste streams as substrate. Furthermore, the group has a strong expertise in the isolation of new biocatalysts and the application of denitrification processes for the decentralized treatment of nitrate contaminated waters. A key technology for many of the developed processes is the microbial bioelectrochemistry. Here, the interaction of microorganisms with electrode surfaces is applied to realize biotechnological processes that are characterized either by the formation of electrical energy as a side product or by the ability of the organisms to use a cathode as energy and electron source.

The developed production strains, processes and technologies all aim to provide bioeconomy with new tools for the sustainable and biology based production of valuable carbon compounds. All developments are modular so that a redesign of processes with regards to new carbon sources or specifically desired end products is possible.

Within the Bioeconomy Research Program, we develop an electrode assisted fermentation for the production of platform chemicals. A number of valuable substances cannot be produced without the concomitant addition of an electron acceptor. This can be costly and is usually connected to efficiency losses. We will solve this problem by developing a process in which an electrode is the electron acceptor. Hence, a surplus of electrons will be used for the production of electrical energy as a valuable side product.

Expertise:	Microbial biotechnology, Bioelectrochemistry, Production of platform-chemicals from CO_2, Microbial electrosynthesis, Anode assisted fermentation, Denitrification processes
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Institute of Catalysis Research and Technology (IKFT)

The **Institute of Catalysis Research and Technology** at KIT contributes to bridging the gap between research and development of new processes and products on a sustainable carbon basis in the field of catalysis and process technology. One aspect includes the sustainable utilization of bio-based feedstocks and their conversion into energy carriers and chemical products. This includes developing new catalytic systems based on fundamentally understanding the processes on a molecular level. Next, processes are developed from laboratory to pilot scale.

Technology for primary biomass conversion comprises conversion of dry biomass into bio-oil and char by fast pyrolysis, and hydrothermal and solvolytic biomass liquefaction of moist feedstocks. IKFT participates in the development of the bioliq® process, operating a pilot plant with partners from the industry. Synthetic fuels are obtained from residual biomass via fast pyrolysis, gasification, gas cleaning and catalytic conversion of the produced syngas into clean fuels.

Within the scope of Bioeconomy Research Baden-Württemberg, IKFT carries out studies on the hydrothermal and catalytic conversion of lignin to bifunctional components for use in the chemical industry. The use of intermediates and residues from the bioliq® process in bio-refinery concepts is also investigated with the goal of coproducing energy and materials, e.g. the use of bio-oil fractions as concentrated, bio-based feedstock for fermentation.

Expertise:	Catalytic processes, Thermochemical conversion, Bio-based value chain process development and scale-up
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Institute for Industrial Production (IIP)

The **Institute for Industrial Production (IIP)** at KIT was established in the year 1982 to combine engineering-economic approaches and quantitative methods of operations research and informatics.

The chair of **Business Administration, Production and Operations Management** performs techno-economic analyses of industrial value chains with a focus on risk management, circulatory economic systems, integrated environmental protection measures, production planning and biomass applications. Furthermore, the group is engaged in optimizing production and logistic systems, managing supply chains and closed-loop systems.

The institutes' research capabilities lie in assessing the sustainability of technologies through parallel consideration of economic, ecological and social aspects. Furthermore, these aspects are applied in the development of strategies for planning, assessment and optimization of sustainable production systems as well as their related logistical, organizational and information functions.

Within the Bioeconomy Program in Baden-Württemberg, IIP utilizes the BIOLOCATE model (Biomass value chain integrated Optimization for Location, Capacity and Technology planning). BIOLOCATE is a mixed-integer linear optimization program that models strategic planning decisions within regional biomass value chains in order to techno-economically and ecologically assess biomass valorization pathways.

Expertise:	Sustainability economics, Techno-economic analysis, Industrial ecology, Life cycle assessment, Operations research, Risk management
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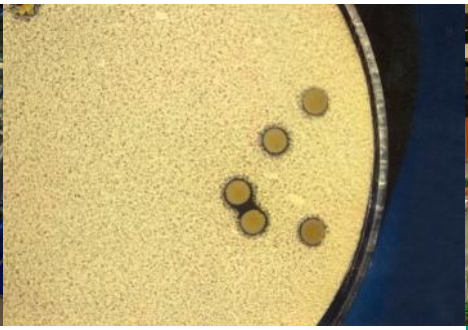
Institute of Process Engineering in Life Science


The **Institute of Process Engineering in Life Science** at KIT integrates four research departments focused on food technology, technical biology, process development and biomolecular separations.

The **Department of Technical Biology**[1] conducts research on bioproducts and biocatalysis using microbial fermentation and enzymatic approaches. Main topics in the field of microbial fermentation are the production of yeast and fungal metabolites as well as syngas fermentation. In the field of industrial biocatalysis the focus is on the production of unnatural α- und β-amino acids and the enzymatic modification and synthesis of surface- and interfacial active compounds, including aspects of enzyme immobilization, e.g. to magnetic carriers, and process development. Studies within the Baden-Württemberg Research Program lead to new concepts to produce sugar esters in environmental friendly “green“ deep eutectic solvent systems.

The expertise of the **Department of Bioprocess Engineering**[2] lies in the development and modeling of phototrophic bioprocesses to product high-value products in algae. Primarily green- and red algae are used for the production of high-value products such as pigments, polyunsaturated fatty acids and microstructured calcite platelets. The department also works with moss and cyanobacteria, which are used for the production of recombinant proteins. A large laboratory for phototrophic bioprocesses including an outdoor cultivation facility at KIT Campus North are available. Within the scope of Bioeconomy Research Program Baden-Württemberg, the team is expanding current algae biotechnology in order to optimize algal production for food ingredients.

Expertise: Biotechnology, Bioprocess engineering, Lab to pilot scale bio-reactor designs, Photobioreactors

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Institute of Pulsed Power and Microwave Technology (IHM)



The **Institute for Pulsed Power and Microwave Technology (IHM)** of KIT conducts research, development and technology transfer in the areas of pulsed power and high-power microwave technologies. The main research activity of the **Department of Pulsed Power Technology** is research and development of scientific and technological knowledge for the generation of repetitive, high voltage pulses (> 10 Hz) with very high power (>1 gigawatt) and pulse energy (>1 kilojoule) for applications in environmental technology, biotechnology and energy technology. For these applications, processes are developed from laboratory to pilot scale .

The basic technology for biomass utilization is the pulsed electric field (PEF) treatment or electroporation, a technology for gentle and efficient extraction of valuable substances from plants. IHM works on identifying best processing routes for economic and energetic valorization of diverse product fractions from microalgae. After separation of high value products, the various residual biomass fractions are then screened for most efficient energetic valorization. Research also aims to develop zero-waste biorefinery process routes.

In the scope of Bioeconomy Research Program Baden-Württemberg, IHM does research on application of PEF as a pre-treatment method for efficient extraction of proteins from microalgae biomass. Extracted proteins are quantified and characterized with regards to their nutritional value and techno-functional properties in collaboration with partners within the research program.

Expertise:	PEF-treatment of biomass, Microalgae biorefineries concepts, Solvent extraction processes, Process development and scale-up
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Institute of Technology Assessment and System Analysis (ITAS)



The **Institute for Technology Assessment and Systems Analysis (ITAS)** at KIT is an interdisciplinary research group that investigates scientific and technological developments with regards to their ethical, ecological, economic, and social impacts. Our major goals are to advise research and technology policy, provide knowledge for the design of socio-technical systems, and organize and observe discursive processes on open and controversial questions within technology policy.

Our investigations address the opportunities and challenges for the development of a sustainable Bioeconomy from the supply of biomass to consumer acceptance of new bio-based products, applying a variety of methods from biomass potential analysis and life cycle based technology assessment to scenario development and policy analysis.

As part of the Bioeconomy Research Program Baden-Württemberg, the institute contributes studies on systems analysis of goals, visions, value chains and implementation steps within a Bioeconomy, and investigates the ecological and economic impacts as well as the public perception of food production with microalgae[1].

Additionally, scenario development with our material flow model CarboMoG (Carbon Flow Model of Germany) is provided[2].

