

## **Supplement S1**

*to the paper "One concept, many opinions – How scientists in Germany think about the concept of bio-economy" by Carmen Priefer and Rolf Meyer*

### **Questionnaire for the cluster "Biogas - Nachhaltige und flexible Wertschöpfungsketten für Biogas"**

#### **Preliminary questions on respondents' affiliation**

Bitte geben Sie an, welchem Handlungsfeld sich Ihr Projekt zuordnen lässt

Biomasseproduktion/Substratbereitstellung	
Biomasseaufschluss und Konversion	
Nutzung der Konversionsprodukte/Produktentwicklung	
Bewertung der Biomassenutzung unter ökonomischen, ökologischen, sozialen und ethischen Aspekten	
Systemanalyse, Potentialabschätzung, Modellierung	
Gesellschaftliche Rahmenbedingungen, Akzeptanz	

Wie würden Sie die Art Ihrer Forschung charakterisieren?

Grundlagenforschung	
Angewandte Forschung	

Wie lange arbeiten Sie schon im Themenfeld Bioökonomie?

Seit Beginn des laufenden Forschungsprojekts	
Bitte Startjahr angeben:	
Schon vor Beginn des laufenden Forschungsvorhabens	
Seit wann?	

# Topic 1 Perspectives on bioeconomy

## Verständnis von Bioökonomie

In den Bioökonomie-Strategien verschiedener Länder und in der wissenschaftlichen Literatur werden unterschiedliche Definitionen von Bioökonomie verwendet.

Wie würden Sie Bioökonomie definieren?

Bitte geben Sie an, in welchem Maße Sie den nachfolgend angeführten Definitionen jeweils zustimmen (1 = stimme voll zu, 2 = stimme eher zu, 3 = stimme eher nicht zu, 4 = stimme überhaupt nicht zu)

<b>Definitionen der Bioökonomie</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>
Bioökonomie ist die Entwicklung und Anwendung moderner Biotechnologie und Biowissenschaften (vgl. OECD)				
Bioökonomie umfasst die Produktion von erneuerbaren biologischen Ressourcen und ihre Konversion in Mehrwert generierende Produkte wie zum Beispiel Nahrungs- und Futtermittel, biobasierte Produkte und Bioenergie (vgl. Europäische Kommission)				
Bioökonomie umfasst die Agrar- und Forstwirtschaft sowie alle produzierenden Sektoren und ihre dazugehörigen Dienstleistungsbereiche, die biologische Ressourcen (Pflanzen, Tiere, Mikroorganismen) entwickeln, produzieren, ver- und bearbeiten oder in irgendeiner Form nutzen (vgl. BMBF)				
Bioökonomie verknüpft Ökonomie und Ökologie auf intelligente Weise und ermöglicht damit biobasiertes und nachhaltiges Wirtschaftswachstum (vgl. BMEL)				

## Visionen und Ziele

In der Bioökonomie-Strategie der Europäischen Kommission und der Bundesregierung werden verschiedene Visionen und weitreichende gesellschaftliche Ziele formuliert, die mit der Realisierung einer Bioökonomie erreicht werden sollen.

Bitte bewerten Sie die unten aufgelisteten Ziele<sup>1</sup> nach ihrer Wichtigkeit auf einer Skala von: 1 = unverzichtbar, 2 = wichtig, 3 = geringere Bedeutung, 4 = eher nebensächlich

Ziele	1	2	3	4
Langfristige Umstellung der wirtschaftlichen Produktionsbasis von fossilen auf biogene Quellen				
Produktion der notwendigen Rohstoffe im Einklang mit den Zielen des Umwelt-, Klima- und Naturschutzes				
Möglichst weitgehende Realisierung der Koppel- und Kaskadennutzung von Biomasse				
Nachhaltiger Konsum als Teil der Wertschöpfungskette der Bioökonomie				
Vorreiterrolle Deutschlands bei der Lösung globaler Herausforderungen wie Klimaschutz und Ernährungssicherung				
Stärkung der Innovationskraft und der internationalen Wettbewerbsfähigkeit des Wirtschafts- und Forschungsstandorts Deutschland				
Wachstumsschub und Schaffung neuer Arbeitsplätze gerade auch im ländlichen Raum				
Stärkung der industriellen Biotechnologie als ein Wirtschaftsgebiet mit hoher Wachstumsdynamik und großem Markt- und Wertschöpfungspotential				
Länder-, disziplin- und institutionenübergreifende Vernetzung von Forschung, Wissenschaft und Wirtschaft				
Stärkung inter- und transdisziplinärer Forschung				
Enges Zusammenwirken wirtschaftlicher, wissenschaftlicher und sozialer Akteure bei der Entwicklung einer Bioökonomie				

<sup>1</sup> Die genannten Ziele stammen aus der Nationalen Politikstrategie Bioökonomie (BMEL 2014), S. 20ff

Ziel des Forschungsverbunds „Nachhaltige und flexible Wertschöpfungsketten für Biogas“ ist die Erforschung von Möglichkeiten für die Entwicklung wettbewerbsfähiger, von traditioneller Förderung weitgehend unabhängiger, effizienter und umweltfreundlicher Technologien und Nutzungspfade in der Biogasproduktion.