Expertise: Sustainability assessment of bio-based technologies and systems

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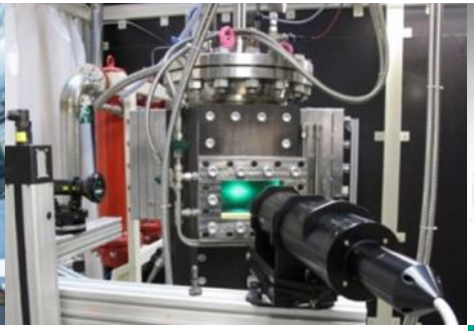
Engler-Bunte-Institute KIT, Fuel Chemistry and Technology


The Division **Fuel Technology** of the **Engler-Bunte-Institute, EBI-ceb,** at KIT focuses its research and teaching on process-specific characterization of fossil fuels and biofuels, and the process technology for converting and conditioning of those fuels. Further key activities are the synthesis of new fuels and utilization of chemical energy carriers as energy storage.

Affiliated to EBI-ceb is the **Gas Technology** Department of the DVGW Research Center, which is focused on technical processes and technologies for gas production, distribution and utilization.

Chemical fuels for technical processes must meet strict standards with respect to purity and fuel composition. Energy-efficient purification technologies are needed in order to meet these specifications. In some cases, fuel purification can also be beneficially integrated into actual fuel production or conversion steps. We consequently develop new concepts for the processing of fuels (mainly gaseous) in experimental and modeling projects, and evaluate those processes in terms of optimizing established processes or developing new processes at EBI-ceb.

In the framework of the Bioeconomy Research Program Baden-Württemberg, the institute contributes to research on power-to-gas (PtG) concepts to produce bio-methane (substitute natural gas) as a storable and safe chemical energy carrier. Two subprojects focus on the comparative modeling of biological methanation reactor concepts and the cleaning of the raw substitute natural gas produced in biological methanation processes through a novel cleaning process based on ionic liquids.

Expertise:	Gasification, Catalytic conversion, Sorption, Multi-phase reaction systems, Reactor modeling, BtX, PtG, Sector coupling
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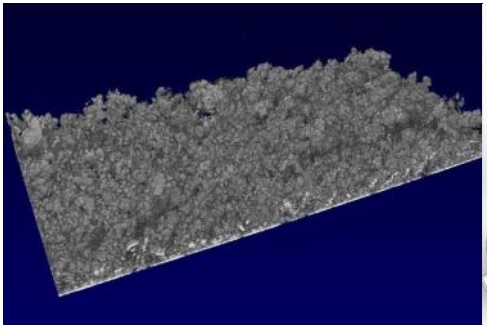
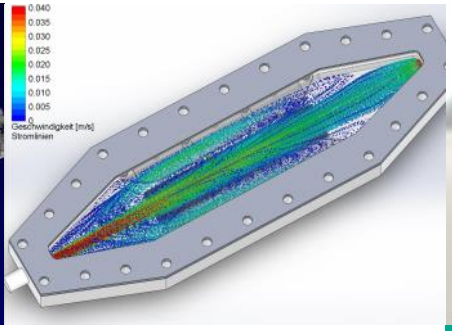
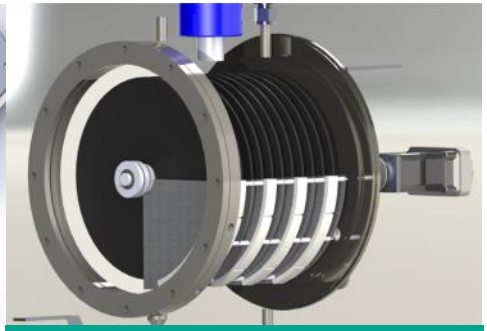
Engler-Bunte-Institute KIT, Water Chemistry and Water Technology







The Division of **Water Chemistry and Water Technology** at the **Engler-Bunte-Institute** has a core competence in water quality both for chemical and microbiological parameters. Moreover, the division is specialized in water treatment with membranes, advanced oxidation and biological processes. A better process understanding is generated with advanced imaging techniques like magnetic resonance imaging (MRI), confocal laser scanning and Raman microscopy (CLSM, RM) and optical coherence tomography (OCT).

The accumulation of microorganisms at interfaces (i.e. biofilms) is a main research topic. In technical systems biofilms are often recognized as unwanted and research is focusing on strategies for removal. On the other side, biofilms in fixed bed reactors for water treatment or biotechnological production are highly interesting compared to systems with suspended biomass as the reactors can be operated as natural retentostats.

One type of biofilm reactors used at the EBI is the Membrane Biofilm Reactor (MBfR), which allows for energy saving supply of gaseous educts like hydrogen and carbon dioxide for the production of methane in a methanotrophic biofilm. Another class are bioelectrochemical biofilm reactors, which offer electrodes as substratum. An anode can provide electrons for bioelectroactive bacteria, allowing for oxidation of educts without using oxygen. This system is used within the Bioeconomy Research Program Baden-Württemberg to produce butanediol in collaboration with the Institute of Applied Biosciences of the KIT.

Expertise:	Water quality, Water treatment , Biofilm systems, Imaging
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Web:	https:// wasserchemie.ebi.kit.edu/

Faculty of Biology
Chair of Geobotany



The **Chair of Geobotany** studies plant-environment relationships, the reactions of terrestrial ecosystems to global changes (in particular land use and climate change), and biodiversity's spatial-temporal dynamics and functional significance.

Short Rotation Coppices (SRC), due to their rapid growth, have great potential to contribute towards increasing biomass demands. For sustainable biomass production in SRC, key aspects such as resource use efficiency, biodiversity maintenance and ecosystem services provisioning must be considered. To date, most existing SRC plantations are willow or poplar monocultures. However, mixed SRC plantations that combine multiple cultivars of one tree species or a mixture of several different tree species potentially could perform better and render the system more stable while also reducing maintenance costs.

The project in the Bioeconomy Research Program Baden-Württemberg aims to investigate the effects of tree species and genetic diversity on a number of ecosystem processes in SRC plantations, with a focus on biomass production, nutrient cycling and associated biodiversity. The ultimate aim is to design more sustainable biomass production systems.

Expertise:	Vegetation ecology, Biodiversity assessment, Quantification of ecosystem functions and services
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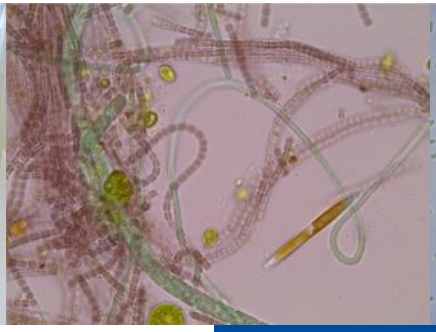
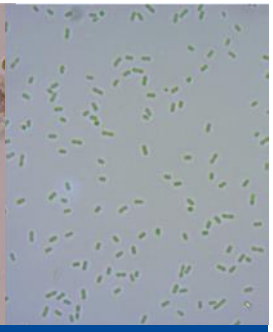
Faculty of Biology

Chair of Molecular Genetics of Prokaryotes



The **Chair of Prokaryotic Molecular Genetics** has a strong research focus on basic and applied research of cyanobacteria, one group of so called microalgae. Cyanobacteria can serve as model organisms for plant photosynthesis, but they are also of interest for bioeconomic applications as producers of many interesting compounds. The fact that cyanobacteria can fix CO_2 and N_2, underlines their potential as part of climate-friendly biomass production systems.

In-depth understanding of regulatory systems in response to environmental changes or for metabolic engineering will help to exploit cyanobacteria in future Bioeconomy value chains. Further scientific interests relate to the study of circadian timing mechanisms and light dependent motility of cyanobacterial cells.

Within the Bioeconomy Research Program Baden-Württemberg, the group conducts strategic research to explore the potential of cyanobacteria for essential amino acid production in close collaboration with the University of Tübingen. Cyanobacteria synthesize the storage compound cyanophycin, a polymer that consists of the amino acids aspartate and arginine, from which pure arginine, an important dietary supplement, can be gained.

Expertise:	Cyanobacterial genetics, Physiology, Photosynthesis
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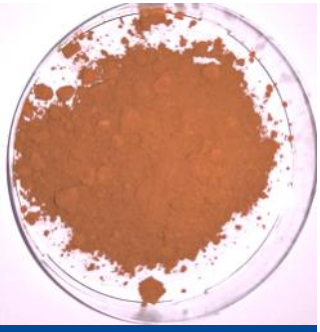
Faculty of Environment and Natural Resources

Chair of Forest Biomaterials



The **Chair of Forest Biomaterials** is a member of the Freiburg Materials Research Center and is part of the Institute of Earth and Environmental Sciences.

Research focuses on the investigation of natural materials and the development of new biomaterials. Fundamental and applied research is connected to valorize renewable forest resources and residues from forestry and wood industry into new materials.

This inherently interdisciplinary research ranges from the various scientific fields of wood science to the synthesis of bio-macromolecules, polymer physics and nanotechnology as well as broader material sciences.

In the frame of the research area lignocellulose of the Bioeconomy Research Program Baden-Württemberg, one focus is valorization of lignin into usable materials. Despite lignin's thermoplastic properties, processing by flowage such as injection molding, wet spinning or calendaring is problematic. Innovative processing and utilization of organosolv lignin by incorporating a template of cellulose nanocrystals (CNCs) have been developed by the research group.

Expertise:	Wood chemistry, Wood polymers, Biocomposites
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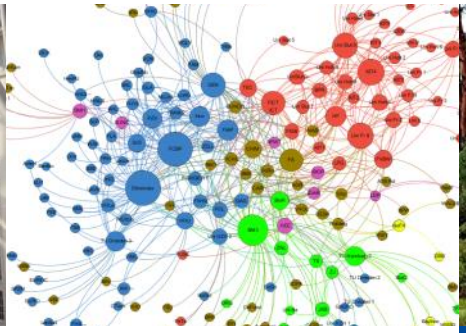
Faculty of Environment and Natural Resources

Chair of Forestry and Environmental Policy
Industrial Ecology Group


The **Chair of Forestry and Environmental Policy**[1] applies social sciences methods to analyze forest, climate, water and nature conservation policies at different political levels with a special interest on issues that affect different policy areas such as sustainability or Bioeconomy. The group is committed to producing empirically grounded and theoretically informed research that furthers the field of policy research and is relevant to policy makers and practitioners. The group's field of expertise covers actor, institutional and idea-based approaches that represent the state of art of political science. The institute is also engaged in advancing the development of these approaches. The institute relies on a broad range of qualitative and quantitative research methods and has a great expertise in inter- and transdisciplinary research processes.

The **Industrial Ecology**[2] group develops computer models to assess the long-term and system-wide consequences of specific sustainable development strategies. A special focus is placed on energy and material efficiency in industrial processes and consumer products. The group's models combine the established tools material flow analysis (MFA), life cycle assessment (LCA) and input-output analysis (IO) to tackle novel research questions. Within the Bioeconomy Research Program Baden-Württemberg, systematic evaluation and scaling guidelines for biomass utilization pathways are developed. The resulting model will assist decision makers and stakeholder in evaluating overall emission mitigation potentials and possible constraints of sustainable development strategies. The scope of the systems approach goes beyond the scale of single products as it comprises the whole supply chain as well as complete bio-based material cycles.

Expertise:	Political sciences, Material cycle modeling, Life cycle assessment, Prospective modeling
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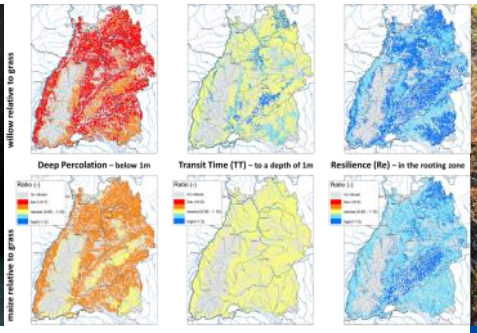

The **Chair of Hydrology** combines experimental hydrology in field studies with modeling approaches. Hydrologists from Freiburg develop and improve hydrological measurement techniques and survey methods within national and international research projects. Innovative experiments are conducted and simulation models are developed to detect, visualize and predict the temporal and spatial dynamics of surface and subsurface water fluxes.

Bioeconomy and resulting land use changes can offer “co-benefits” in water quality management since short rotation crops and other perennial plants represent a type of extensive land use with potentially lower hydrologic impacts due to reduced fertilizer use, pesticide emissions, soil compaction, the risk of soil erosion, and energy consumption per cultivated area. However, without strategical management, it also offers serious risks for water quality.

Within the Bioeconomy Research Program Baden-Württemberg, a method to assess these possibilities and risks has been developed based on rapid measurement approaches and a soil hydrological model. Resulting information about deep percolation, transit time and resilience can be used for land use planning and water protection. This facilitates locations to be proposed where specific bioenergy crops may be suitable to improve current soil functioning, e.g. by increasing the protection of groundwater, reducing erosion risks or increasing water availability.

Expertise: Water geochemistry, Catchment hydrology, Global hydrology, Modeling, Tracer hydrology, Runoff generation research, Urban hydrology

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Faculty of Environment and Natural Resources

Chair of Remote Sensing and Landscape Information Systems

The **Chair of Remote Sensing and Landscape Information Systems** studies development and application of spatial information systems with a focus on qualitative and quantitative condition assessment, monitoring, spatial modeling and visualization of woods, forests and landscapes.

In collaboration with partners from the Bioeconomy Research Program Baden-Württemberg, innovative remote sensing methods and data from the National Forest Inventory have been combined to regionally assess the quantity and quality of lignocellulose in the federal state of Baden-Württemberg.

Our logistics module uses geographic information systems to model and optimize the supply chain. We estimated the spatially explicit regional supply of woody biomass from in and outside forests. We also used routable data to find the most suitable positions for biomass conversion facilities by minimizing transport distances and costs. For this we have applied several restrictions, compiled different scenarios, optimized transport distances and identified wood assortments.

Expertise: Landscape planning and Geospatial modeling, Remote sensing, Forestry

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Faculty of Environment and Natural Resources

Chair of Silviculture
Chair of Soil Science



The **Chair of Silviculture**[1] at the Institute of Forest Science researches questions regarding the utilization of forest ecosystems to reach economic, ecological and social management goals.

The specific focus areas are structure and dynamics of forests, carbon and nutrient cycles, ecological interactions within forest ecosystems and the adaptation of forests to global change. In addition, the consequences of forest management on ecosystem functions and processes are analyzed. Under the Bioeconomy Research Program Baden-Württemberg, the influence of forest harvesting intensities on species and structural diversity of forests is studied.

The **Chair of Soil Science**[2] investigates soil as part of the forest ecosystem. More intensive removal of woody biomass for the Bioeconomy has the potential to affect litter and succession cycles. Especially at risk is the retention of fine and coarse woody debris, which are crucial factors in forest biodiversity and nutrient cycling.

Studies within the Bioeconomy Research Program will lead to recommendations for woody debris management regarding site- and tree species-specific conditions with the goal to improve forest soil functioning, productivity and overall resilience. The institute hosts modern soil chemical and soil physical infrastructure .

Expertise:	Silviculture, Climate change adaptation, Mixed species forests, Nutrient cycling
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Web:	www.waldbau.uni-freiburg.de www.bodenkunde.uni-freiburg.de

UNIVERSITÄT HEIDELBERG
ZUKUNFT SEIT 1386

Centre for Organismal Studies



The **Centre for Organismal Studies (COS)** at Heidelberg University aims to study organismic biology beyond the borders of organizational levels.

Research and teaching at COS is dedicated to studying organismic biology from the basic molecular principles to cell biology, developmental biology and physiology in both plants and animals, and further extensions into evolution, biodiversity, systems biology and biotechnology .

Within the Bioeconomy Research Program Baden-Württemberg, the plant physiology group studies transcriptional regulation of cell wall and lignin biosynthesis in the giant grass *Miscanthus*, one of the most promising perennial biomass plants in Europe. Furthermore, the impact of genotype and environmental cues on the kinetics of lignin biosynthesis are investigated.