Bitte geben Sie eine Einschätzung, welchen Beitrag Ihre voraussichtlichen Forschungsergebnisse zur Verwirklichung der unten angeführten Ziele<sup>2</sup> der baden-württembergischen Forschungsstrategie Bioökonomie leisten können (1 = hoher Beitrag, 2 = mäßiger Beitrag, 3 = geringer Beitrag, 4 = kein Beitrag)

Ziele	1	2	3	4
Zunehmende Unabhängigkeit des Landes von importierten fossilen Rohstoffen				
Nutzung der im Land vorhandenen Vielfalt pflanzlicher Biomasse				
Entwicklung neuer Verfahren/Technologien zur Biomassebereitstellung und -konversion				
Entwicklung von Kaskadennutzungen und Einsatz von nicht nutzbaren Koppelprodukten als Energieträger				
Entwicklung neuer hochwertiger und konkurrenzfähiger biobasierter Stoffe und Materialien				
Steigerung der lokalen Wertschöpfung und Beitrag zur positiven Beschäftigungsentwicklung in ländlichen Regionen				
Beitrag zur nachhaltigen Sicherung der natürlichen Lebensgrundlagen auf globaler Ebene				
Sicherung einer qualitativ hochwertigen Ernährung, sowohl in Baden-Württemberg als auch weltweit				
Stärkung der Innovationskraft des Landes, Ausbau der Technologieführerschaft				
Erhöhung der internationalen Sichtbarkeit und Konkurrenzfähigkeit des Wirtschafts- und Forschungsstandorts Baden-Württemberg				
Landesweite Vernetzung von Forschungseinrichtungen und Bündelung der baden-württembergischen Kompetenzen im Bereich der Bioökonomie				
Verbesserung des Informationsflusses zwischen Wirtschaft, Forschung und Gesellschaft				

<sup>2</sup> Die genannten Ziele stammen aus der baden-württembergischen Forschungsstrategie „Bioökonomie im System aufstellen“ von 2013, S. 6f

## Alternative Umsetzungspfade

Im Rahmen der Bioökonomie werden unterschiedliche alternative Umsetzungspfade diskutiert. Während die einen auf den Einsatz neuer Technologien wie industrielle Biotechnologie, Gentechnik und synthetische Biologie bauen, fordern andere Veränderungen im Konsumverhalten und eine Orientierung der Wirtschaft an der Tragfähigkeit ökologischer Systeme. Dem Bestreben, biologische Systeme so zu verändern, dass sie der Befriedigung ökonomischer und gesellschaftlicher Bedürfnisse dienen, steht die Forderung nach Einbettung industrieller Wirtschafts- und Produktionsprozesse in natürliche Stoffkreisläufe gegenüber.

Im Folgenden haben wir zum Teil gegensätzliche Positionen zur zukünftigen Ausgestaltung der Bioökonomie zusammengestellt und bitten Sie diese nach folgenden Kategorien zu bewerten: 1 = stimme voll zu, 2 = stimme eher zu, 3 = stimme eher nicht zu, 4 = stimme überhaupt nicht zu

Alternative Umsetzungspfade	1	2	3	4
Erhöhung der Ressourceneffizienz entlang biobasierter Wertschöpfungsketten (weniger Rohstoffinput pro Produkteinheit, Schließung von Kreisläufen, Koppel- und Kaskadennutzung)				
Förderung nachhaltiger Konsummuster (z.B. Reduktion des Fleischverzehrs, Konsum regional erzeugter Nahrungsmittel, Vermeidung von Lebensmittelverschwendung, Verringerung des Verbrauchs fossiler Energien)				
Ausbau der Technologie-Führerschaft, der Verfügung über geistiges Eigentum (z. B. Patente) und des wirtschaftlichen Einflusses von multinationalen Unternehmen				
Förderung sozialer Innovationen, der Nutzung von lokalem Wissen und den Erfahrungen verschiedener Stakeholder (Landwirte, KMU, zivilgesellschaftliche Gruppen)				
Förderung von Forschung und Innovation auf dem Gebiet der Lebenswissenschaften als Schlüsseltechnologien (Gentechnik, Synthetische Biologie, DNA-Sequenzierung, Bioinformatik etc.)				
Stärkung einer multifunktionalen, agro-ökologischen Landbewirtschaftung, die an Kriterien wie Diversität, Resilienz und Selbstregulierung orientiert ist				
Anpassung der Natur an industrielle Prozesse und Kreisläufe				
Anpassung des industriellen Metabolismus an natürliche Kreisläufe				
Schaffung enger Partnerschaften zwischen Unternehmen, Forschung und Politik mit dem Ziel Investitionen, Kenntnisse und Erfahrungen im Bereich von Schlüsseltechnologien zu fördern				
Beteiligung der Zivilgesellschaft an der Ausgestaltung einer Bioökonomie				

## Topic 2 Value chains

### Wertschöpfungsketten

Die Situation in Baden-Württemberg ist gekennzeichnet durch einen hohen Bestand von Biogasanlagen bei gleichzeitig sinkender Wirtschaftlichkeit der Biogasproduktion infolge der Novellierung der EEG-Förderung in 2014 (u.a. kein Bonus mehr für den Einsatz landwirtschaftlicher Energiepflanzen). Daran anknüpfend sollen im Verbundprojekt einerseits die Einsatzmöglichkeiten alternativer Substrate wie Landschaftspflegematerial, Lebensmittelabfälle, biogene Siedlungsabfälle, Gülle oder Klärschlamm untersucht werden, andererseits die technische Optimierung bestehender Anlagen (Repowering) sowie alternative Nutzungswege des erzeugten Biogases. Dazu gehört die stoffliche Nutzung von Biogas sowie die Speicherung und Nutzung von Biogas als Regel- bzw. Bedarfsenergie, zum Ausgleich des diskontinuierlichen Anfalls anderer erneuerbarer Energien.