These results are important for the selection of suitable strains and optimal cultivation conditions for producing purpose-specific biomass.

Expertise: Plant molecular biology, Transcriptional regulation, Core facilities for life imaging, Next generation sequencing, Metabolomics

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UNIVERSITY OF HOHENHEIM

Institute of Agricultural Engineering



The **Institute of Agricultural Engineering** at the Faculty of Agricultural Science combines the expertise of different departments dealing with various fields of process engineering and with the common motto: “Adaption of technologies to nature, not nature to technology”.

In the Bioeconomy Research Program Baden-Württemberg, the department **Conversion Technologies of Biobased Resources** works on several projects to create new products from agricultural residues and biomass. This includes the production of platform chemicals derived from biomass for the production of polymers for fibers and packages.

To further develop this process, a bench-scale plant is built at the research station “Unterer Lindenhof”. It is an on-farm lignocellulose bio-refinery, splitting grassy biomass into hydroxymethylfurfural, furfural and phenols.

Another field of research is the production of new, carbon-rich materials from biomass (biochar, activated coal, carbon black, materials for fuel cells and batteries, and supercapacitors).

The department also has broad expertise in developing innovative separation processes, especially for bio-based processes including tailor-made extraction processes to retrieve valuable products from microalgae.

In addition, the team works on the recovery and recycling of phosphate and nitrogen from sewage sludge and digestates.

Expertise:	Thermochemical and biochemical conversion technologies, Process development and simulation, Chemical kinetic modeling
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UNIVERSITY OF HOHENHEIM

State Institute of Agricultural Engineering and Bioenergy



The **State Institute of Agricultural Engineering and Bioenergy** represents an interface between university research and agricultural practice. It offers practice-focused and advanced research, consultancy for farmers and companies, and training for experts and consulting services. Major focus of research and consulting include:

- Sustainable energy and resource management
- Bioenergy production and smart energy systems
- Anaerobic digestion processes, production of platform chemicals and nutrient management of residues
- Use of by-products from agriculture and food industry for energy-related use

The institute hosts laboratories for determining biogas and methane yields in continuous and batch digesters, up-to-date process monitoring equipment, solid-phase and two-stage anaerobic digestion plants both at the lab scale, batch and continuous high pressure methane reactors of up to 200 bars and a full-scale research biogas plant (355 kWel) at the research station “Unterer Lindenhof“.

Within the Bioeconomy Research Program Baden-Württemberg, the institute studies two reactor systems for power-to-gas applications by microbial hydrogen methanation (BHM) in collaboration with KIT. This could as a vector technology interlink power grids and the natural gas network, the most powerful energy transmission- and storage system in Europe.

Expertise:	Renewable energy systems, Biogas, Anaerobic digestion, Process monitoring, Consulting
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UNIVERSITY OF HOHENHEIM

Institute of Animal Science



The **Institute of Animal Science** focuses on resource-efficient and animal-friendly livestock husbandry, including poultry. Teaching and research primarily cover metabolic and adaptation processes of animals, and their consequences for the livestock production sector. State-of-the-art approaches and methods are used for the genotypic and phenotypic characterization of animals. Another research focus of the institute is the microbiome of the digestive tract and its mutual impact on the animal and the environment.

The work of the institute integrates different disciplines within teaching and major research programs. This includes animal health, genetics, physiology, nutrition and microbiology. Experimental approaches and methods include molecular tools, cell culture and tissue models, *in vitro* techniques and animal trials. The department of animal nutrition optimizes feeding systems that combine adequate nutrition and reduced environmental impact. This requires further understanding of digestive processes and requirements of livestock and improved feedstuff evaluation systems.

Within the research area microalgae, the department **Animal Nutrition** investigates the suitability of different microalgae as animal feed, specifically for ruminants. The investigations include analysis of the nutrient composition, *in vitro* studies for estimating digestibility and analysis of energy value and protein value of microalgae. In addition, the effect of cell disruption on nutritional characteristics of microalgae is studied.

Expertise:	Nutrition, Molecular techniques, *In vitro* models of digestion, Chemical analyses of feed and other substrates, Proteins
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UNIVERSITY OF HOHENHEIM

Institute of Crop Science, Biobased Products and Energy Crops



The Institute of Crop Science at the Faculty of Agricultural Sciences consists of nine departments covering basic and applied research on agricultural crops, agronomy and farming systems. The department **Biobased Products and Energy Crops** focuses on sustainable biomass production and supply systems, and the use of perennial energy crops, such as miscanthus, in a growing Bioeconomy. More specifically, these activities cover:

- Approaches to sustainable intensification of agriculture
- Multiple land-use systems
- Development of low-input production systems for new crops for energy and industry
- Biomass potential assessment and regional supply concepts
- Optimizing biomass quality for various applications
- Life cycle assessment of biobased value chains

The department is equipped with laboratories for biomass quality analysis. Field trials are performed at the university´s agricultural experimental stations, which cover approx. 400 hectares spread over five sites in different climatic regions of southern Germany.

As part of the Bioeconomy Research Program Baden-Württemberg, the institute investigates optimal conditions for miscanthus growth on marginal land as well as evaluates environmental impacts of crop cultivation and subsequent biomass use in various conversion pathways and value chains.

Expertise:	Biomass production systems, Bio-based value chains, Life cycle assessment
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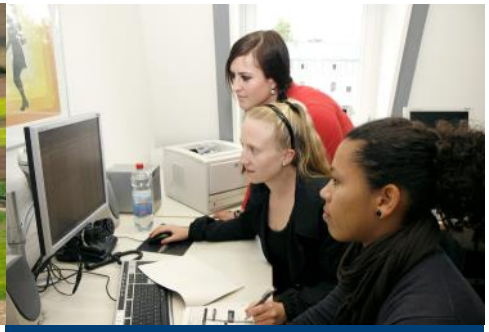
Web:	www.agrar.uni-hohenheim.de/en/organization/institution/institute-of-crop-science

UNIVERSITY OF HOHENHEIM

Institute of Farm Management





The Institute of Farm Management integrates modern planning theory with empirical studies on sustainable agricultural concepts that seek to integrate economic, technological and environmental requirements into a harmonious approach. The aim is to provide scientific contributions as well as recommendations for policy and agricultural practice.

The department **Farm Management**[1] follows inter- and transdisciplinary approaches centered on the individual farm as well as upstream and downstream sectors. Correlations are modelled and mapped with budgetary accounting in combination with evaluation and taxation questions from individual investment theories, multivariate analyses and experimental economics. The Economic Farm Emission Model (EFEM) developed by the department is used to simulate agricultural production on farm- and regional levels as part of the Modeling competence network. EEFM is a supply model based on static linear programming (LP) and considers the most important agricultural production methods differentiated by yield, intensity, productivity and cost at regional scales.

The department **Production Theory and Resource Economics in Agriculture**[2] is also involved in interdisciplinary research. Inter alia, farm programming models are developed and used to analyze the effects of changing environmental and economic conditions. This approach is complemented by econometric studies. In a recent research project, the department analyzed the profitability, associated risks and implementation potential of ligneous perennial plant cultivation for the Bioeconomy in Baden-Württemberg from statistical data and information obtained from a survey (with discrete choice experiment) among farmers.

Expertise:	Participatory and qualitative methods, Economic-ecological modeling, Experimental economics, Econometry, Mathematical programming
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Web:	www.uni-hohenheim.de/en/organization/institution/institute-of-farm-management

UNIVERSITY OF HOHENHEIM

Institute of Food Science and Biotechnology



The **Institute of Food Science and Biotechnology** hosts scientists across a broad spectrum combining natural sciences and engineering expertise. Entire value-added chains of food systems and the complex interdependencies among ingredients, procedures and functionality are important pillars of current research towards the optimal processing and use of raw materials from agricultural production systems as foodstuffs with high standards of quality and safety.

Within the Bioeconomy Research Program Baden-Württemberg, the institute coordinates the research area on microalgae and conducts studies with the goal to develop new products based on microalgae proteins and lipids. Food structures are the main focus area of the department **Food Physics and Meat Sciences**[1], where a wide range of modern biophysical analytical techniques are available. Dispersion manufacturing technologies have been set up in the pilot plant section of the institute, including membrane and high pressure homogenization, high intensity ultrasonication, colloid milling and microfluidization. The stability of algae-based lipids is studied by the department **Process Engineering and Food Powders**[2], where state-of-the-art spray drying towers are used at the pilot scale.

The department **Bioprocess Engineering**[3] focuses on process development for microbial production of bio-based chemicals and platform chemicals. Special emphasis is on microbial surfactant (rhamnolipids and surfactin) production based on renewable resources. The department contributes to the research area lignocellulose with projects to produce valuable compounds from pyrolysis oil and lignocellulose hydrolyzates.

Expertise:	Food technology, Food structures, Spray drying, Proteins, Lipids, Microbial production systems, Bio-based surfactants
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[3]Contact:	Prof. Dr. Rudolf Hausmann rudolf.hausmann@ uni-hohenheim.de
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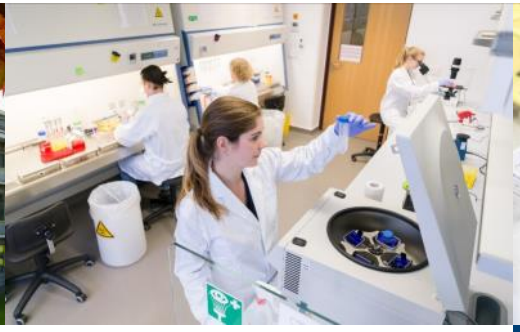
UNIVERSITY OF HOHENHEIM

Institute of Nutritional Medicine


The **Institute of Nutritional Medicine** covers research and teaching in the areas of medicine, immunology, dietetics, nutritional psychology and food habits with a specific focus on preventative health through nutrition.

Microalgae are rich in essential nutrients such as carbohydrates, vitamins, minerals, trace elements and phytochemicals. Additionally, microalgae contain significant amounts of protein, omega-3 fatty acids and carotenoids. They therefore could provide the basis for a balanced diet, leading to an improvement in quality of life while conserving resources.

For the development of new nutritional concepts within a Bioeconomy strategy, proper investigation of bioavailability, potential health benefits and food safety are essential prerequisites.

In the Bioeconomy Research Program Baden-Württemberg, the institute studies possible anti-proliferative, anti-inflammatory and anti-oxidative effects of whole microalgae, and specific fractions of their extracts. Further investigations are directed towards the role of the intestinal microbiome for their digestion and uptake.

Expertise:	Obesity, Malnutrition, Food allergy, Gastrotinestinal barrier, Inflammation, Dietetics
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University of Applied Forest Sciences Rottenburg
University of Applied Sciences

University of Applied Forest Sciences Rottenburg



The **University of Applied Forest Sciences Rottenburg (HFR)** has consistently orientated towards applying research results and the principles of sustainability. In the research areas

- Biomass - Logistics and Conversion,
- Forestry and Timber, and
- Management and Development of Rural Areas,

scientists develop cross-industry solutions for and in collaboration with science, business, politics and other social interest group networks. Most scientific activities can be attributed to Bioeconomy.

In the field of biomass utilization, open questions concerning technical application of biomass fuels or new biomass-based products and processes are being addressed. For example, HFR is currently developing new filters for biomass combustion plants, designing fuels from different raw materials and producing wood construction products based on alternative raw material sources. At the same time, ecological and economic impacts and interactions of resource provision from biomass and the accompanying social dialogue are simultaneously considered. Frequently these tasks are conducted in intensive exchange with international partners.

In the Bioeconomy Research Program Baden-Württemberg, HFR studies land use and biodiversity aspects in product eco-balances. The aim is a regionalized analysis of biomass life cycle assessments.

Expertise:	Biomass conversion, Technological impact assessment, Resource management, Product development
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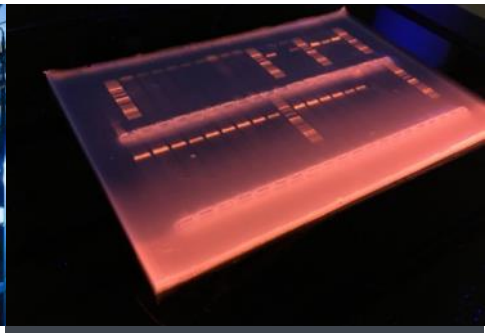
University of Stuttgart
Germany

Institute of Biochemical Engineering



Research at the **Institute of Biochemical Engineering (IBVT)** of the University of Stuttgart focuses on subcellular, cellular and intercellular studies to gain a quantitative understanding of underlying regulatory mechanisms in microbial and mammalian cells. Studies cover a broad range of regulation levels including RNA-RNA interactions and metabolic and transcriptional control regimes. Following the mindset of metabolic engineering the results are used to identify promising genes for improving production hosts to develop novel bioprocesses up to industrial scale. Accordingly, strain and process engineering are intertwined making thorough use of genome scale modelling, metabolic control and metabolic flux analysis. Besides, research strongly focuses on the transfer of lab results to industrial scale application. Accordingly, cellular models derived from systems analysis are applied to optimize and to predict performance of bioprocesses on an industrial scale. At IBVT 300 L bioreactors are used for pilot scale tests.

IBVT is tightly networked with national and international research groups and industrial partners, thereby working on bioprocesses for commodities, fine chemicals, aroma compounds and biopharmaceutical proteins. Intrinsically, sustainable bioeconomy is the key driving force for most of the research cooperations, in particular with industrial partners. Supporting the idea of a circular economy, syngas-based fermentations are studied using acetogens. Investigations yield to exploit the metabolic potential of the cells and to design large-scale bioreactors using CO, CO_2 and H_2 mixtures.

Expertise:	Systems metabolic engineering, Synthetic biology, Biochemical engineering, Process development
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University of Stuttgart
Germany

Institute of Interfacial Process Engineering and Plasma Technology



The **Institute of Interfacial Process Engineering and Plasma Technology (IGVP)** at the University of Stuttgart is dedicated to inter- and cross-disciplinary research in the field of materials science, life sciences, process engineering and plasma science. The institute has well-equipped laboratory and technical facilities on the university campus and has strong interactions with the Fraunhofer Institute for Interfacial Engineering and Biotechnology IGB in the same building.

IGVP covers various research areas in the Bioeconomy including, for example, design, functionalization and characterization of bio-based materials, as well as simulation and engineering of interfacially-driven processes, such as in membrane technology and biotechnology.

It contributes to the research area microalgae by microalgae biomass production and developing novel cell disruption and nutrient extraction methods.

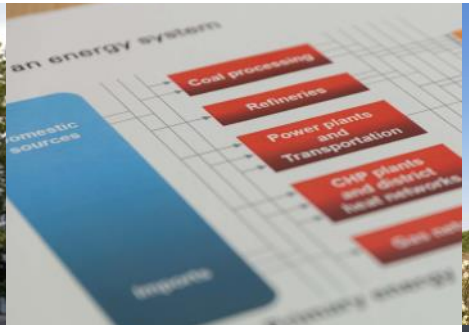
Within the research area lignocellulose, IGVP investigates the fractionation of distinct types of lignocellulosic material with the aim to generate monomeric C6- and C5-sugars as well as lignin streams that are optimized for fermentation processes and material development.

Within the research area biogas, IGVP analyzes the potential of waste-stream sludge as a source for biogas production. Another project is developing a new reactor concept for synthesizing industrial and pharmaceutical products from biogas with aerobic methanotrophic organisms.