- Welche Wertschöpfungskette/n soll im Rahmen Ihres Forschungsprojekts auf- bzw. ausgebaut werden? Bitte geben Sie jeweils Ausgangsstoff, Konversionsverfahren, Ziel- und Nebenprodukte an.

Wertschöpfungskette:
Ausgangsstoff/e:
Konversionsverfahren:
Zielprodukt/e:
Nebenprodukt/e:

- Was waren Ihre Auswahlkriterien für die Festlegung auf diese Wertschöpfungskette/n (z. B. besonders hohe Wertschöpfung, besonders einfaches Verfahren, günstige Kosten-Nutzen-Relation)?

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- Welche energetische und/oder stoffliche Nutzung ist für das/die angestrebte/n Zielprodukt/e vorgesehen?

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- Welche Nutzung ist für die anfallenden Nebenprodukte (z.B. Gärreste) vorgesehen?

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- Von welchem Zeithorizont gehen Sie aus, bis alle Technologien und Verfahren zur Realisierung einer zukunftsfähigen, umweltfreundlichen und wettbewerbsfähigen Biogaserzeugung in der Praxis zur Verfügung stehen?

- Welche Chancen räumen Sie dem weiteren Betrieb bestehender Biogasanlagen nach dem Auslaufen der zwanzigjährigen EEG-Förderung ein?

- Welche Chancen räumen Sie dem weiteren Zubau von Biogasanlagen unter den aktuellen EEG-Förderbedingungen ein?

- Wie schätzen Sie die Wirtschaftlichkeit des Einsatzes von Rest- und Abfallstoffen als Biogassubstrat ein?

## Topic 3 Potentials and competing uses

### Potenziale und Nutzungskonkurrenzen

Nach der Bioökonomiestrategie der Bundesregierung soll der globalen Ernährungssicherung und der ausreichenden Versorgung mit gesunden und sicheren Lebensmitteln Vorrang vor allen anderen Nutzungspfaden biogener Rohstoffe eingeräumt werden. Da das Angebot an Fläche begrenzt und nicht vermehrbar ist, sind Flächennutzungskonkurrenzen nicht auszuschließen. Um mögliche Konflikte zu vermeiden, soll im Verbundprojekt in erster Linie der Einsatz von Rest- und Abfallstoffen als Biogassubstrat geprüft werden. Dabei sind zwar keine Landnutzungskonkurrenzen zu erwarten, wohl aber – bei bestimmten Einsatzstoffen wie biogenen Siedlungsabfällen oder Klärschlamm – Konkurrenzbeziehungen zu etablierten Verwertungswegen wie Kompostierung, Vergärung oder thermischer Behandlung.

- Wie wird sich die Nachfrage nach Bioenergiepflanzen durch die im Verbundprojekt anvisierten Wertschöpfungsketten verändern?

- Welche erschließbaren, bisher noch nicht genutzten Potentiale von Rest- und Abfallstoffen (Landschaftspflegematerial, Abfälle aus der Lebensmittelindustrie, biogene Siedlungsabfälle, Gülle, Klärschlamm) können in Baden-Württemberg für die Realisierung der geplanten Wertschöpfungsketten mobilisiert werden?

- Reichen Ihrer Ansicht nach die mobilisierbaren Rest- und Abfallstoffe in Baden-Württemberg aus, um den Substratbedarf der bestehenden Biogasanlagen zu befriedigen?

- Inwieweit erwarten Sie beim Einsatz von Rest- und Abfallstoffen Konkurrenzbeziehungen zu bereits etablierten Verwertungswegen wie Kompostierung, Vergärung und thermischer Behandlung?

- Ist langfristig eine Konkurrenzsituation zwischen dem Biogas-Pfad und dem Lignozellulose-Pfad im Hinblick auf bestimmte Ausgangsstoffe (z. B. Miscanthus, Landschaftspflegematerial) wahrscheinlich?

- In welchem Umfang könnten landwirtschaftliche Flächen in Baden-Württemberg durch die Substratumstellung (von Mais auf Rest- und Abfallstoffe) freigesetzt werden?

- Die bestehenden Biogasanlagen sind in der Regel rohstoffnah im ländlichen Raum angesiedelt. Halten Sie beim Einsatz von alternativen Substraten wie Lebensmittelabfällen, biogenen Siedlungsabfällen und Klärschlamm eine Verlagerung von Anlagen an siedlungsnahen Standorten für erforderlich?

- Würde eine solche Standortverlagerung aus Ihrer Sicht zu erhöhten Akzeptanzproblemen bei der betroffenen Bevölkerung führen?

## Topic 4 Effects on the environment

### Auswirkungen einer optimierten Biogasproduktion auf die Umwelt

Die häufig beklagten negativen Auswirkungen des Anbaus von Mais und anderen landwirtschaftlichen Biogassubstraten auf die Umwelt (Boden, Wasser, Biodiversität, Ökosystemfunktionen) würden durch die verstärkte Nutzung von Rest- und Abfallstoffen weitgehend vermieden. In Anbetracht des hohen Bestands an Biogasanlagen in Baden-Württemberg ist aber zu vermuten, dass auf Anbau und Nutzung von Energiepflanzen dennoch nicht ganz verzichtet werden kann. Im Verbundprojekt ist daher explizit die Nutzung mehrjähriger Energiepflanzen vorgesehen.

- Welche sowohl positiven als auch negativen ökologischen Auswirkungen (Boden, Wasser, Biodiversität, Ökosystemfunktionen) sind durch die im Rahmen des Verbundprojekts vorgesehene Nutzung von mehrjährigen Energiepflanzen zu erwarten?

- Wie sind die ökologischen Auswirkungen im Vergleich zu konventionellen Energiepflanzen (Mais, Zuckerrüben, Weizen) zu bewerten?

- Welche sowohl positiven als auch negativen Umweltwirkungen sind von dem Einsatz von Rest- und Abfallstoffen als Biogassubstrate anstelle von Energiepflanzen zu erwarten?

## Topic 5 Collaborations

### Akteure

Wie dem Verbundantrag zum Forschungsfeld Biogas zu entnehmen ist, bestehen zahlreiche Synergien zwischen den Teilprojekten und auch Anknüpfungspunkte zum Lignozellulose-Verbund, die eines erheblichen Koordinierungsaufwands bedürfen. Ein zentrales Anliegen der baden-württembergischen Forschungsstrategie Bioökonomie ist es daher, eine landesweite Vernetzung von Forschungseinrichtungen unter einem gemeinsamen Forschungsfokus zu verwirklichen und den Informationsfluss zwischen Forschung, Wirtschaft und Gesellschaft auszubauen. Vor diesem Hintergrund interessiert uns, welche Kooperationen in Ihrem Forschungsprojekt stattfinden, die über die Forschungsverbundtreffen und die Statusseminare hinausgehen.

Haben Sie Kooperationen...	Ja	Nein	Falls ja, mit welchen Einrichtungen bzw. Akteuren?
innerhalb des Verbunds?			
innerhalb des gesamten Forschungsprogramms?			
mit Forschungseinrichtungen, die nicht am Forschungsprogramm Bioökonomie teilnehmen?			
mit Unternehmen aus den Bereichen Biotechnologie und Chemie?			
mit Unternehmen aus der Lebensmittelindustrie?			
mit Unternehmen aus dem Bereich Erneuerbare Energien?			
mit Unternehmen aus anderen Branchen?			
mit Unternehmen und Einrichtungen aus dem BioPro-Akteursnetzwerk?			
mit Landwirten oder landwirtschaftlichen Verbänden?			
mit zivilgesellschaftlichen Gruppen wie Umwelt- und Verbraucherschutzverbänden?			
mit potentiellen Nutzern?			

<b>In welcher Weise kooperieren Sie?</b>	<b>Ja</b>	<b>Nein</b>	<b>Falls ja, mit welchen Einrichtungen bzw. Akteuren</b>
(Regelmäßige) Arbeitstreffen zum Informationsaustausch			
Diskussion, Austausch und/oder Weitergabe von Ergebnissen			
Gemeinsame Erarbeitung von Forschungsfragen			
Gemeinsame Nutzung von Geräten und Infrastruktur			
Abstimmung über zu verwendende Ausgangsstoffe			
Verständigung über Untersuchungsmethoden			
Ermittlung von Interessenslagen			
Diskussion gemeinsamer Vermarktungsstrategien			
Entwicklung neuer Business-Modelle (z. B. Start-ups, Public-Private Partnerships)			

# Questionnaire for the cluster "Lignocellulose - Changing to an alternative raw material platform for new materials and products"

## Preliminary questions on respondents' affiliation

Please indicate to which field of activity your project can be assigned

Biomass production/substrate provision	
Biomass digestion and conversion	
Use of conversion products/product development	
Evaluation of biomass utilization under economic, ecological, social, and ethical aspects	
Systems analysis, assessment of biomass potentials, modelling	
Societal framework conditions, acceptance	

How would you characterize your type of research?

Basic research	
Applied research	

For how long have you been working in the field of bioeconomy?

Since the start of the current research project Please indicate the year in which the project was launched:	
Even before the start of the current research project Since when?	

# Topic 1 Perspectives on bioeconomy

## Understanding of bioeconomy

Various definitions of bioeconomy are used in the bioeconomy strategies of different countries and in academic literature.

How would you define bioeconomy?

Please indicate to what extent you agree with each of the following statements.