Expertise:	Industrial Biotechnology, Microalgae Technology, Bioprocess Engineering, Material use of biogas
Contact:	Dr.-Ing. Ursula Schließmann ursula.schliessmann@igb.fraunhofer.de Prof. Dr. Steffen Rupp steffen.rupp@igb.fraunhofer.de
Address:	University of Stuttgart Institute of Interfacial Process Engineering and Plasma Technology Nobelstr. 12 70569 Stuttgart Germany
Web:	www.igvp.uni-stuttgart.de

University of Stuttgart
Germany

Institute of Energy Economics and Rational Energy Use (IER)



The **Institute of Energy Economics and Rational Energy Use (IER)** is engaged in research and teaching at the University of Stuttgart. Emphasis is placed on evaluating the outline and parameters of a robust, resilient and sustainable energy system with its subsystems electricity, heating/cooling and mobility. IER's work is interdisciplinary across the fields of technology, economy, environment and society. The institute's focus is on:

- Analysis and evaluation of new and emerging technologies,
- Systemic technology assessment,
- Environmental and economic analyses

To address these topics, IER develops and applies models and decision support tools for energy policy, energy markets, energy economic system analysis and rational energy application.

The institute has a team of more than 50 engineers and researchers in the natural, agricultural, economic and social science.

Within the Bioeconomy Research Program Baden-Württemberg, IER has developing repowering concepts for the local biogas sector and is working towards developing a Bioeconomy index[1].

Within the competence network, the Bioeconomy sector is modeled using the TimesPanEU model, which is additionally coupled with other models from partners who model the agriculture sector[2].

Expertise:	Energy system and energy market models, GAMS optimization models, Life cycle analysis, Matlab modeling, (Socio)economic evaluation of energy systems, Renewable and new energy technologies, Bioeconomy indicator evaluation
[1]Contact:	Dr. Ludger Eltrop ludger.eltrop@ ier.uni-stuttgart.de
[2]Contact:	PD Dr.-Ing. Markus Blesl markus.blesl@ier.uni-stuttgart.de
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Web:	www.ier.uni-stuttgart.de

University of Stuttgart
Germany

Institute for Acoustics and Building Physics
Dept. Life Cycle Engineering GaBi



The department **Life Cycle Engineering GaBi** at the Institute for Acoustics and Building Physics IABP has an excellent track record in life cycle engineering (LCE) including life cycle assessment (LCA), land use assessment using LANCA®, biodiversity impact assessment (BIA), design for environment (DfE), energy efficiency benchmarks and material flow analysis (MFA). In cooperation with Fraunhofer IBP, the GaBi team is one of the world's largest and most recognized LCA working groups linked both to research and professional application.

Further to providing services in application and adaptation of these methods, the department plays an active role in developing methods for sustainability assessment. The integration of social and economic aspects as well as the inclusion of environmental impacts through land use or effects on biodiversity are difficult but necessary in a comprehensive sustainability assessments. The method LANCA® (Land Use Indicator Value Calculation in Life Cycle Assessment), which is recommended by the EU for use in Environmental Footprint studies, was developed by the department. An additional goal of the department is to develop methods and tools conducive to practical implementation despite of growing complexity of such analyses.

In the scope of Bioeconomy Research Program Baden-Württemberg, the department has developed recommendations for harmonized LCA of bio-based products in the competence network modeling the Bioeconomy; they are already published with open access. As part of the research area lignocellulose, the department evaluates regionalized land use and biodiversity through LCA of bio-based products.

Expertise:	Life cycle assessment, Design for environment, Carbon footprint analysis, LCA software solutions
Contact:	Dr. Stefan Albrecht stefan.albrecht@ iabp.uni-stuttgart.de
	Stephanie Maier stephanie.maier@ iabp.uni-stuttgart.de
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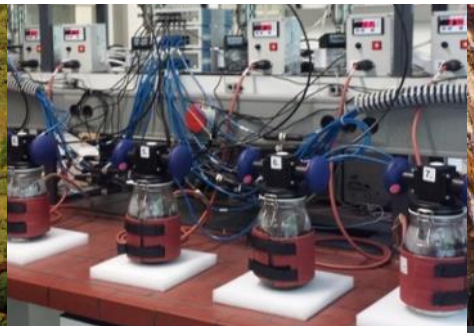
Web:	www.lbp-gabi.de

University of Stuttgart
Germany

Institute for Sanitary Engineering, Water Quality and Solid Waste Management (ISWA)


The **Institute for Sanitary Engineering, Water Quality and Solid Waste Management (ISWA)** of the University of Stuttgart is an interdisciplinary institution within the Faculty of Civil- and Environmental Engineering. The department of Waste Management and Emissions is renown for research on:

- Modeling, simulating and evaluating waste management systems
- Biotechnical processes for waste treatment
- Surveys on food waste generation and development of waste prevention strategies
- In-situ aerobization of old landfills
- Infrastructure development in the field of solid-waste for future megacities
- Laser-based measuring of methane emissions and measuring of odor emissions
- Analysis of waste and emissions

The department is equipped with laboratories for waste analysis, on site emission measurement systems and lab scale plants for aerobic and anaerobic treatment of waste.

Within the Bioeconomy Research Program Baden-Württemberg, the institute conducts spatial assessment of organic waste potential from households using geographic information systems (GIS). A second project includes systematic comparative assessment for the optimization of fermentation plants for biodegradable waste.

Expertise:	Waste- and resource management, Food waste potential estimates, Process monitoring and optimization, Composting, Anaerobic digestion, Emissions from waste treatment plants
Contact:	Prof. Dr.-Ing. Martin Kranert martin.kranert@ iswa.uni-stuttgart.de
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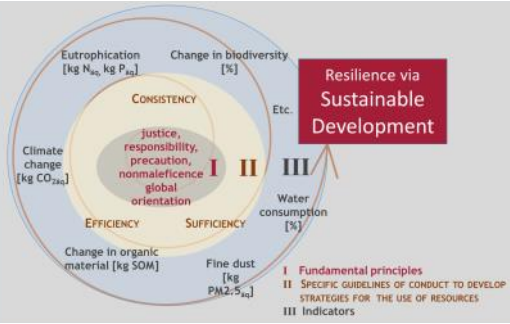
Web:	www.iswa.uni-stuttgart.de

EBERHARD KARLS
UNIVERSITÄT
TÜBINGEN

International Centre for Ethics in the Sciences and Humanities (IZEW)



Science, technology and the advancement of knowledge are changing our world at an ever increasing pace. This raises substantial ethical questions that the **International Centre for Ethics in the Sciences and Humanities (IZEW)**, an interdisciplinary center at the University of Tübingen, has addressed since 1990. We connect researchers from all disciplines to analyze values, risks and benefits, critically assess normative assumptions, interact with other societal actors and prepare for well-balanced decisions.

Research at the IZEW addresses various topics including biotechnology, sustainable development, environmental ethics, security technologies, digitalization and future working conditions. We consider fundamental questions of interdisciplinary ethics and develop methods to foster ethical reflection and judge competencies.

As part of the Bioeconomy Research Program in Baden-Württemberg, the IZEW developed a sub-project for ethical reflection within an integrated Sustainable Development approach. Most of the globally traded biomass is produced under critical conditions with respect to ethical and broader societal aspects; in that sense, Bioeconomy understood as a strategy for the increasing use of renewables is not per se sustainable (Kroeber and Potthast 2015). This analysis is the background to define key sustainability indicators for an integrated assessment of biomass value chains. The constitutive normative elements are intra- and intergenerational justice, responsibility, precaution, non-harm and global orientation. With these ethical criteria, strategies for consistency, efficiency and sufficiency are to be specified for concrete approaches in Bioeconomy.