(1 = fully agree, 2 = rather agree, 3 = slightly disagree, 4 = fully disagree)

<b>Definitions of bioeconomy</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>
Bioeconomy is the development and application of modern biotechnology and life sciences (cf. OECD)				
Bioeconomy covers the production of renewable biological resources and their conversion into products which generate additional value like, e.g. food and animal feed, bio-based products, and bioenergy (cf. European Commission)				
Bioeconomy covers agriculture and forestry as well as all producing sectors with their respective service sectors which develop, produce, process, and work on biological resources (like plants, animals, microorganisms) or use them in any form (cf. BMBF)				
Bioeconomy combines economy and ecology in an intelligent way and thus enables a bio-based and sustainable economic growth (cf. BMEL)				

## Visions and objectives

The bioeconomy strategy of the German Federal Government articulates various visions and far-reaching societal targets which shall be achieved with the realization of a bioeconomy.

Please rate the following goals<sup>3</sup> according to their importance on a scale of: 1 = essential, 2 = important, 3 = less important, 4 = rather negligible

Objectives	1	2	3	4
Conversion of the economic production base from fossil to biogenic sources in the long term				
Producing the required raw materials in line with the objectives of environmental and climate protection and nature conservation				
Implementating coupled and cascading utilization of biomass				
Implementing sustainable consumption as part of the value-added chain of bioeconomy				
Leading position of Germany in solving global challenges like climate protection and food security				
Strengthening the innovative capacities and the international competitiveness of the business and research location Germany				
Triggering a growth spurt and creation of new jobs, especially in rural areas				
Strengthening industrial biotechnology as an economic field with high growth dynamics and a large market and value creation potential				
Networking of research, science, and business across borders, disciplines, and institutions				
Strengthening inter- and transdisciplinary research				
Close cooperation between economic, scientific, and social players in the development of a bioeconomy				

<sup>3</sup> The mentioned objectives are taken from the “Nationale Politikstrategie Bioökonomie“(National Policy Strategy on Bioeconomy) (BMEL 2014), p. 20ff

The thematic cluster “Lignocellulose-based value-added chains” aims at an integral use of lignocellulosic biomass for the production of bio-based chemical products and fuels through thermochemical and biochemical conversion processes.

Please assess the contribution of your expected research results to the realization of the objectives<sup>4</sup> of the Baden-Württemberg research strategy on bioeconomy mentioned below

(1 = significant contribution, 2 = moderate contribution, 3 = small contribution, 4 = no contribution)

<b>Objectives</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>
Increasing the country’s independence from imported fossil fuels				
Using the country’s diversity of plant biomass				
Developing new methods/technologies for the supply and conversion of biomass				
Developing cascade systems and using non-utilizable co-products as an energy source				
Developing new high-quality and competitive bio-based substances and materials				
Enhancing local added value and contributing to a positive employment trend in rural regions				
Contributing to the sustainable conservation of natural resources at global level				
Ensuring a high standard of nutrition, both in Baden-Württemberg and worldwide				
Strengthening the innovative capacity of the country, extending the technological leadership				
Increasing the international visibility and competitiveness of the business and research location Baden-Württemberg				
Networking of the country’s research institutes and bundling the competences in the field of bioeconomy in Baden-Württemberg				
Improving the information flow between business, research, and society				

<sup>4</sup> The mentioned objectives are part of the Baden-Württemberg research strategy “Establishing Bioeconomy in the System” of 2013, p. 6f, 81

## Alternative implementation paths for the bioeconomy

Different alternative implementation paths are discussed within the concept of bioeconomy. While some rely on the use of new technologies like industrial biotechnology, genetic engineering, or synthetic biology, others call for changes in consumer behavior and request an orientation of the economy on the carrying capacity of ecological systems. The endeavor to change biological systems in such a way that they serve to satisfy economic and societal needs is contrary to the call for embedding industrial production processes into natural biogeochemical cycles.

In the following we have compiled a number of (partly opposing) positions on the future shaping of the bioeconomy and would like to ask you to assess them according to the following categories:

1 = fully agree, 2 = rather agree, 3 = slightly disagree, 4 = fully disagree

Alternative implementation paths	1	2	3	4
Improving resource efficiency along bio-based value-added chains (less raw material input per product unit, closing cycles, coupled and cascade utilization)				
Promoting sustainable consumption patterns (e.g. reducing meat consumption, consuming regionally produced food, avoiding food waste, reducing the use of fossil energies)				
Extending technological leadership, intellectual property (e.g. patents), and economic influence of multi-national organizations				
Promoting social innovations, the use of local knowledge and the experience of various stakeholders (farmers, SMEs, non-governmental groups)				
Promoting research and innovation in the field of life sciences as key technologies (genetic engineering, synthetic biology, DNA sequencing, bioinformatics, etc.)				
Strengthening a multi-functional, agro-economic land cultivation which is oriented towards criteria like diversity, resilience, and self-regulation				
Adjusting nature to industrial processes and cycles				
Adjusting industrial metabolism to natural cycles				
Establishing close partnerships between companies, research, and politics aiming at promoting investments, skills, and experiences in the field of key technologies				
Involving civil society in shaping and advancing a bioeconomy				

## Topic 2 Value chains

### Value-added chains

Lignocellulose is the most common type of biomass which has been used by mankind in many ways since pre-industrial times. Different biomass sources are available for the production of lignocellulose which can be processed into a broad range of final products by using a number of conversion and manufacturing methods. The following questions should help us to gain additional information on the examined value-added chains and the intended intermediates and final products.

- Which value-added chain/s should be established or extended in the framework of your research project? Please specify raw material/s, conversion method, target product/s and intermediate/s

Value-added chain:
Raw material/s:
Conversion process:
Target product/s:
Intermediate/s:

- Which innovative product lines can be established on the basis of your target products? (e.g. new materials like bioplastics, insulating foams, high-performance nanocomposites, etc.)

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- Which further synthesis or processing steps are required to get from your target product/s to the desired final product/s?

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- Which were the selection criteria for defining these value-added chain/s (e.g. extraordinarily high added value, extremely simple process, favorable cost-benefit-balance)?

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- Shall the intended target product/s substitute existing products based on fossil fuels or do you aim at innovative products?

- Do/es the value-added chain/s aim at including the resulting target product/s into established petrochemical processes or do you aim at new, independent synthesis routes?

- Are there any co-products respectively residuals in your value-added chain/s and if so, which kind of use is intended for them?

- Do/es your value-added chain/s allow for a multi-level cascade utilization (i.e. reuse of end products) and if so, in which way?

- Do you assume that there are other ways to use the lignin and/or terpene fractions of lignocellulose than combustion in the foreseeable future? What do you think is the most promising way?

- Which time frame would you estimate for the availability of all technologies and processes required for realizing an integral use of lignocellulosic biomass in practice?

### Topic 3 Potentials and competing uses

According to the bioeconomy strategy of the German Federal Government, global food security and a sufficient supply of healthy and secure food should take priority over all other uses of biomass. Since the available land is limited and cannot be extended, food production for a growing world population and the conservation and protection of the essential ecosystem services may have to compete with an increasing material and energetic use of biomass. To avoid possible conflicts, the production of the required biomass shall be restricted – according to the cluster’s proposal – to those areas in Baden-Württemberg which are less suitable for food production.

- Which additional demand for lignocellulose is created by the intended value-added chains?

- Which exploitable, previously untapped wood potentials in Baden-Württemberg could be mobilized for the realization of the intended value-added chains?

- Which alternative raw materials (e.g. waste wood, landscape conservation material, residues from wood industry, forestry and agriculture, e.g. straw) are best suited from your point of view? Are they available in sufficient amounts?

- Do you assume that there is enough domestic biomass available to meet the foreseeable demand of biomass or do we need imports from abroad?

- Regarding the raw material, to what extent do you expect competition with established ways of marketing and utilization, e.g. wood, paper, building and furniture industries or the heating market?

- From your point of view, to what extent will new land use concepts with perennial plants (e.g. short rotation coppice, Miscanthus) become established in Baden-Württemberg within the current framework conditions?

- Do you assume that the additional land requirement for this cultivated lignocellulose could be met on areas in Baden-Württemberg?

- Do you expect the intended transformation of lignocellulose will likely take place in large-scale plants (e.g. on chemical sites) or decentralized in local small-scale plants (commodity-related)?

## Topic 4 Effects on the environment

### Environmental impacts of an intensified use of lignocellulose

The increasing harvesting of woody biomass from forests as well as its production on arable land in the form of perennial plants may have positive as well as negative impacts on nature and the environment – its extent mainly depends on the respective harvesting and/or cultivation strategy.

- What kind of negative ecological effects (soil, water, biodiversity, ecosystem services) can be caused by an increasing harvesting of woody biomass from forests?

- How and to what extent can such negative effects be prevented by innovative silvicultural systems?

- Could such new silvicultural systems even be realized to a sufficient scale in Baden-Württemberg if the demand for raw materials is strongly increasing?

- From your point of view, which kind of positive as well as negative ecological impacts on soil, water, biodiversity, and ecosystem services have to be expected from the cultivation of lignocellulose supplying, perennial plants on arable land?

- To what extent could possible negative impacts be avoided by the type of cultivation (e.g. increasing plant diversity in short rotation coppice instead of monocultures)?

- How would you assess the impacts of the production of lignocellulose supplying plants on arable land compared with the ecological impacts of the cultivation of conventional energy crops (maize, rape)?

## Topic 5 Collaborations

As the cluster's proposal for the research area lignocellulose critically points out, the network of working groups in the field of bioeconomy in Baden-Württemberg is still immature and little organized. Therefore the realization of a state-wide network of research institutions with a common research focus and an improved information flow between research, economy, and society are key priorities of the Baden-Württemberg research strategy bioeconomy. Against this background we would like to know if you are involved in any co-operations apart from the meetings of the thematic cluster and status seminars.

Are you involved in any co-operations ...	Yes	No	If yes, with which organizations and/or players?
within the thematic cluster?			
within the overall research program?			
with research institutions which do not participate in the research program bioeconomy ?			
with companies in the fields of biotechnology and chemistry?			
with companies in the food industry			
with companies in the field of renewable energies?			
with companies in other sectors?			
with companies and institutions of the BioPro network?			
with farmers or agricultural associations?			
with non-governmental groups like environmental and consumer protection associations?			
with potential users?			