Expertise: Ethical reflection, Integrated sustainable development, Interdisciplinary Communication

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potthast@uni-tuebingen.de

Dr. Birgit Kröber
birgit.kroeber@
uni-tuebingen.de

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Germany

Web: www.izew.uni-tuebingen.de

EBERHARD KARLS
UNIVERSITÄT
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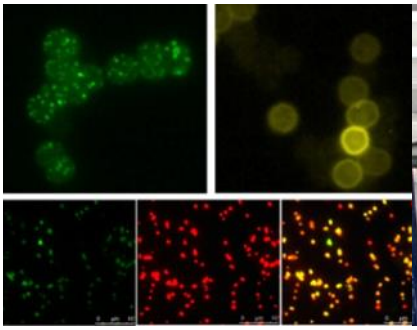
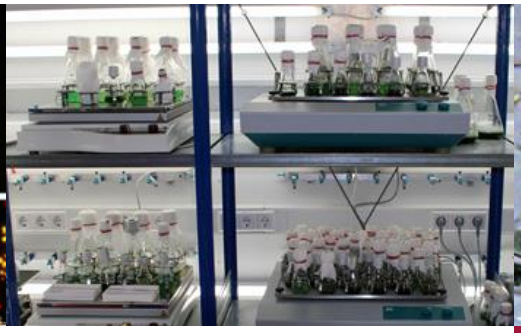
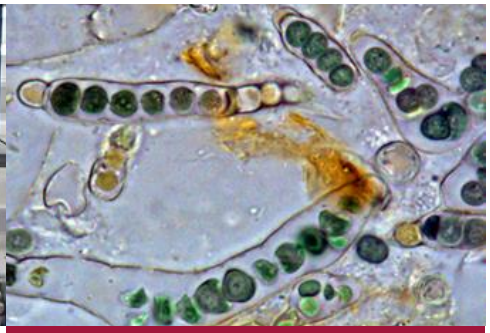
Interfaculty Institute of Microbiology and Infection Medicine
Department of Organismic Interactions

The **Department of Microbiology/Organismic Interactions** at the University of Tübingen exhibits great expertise in basic and applied research with a focus on the phylum of cyanobacteria. The department mainly deals with the question: How do cyanobacteria sense their environment and which mechanisms do they employ to adapt to environmental changes? Along with this question, the focus is on research areas involving biopolymers, carbon/ nitrogen metabolism, stress acclimation, differentiation on multicellular cyanobacteria and the cell envelope.

Compared to heterotrophic bacteria cyanobacteria are unique as they use sunlight and CO_2 as energy and carbon source. They have been identified as a rich source of several biologically active compounds and producers of biomass as raw material for biofertilizers, bioplastics, food and feed. Due to the increasing importance of environmentally-friendly production, cyanobacteria are expected to play a major role in the emerging field of Bioeconomy. In order to make cyanobacteria suitable for biotechnological industry, the department is working on high value production strains by modulating metabolic pathways. Therefore, the focus is on two industrial relevant biopolymers: polyhydroxybutyrate (PHB) and cyanophycin (CGP).

As part of the Bioeconomy Research Program Baden-Württemberg, the department is involved in designing, generation and characterization of a cyanobacterial CGP producer strain. CGP serves as a source for dipeptides and amino acids in food, feed and pharmaceutical industry. The amino acids arginine (semi-essential) and aspartate (non-essential) derived from CGP have a broad spectrum of nutritional or therapeutic applications.

Expertise:	Cyanobacterial physiology, Molecular biology, Genetic techniques, Metabolic engineering, Biopolymers
Contact:	Prof. Dr. Karl Forchhammer karl.forchhammer@uni-tuebingen.de
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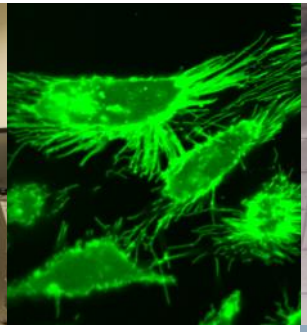
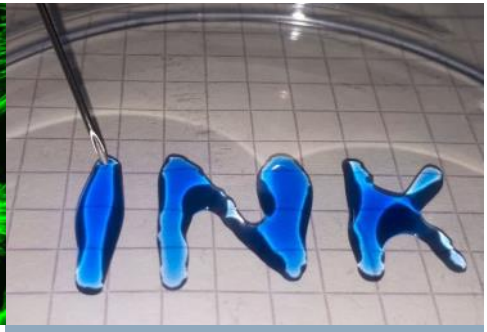
Web:	www.imit.uni-tuebingen.de/arbeitsgruppen/mikrobiologie-organismische-interaktionen

ulm university universität ulm

Competence Centre for Translational Peptide Research



The **Competence Centre for Translational Peptide Research** has expertise in the field of protein and peptide drugs for translational research. Founded by scientists from the Institutes of Molecular Virology, Organic Chemistry and Pharmaceutical Biotechnology at the University of Ulm, the center has the core expertise and key technologies necessary to successfully develop peptide- and protein-based active ingredients through peptide identification, synthesis, optimization and (biotechnical) production.

The Pharmaceutical Biotechnology group of the center develops bioinspired hydrogel materials with novel functionalities based on different biological polymers for biomedical and printing applications. The second focus of interest is the molecular biotechnology of recombinant bio-surfactants (e.g. rhamnolipids) including the creation of synthetic biosynthesis pathways, strain development and optimization of bioprocesses in co-operation with bioengineering experts.

Within the Bioeconomy Research Program Baden-Württemberg, the center contributes to the development of a self-regulating microbial system for producing recombinant proteins from renewable sources with an aim to produce high-value food ingredients and tailor-made monomers for novel protein-based biomaterials.

Expertise:	Biomaterials, Synthetic biology, Microbial expression technology, Pharmaceutical biotechnology, Industrial microbiology
Contact:	Dr. Frank Rosenau frank.rosenau@uni-ulm.de
Address:	University of Ulm Competence Center for Translational Peptide Research Albert-Einstein-Allee 11 89081 Ulm Germany
Web:	www.uni-ulm.de/en/nawi/nawi-zfp

BIOPRO Baden-Württemberg GmbH

BIOPRO Baden-Württemberg GmbH comes under the auspices of the Baden-Württemberg government and is specifically focused on bioeconomy, biotechnology, pharmaceutical industry and medical technology (healthcare industry).

- We work in partnership with science, the economic sector and business and science networks.
- We contribute to cross-sectoral cooperation across the entire value creation chain and hence to innovation.
- We support technology transfer and offer comprehensive support for start-up projects as a professional partner and expert in life sciences.
- We provide you with comprehensive information via our online portals and industry reports.

All these activities contribute to the positive development of Baden-Württemberg. One of our major objectives is to present and explain the healthcare industry and the bioeconomy to the public and highlight the benefit of innovations. As a central point of contact for issues relating to the healthcare industry and the bioeconomy, we represent Baden-Württemberg on both the national and international level.

Within the Bioeconomy Research Program Baden-Württemberg BIOPRO supports research projects with product and market studies and organizes exchange with industry and business partners as well as other important stakeholders. In 2017 / 2018 we organized the stakeholder process for the upcoming Baden-Württemberg policy strategy on sustainable bioeconomy.

Expertise:	Regional bioeconomy concepts, Creating value chains, Technology transfer support, Cooperation support, Start-up support, Public relations
Contact:	Dr. Barbara Jonischkeit jonischkeit@bio-pro.de
Address:	BIOPRO Baden-Württemberg GmbH Alexanderstraße 5 70184 Stuttgart Germany
Web:	www.bio-pro.de/en

Centre for European Economic Research GmbH (ZEW)



The **Centre for European Economic Research (ZEW)** is a non-profit institute with the legal form of a limited liability company (GmbH). Founded in 1990 on a public-private initiative in co operation with the University of Mannheim, ZEW is one of Germany's leading economic research institutes, and enjoys a strong reputation throughout Europe. ZEW pursues four key objectives:

- To conduct research of the highest quality
- To provide scientifically grounded economic policy advice
- To train up-and-coming economists, and
- To inform professionals and the lay public

The research department **Environmental and Resource Economics, Environmental Management** investigates the optimal function of markets and institutions with regards to environmental aspects and resource scarcity. Special emphasis is placed on European climate and economic assessments of policies that impact the environment, such as transport, energy, technology, and economic policies. Conflicts between economic and environmental goals are also identified. Given the universal shortage of resources, cost efficiency — that is, the ability of a policy to achieve a defined goal at minimal cost — and their equitable distribution in society are key criteria in the assessments.

Within the Bioeconomy Research Program Baden-Württemberg, ZEW contributes to the competence network modeling the Bioeconomy by developing approaches to identify the macroeconomic effects of increased biomass use through a Computable General Equilibrium (CGE) model.