In which way do you cooperate?	Yes	No	If yes, with which organizations and/or players?
Regular meetings to exchange information			
Discussion, exchanging and/or passing on of results			
Joint definition of research questions			
Joint use of equipment and infrastructure			
Agreement on raw materials to be used			
Agreement on the research methods			
Sounding out common interests			
Discussion of a common marketing strategy			
Development of new business models (e.g. start-ups, public-private partnerships)			

# Questionnaire for the thematic cluster “Microalgae – Integrated use for food and feed”

## Preliminary questions on respondents' affiliation

Please indicate to which field of activity your project can be assigned

Biomass production/substrate provision	
Biomass digestion and conversion	
Use of conversion products/product development	
Evaluation of biomass utilization under economic, ecological, social, and ethical aspects	
Systems analysis, assessment of biomass potentials, modelling	
Societal framework conditions, acceptance	

How would you characterize your type of research?

Basic research	
Applied research	

For how long have you been working in the field of bioeconomy?

Since the start of the current research project	
Please indicate the year in which the project was launched:	
Even before the start of the current research project	
Since when?	

# Topic 1 Perspectives on bioeconomy

## Understanding of bioeconomy

Various definitions of bioeconomy are used in the bioeconomy strategies of different countries and in academic literature.

How would you define bioeconomy?

Please indicate to what extent you agree with each of the following statements.

(1 = fully agree, 2 = rather agree, 3 = slightly disagree, 4 = fully disagree)

<b>Definitions of bioeconomy</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>
Bioeconomy is the development and application of modern biotechnology and life sciences (cf. OECD)				
Bioeconomy covers the production of renewable biological resources and their conversion into products which generate additional value like, e.g. food and feed, bio-based products, and bioenergy (cf. European Commission)				
Bioeconomy covers agriculture and forestry as well as all producing sectors with their respective service sectors which develop, produce, process, and work on biological resources (like plants, animals, microorganisms) or use them in any form (cf. BMBF)				
Bioeconomy combines economy and ecology in an intelligent way and thus enables a bio-based and sustainable economic growth (cf. BMEL)				

## Visions and objectives

The bioeconomy strategy of the German Federal Government articulates various visions and far-reaching societal targets which shall be achieved with the realization of a bioeconomy.

Please rate the following goals<sup>5</sup> according to their importance on a scale of: 1 = essential, 2 = important, 3 = less important, 4 = rather negligible

Objectives	1	2	3	4
Conversion of the economic production base from fossil to biogenic sources in the long term				
Producing the required raw materials in line with the objectives of environmental and climate protection and nature conservation				
Implementing coupled and cascading utilization of biomass				
Implementing sustainable consumption as part of the value-added chain of bioeconomy				
Leading position of Germany in solving global challenges like climate protection and food security				
Strengthening the innovative capacities and the international competitiveness of the business and research location Germany				
Triggering a growth spurt and creation of new jobs, especially in rural areas				
Strengthening industrial biotechnology as an economic field with high growth dynamics and a large market and value creation potential				
Networking of research, science, and business across borders, disciplines, and institutions				
Strengthening inter- and transdisciplinary research				
Close cooperation between economic, scientific, and social players in the development of a bioeconomy				

<sup>5</sup> The mentioned objectives are taken from the “Nationale Politikstrategie Bioökonomie“(National Policy Strategy on Bioeconomy) (BMEL 2014), p. 20ff

The thematic cluster “Microalgae – Integrated use for food and feed” aims to identify microalgae with useful technofunctional and physiochemical proteins and lipids, to develop harmonized cultivation and extraction processes, to generate stand-alone und hybrid products by substitution of animal-derived ingredients, and to evaluate the nutritional value of microalgae products for human and animal nutrition.

Please assess the contribution of your expected research results to the realization of the objectives<sup>6</sup> of the Baden-Württemberg research strategy on bioeconomy mentioned below  
(1 = significant contribution, 2 = moderate contribution, 3 = small contribution, 4 = no contribution)

<b>Objectives</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>
Increasing the country’s independence from imported fossil fuels				
Using the country’s diversity of plant biomass				
Developing new methods/technologies for the supply and conversion of biomass				
Developing cascade systems and using non-utilizable co-products as an energy source				
Developing new high-quality and competitive bio-based substances and materials				
Enhancing local added value and contributing to a positive employment trend in rural regions				
Contributing to the sustainable conservation of natural resources at global level				
Ensuring a high standard of nutrition, both in Baden-Württemberg and worldwide				
Strengthening the innovative capacity of the country, extending the technological leadership				
Increasing the international visibility and competitiveness of the business location Baden-Württemberg				
Networking of the country’s research institutes and bundling the competences in the field of bioeconomy in Baden-Württemberg				
Improving the information flow between business, research, and society				

<sup>6</sup> The mentioned objectives are part of the Baden-Württemberg research strategy “Establishing Bioeconomy in the System” of 2013, p. 6f

### Alternative implementation paths for the bioeconomy

Different alternative implementation paths are discussed within the concept of bioeconomy. While some rely on the use of new technologies like industrial biotechnology, genetic engineering, or synthetic biology, others call for changes in consumer behavior and request an orientation of the economy on the carrying capacity of ecological systems. The endeavor to change biological systems in such a way that they serve to satisfy economic and societal needs is contrary to the call for embedding industrial production processes into natural biogeochemical cycles.