Expertise:	Economic evaluation of environmental and energy policies, Computable General Equilibrium Modeling, Experimental economics
Contact:	Dr. Sebastian Voigt sebastian.voigt@zew.de
Address:	Centre for European Economic Research L 7.1 68161 Mannheim Germany
Web:	www.zew.de

Dialogik gGmbH



DIALOGIK is a Stuttgart-based non-profit research institute organized in the legal form of a limited company. It conducts systematic research into practical forms of communication and cooperation within the triangle of politics, economy and civil society. This is led by the assumption that effective, fair and socially acceptable decisions are at least partially dependent on the organization and performance of communication and cooperation.

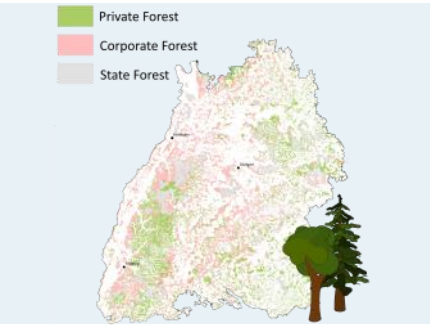
In particular, communication and cooperation are paramount for social debates on technology, environment, health and consumer protection. Controversial views about how to deal with opportunities and risks often lead to fruitless maneuvering, endless debates and frequent blockages between politics, economy and society. DIALOGIK's objective is to find new pathways for improving the governance of valuable resources, be they natural, economic or social. In a constant process of searching and learning, DIALOGIK has the ambition to make a difference by offering conceptual, theoretical and practical contributions towards a new communication culture in the common quest for a sustainable future.

Integrating technology assessments and foresight activities into governance processes is another area of interest. In the Bioeconomy Research Program Baden-Württemberg, DIALOGIK analyzes framework conditions and requirements for good governance in the Bioeconomy on the basis of case studies in the fields of lignocellulose- and biogas-based value chains.

Expertise:	Social scientific approaches, Qualitative and quantitative social research, Participative methods
Contact:	Dr. Dirk Scheer scheer@dialogik-expert.de Dr. Wilfried Konrad konrad@dialogik-expert.de
Address:	Dialogik gGmbH Lerchenstraße 22 70176 Stuttgart Germany
Web:	www.dialogik-expert.de

Forstliche Versuchs- und Forschungsanstalt Baden-Württemberg

Forest Research Institute Baden-Württemberg



The **Forest Research Institute Baden-Württemberg (FVA)** is the research facility of the German federal state Baden-Württemberg and belongs to the Ministry of Rural Affairs and Consumer Protection. It closely cooperates with the Faculty of Environment and Natural Resources of the University of Freiburg and has a strong focus on applied research.

In the Bioeconomy Research Program Baden-Württemberg, the institute conducts the research project “Picturing the behavior of actors in forest development and wood supply models”.

The aim is to complement „The Forest Development and Wood Supply Model“ (WEHAM), which has been developed to predict raw timber potentials for the next 40 years. Along with a socio-economic component analysis that will help estimate future silvicultural actions and market behavior of forest holdings within Baden-Württemberg, statistical analyses of recent WEHAM projections as well as empirical studies constitute the methodological basis of the research.

Expertise:	Biometry, Informatics, Forest economy, Forest Development and Wood Supply Model (WEHAM)
Contact:	Dr. Gerald Kändler gerald.kaendler@ forst.bwl.de
Address:	Forest Research Institute Baden-Württemberg Wonnhaldestraße 4 79100 Freiburg Germany
Web:	www.fva-bw.de

Fraunhofer Institute for Chemical Technology (ICT)

The **Fraunhofer Institute for Chemical Technology (ICT)** is one of the 67 institutes that currently constitute the Fraunhofer-Gesellschaft. ICT focuses on research and development in key competence areas of energy materials, energy systems, applied electrochemistry, environmental engineering and polymer engineering.

The Environmental Engineering Department is focused on the development of sustainable synthesis, production and recovery processes, and on the qualification of technical products according to standardized or advanced and customer-specific testing procedures. Such development of modern, sustainable processes requires a highly efficient use of existing resources combined with exploitation of new material sources such as sustainable raw materials in manufacturing new products with improved properties.

In the Bioeconomy Research Program Baden-Württemberg, Fraunhofer ICT researches production of lignin-based, tailored poly-functionally building blocks for material applications (i.e., resins, paints, adhesives, thermoplastic materials).

Expertise:	Thermo-chemical & base catalyzed conversion, Fractionation processes, Sustainable, catalyzed and tailored grafting processes on lignin, Analytical characterization, Development of material applications, Engineering and testing
Contact:	Dr. Detlef Schmiedl detlef.schmiedl@ict.fraunhofer.de
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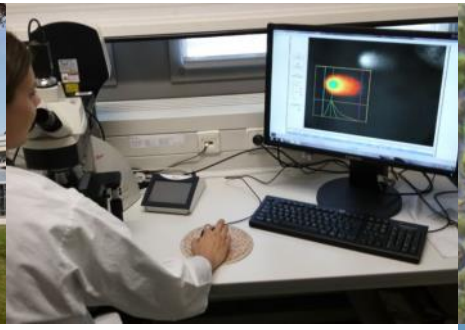
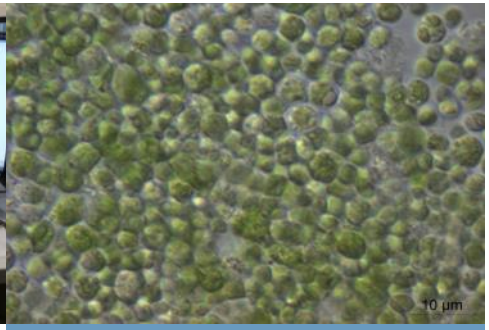
Web:	www.ict.fraunhofer.de

Max Rubner-Institut
Federal Research Institute of Nutrition and Food





Research at the **Max Rubner-Institut (MRI)** focuses on consumer health protection in the nutrition sector. The MRI advises the Federal Ministry of Food and Agriculture (BMEL) in the field of nutrition and food.

Four of MRI's eight departments use cross-product approaches focusing on nutritional behavior, nutritional physiology and biochemistry, food microbiology and bioprocess engineering. The research of the other four departments relates to safety and quality aspects of major food groups. Investigations span the entire food chain. The findings of MRI research contribute to refine recommendations for healthy nutrition in Germany.

Within the scope of the Bioeconomy Research Program Baden-Württemberg, the MRI conducts studies on the health benefits of microalgae, including processed microalgae products and their possible adverse effects. A fundamental requirement for microalgae nutritional benefits is a high bioavailability of key constituent compounds. More specifically, the bioavailability of microalgae nutrients and their potential benefits highly depend on the application of processing methods. Such knowledge is important more broadly for the implementation of new microalgae-based concepts in human nutrition.

Expertise:	Nutritional physiology, Bioactivity of food/food constituents
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Web:	www.mri.bund.de

State Research Institute and Education Center for Viticulture and Oenology and Fruit-growing, Weinsberg



The **State Research Institute and Education Center for Viticulture and Oenology and Fruit-growing (LVWO)** is the research facility of the German federal state Baden-Württemberg and belongs to the Ministry of Rural Affairs and Consumer Protection.

In the Bioeconomy Research Program Baden-Württemberg, the institute cooperates with the University of Stuttgart in the research project "Microalgae value chains for the bioeconomy in Baden-Württemberg (MIATEST-BW)".

Within the research project, LVWO Weinsberg investigates the biological efficacy of laminarin as plant strengthener with regard to the main fungal diseases Oidium *(Uncinula necator)* and Peronospora (*Peronospora viticola*) in viticulture. The application of laminarin as a plant strengthener aims to the reduction of the pesticide use in viticulture. The quantification of the laminarin impact is carried out by infection experiments in laboratory. Hyper- and multispectral analysis methods of grapevine leaves are applied to examine the infestation of the different fungal diseases. The examination under field conditions in vineyards analyzes the laminarin effect in the practical context.

Expertise:	Hyper- & multispectral analysis, Plant protection, Viticulture
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Web:	www.lvwo-bw.de

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