In the following we have compiled a number of (partly opposing) positions on the future shaping of the bioeconomy and would like to ask you to assess them according to the following categories:

1 = fully agree, 2 = rather agree, 3 = slightly disagree, 4 = fully disagree

Alternative implementation paths	1	2	3	4
Improving resource efficiency along bio-based value-added chains (less raw material input per product unit, closing cycles, coupled and cascade utilization)				
Promoting sustainable consumption patterns (e.g. reducing meat consumption, consuming regionally produced food, avoiding food waste, reducing the use of fossil energies)				
Extending technological leadership, intellectual property rights (e.g. patents), and economic influence of multi-national organizations				
Promoting social innovations, the use of local knowledge and the experience of various stakeholders (farmers, SMEs, non-governmental groups)				
Promoting research and innovation in the field of life sciences as key technologies (genetic engineering, synthetic biology, DNA sequencing, bioinformatics, etc.)				
Strengthening multi-functional, agro-ecological land cultivation which is oriented towards criteria like diversity, resilience, and self-regulation				
Adjusting nature to industrial processes and cycles				
Adjusting industrial metabolism to natural cycles				
Establishing close partnerships between companies, research, and politics aiming at promoting investments, skills, and experiences in the field of key technologies				
Involving civil society in shaping and advancing a bioeconomy				

## Topic 2 Value chains

### Value-added chains

The research on microalgae was until now concentrated on pharmaceutical products and bio-fuels. The development of high-value nutrients from microalgae is still in the beginning. An early identification of possible future value-added chains based on microalgae is an important precondition for successful innovations. The following questions should help us to gain additional information on the examined value-added chains and the intended final products

- Which value-added chain/s should be developed in the framework of your research project?  
Please specify type of used microalgae, cultivation process, extraction process, final product/s and co-product/s

Value-added chain:
Used microalgae/s:
Cultivation process:
Extraction process:
Final product/s:
Co-product/s:

- Which innovative food components or food products can be established on the basis of your target products? (e.g. dietary supplements, functional foods, substitute products for animal-derived foods, etc.)

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- Which further processing steps are necessary to get from your final product/s to the intended food components or food products?

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- Which were the selection criteria for defining the/se value-added chain/s (e.g. extraordinarily high added value, extremely simple process, favorable cost-benefit-balance)?

- Shall the intended new food components and/or food products from microalgae substitute animal-derived foods or will novel food products be developed?

- Which use is intended for the resulting co-products respectively residuals?

- Which time frame would you estimate for the availability of all technologies and processes required for realizing food production from microalgae in practice?

### Topic 3 Potentials and competing uses

#### Potentials and competing uses

According to the bioeconomy strategy of the German Federal Government, global food security and a sufficient supply of healthy and secure food should take priority over all other uses of biomass. The research cluster Microalgae intends to contribute to the task of reducing the pressure on the available biological resources. No agricultural land is needed for the production of microalgae. So, potential land use conflicts with agriculture are avoided. Nonetheless, competitions with other land uses cannot be totally excluded. Additionally, the introduction of new products based on microalgae can cause multiple competition relations to the conventional production of foods such as milk and meat.

- Which locations in Baden-Württemberg are suitable for the production of microalgae?  
Which kind of land use will be displaced?

- Which area needs are expected for microalgae reactors?

- Are there factors which make a realization of the targeted value-added chains outside of Baden-Württemberg more likely? Which locations would be more attractive?

- Do you think that single stages of the value-added chain could be realized at different sites? Which combination of locations would be possible and why?

- Which CO<sub>2</sub>-resources will be used and which CO<sub>2</sub>-demand is expected?

- How do you see the consumer acceptance for algae-based food products?

- Which promoting factors (e.g., health benefits) and which restraining factors (e.g., expectations on "naturalness" of food) are influencing the consumer acceptance for algae-based food products in your opinion?

- Which interest of the food industry in algae-based food products do you expect?

- From your point of view, to which extent can the demand for animal-based food be replaced by algae-based food products?

- Do you see possible competition with organic farming or other approaches to enhance animal welfare and the environmental performance of conventional agriculture?

- How do you see the competition with other innovative approaches to substitute animal-derived food (In-vitro-meat, plant-based milk, single cell protein, insects, etc.)?

- Which changes (extent and type) in agricultural husbandry and the feed production do you expect from a successful introduction of algae-based food?

- Do you think that in the future a competition between an energetic and material use of microalgae is likely?

## Topic 4 Effects on the environment

### Environmental impacts of an utilization of microalgae

Value-added chains based on microalgae – like all production processes – are associated with the use of resources (e.g., energy, water, nutrients) and potential environmental impacts (e.g., emission of greenhouse gases).

- Which impacts on landscapes or townscapes are expected from the installation of microalgae reactors?

- To which extent could agricultural land be freed up by the production of microalgae for nutrition purposes?

- What is the energy balance of the regarded value-added chain/s?

- Which water demand is associated with the regarded value-added chain/s?

- Which demand for nutrients is associated with the cultivation of microalgae? Which nutrient sources can be used?

- Which additional additives and process agents are needed in the regarded value-added chain/s?

- How is your overall assessment of the environmental balance of the regarded value-added chain/s in comparison to conventionally produced feed and animal-based food?

## Topic 5 Collaborations

### Players

In the cluster's proposal for the research area "Microalgae – Integrated use for food and feed", the exchange of materials and information as well as the common use of infrastructure are important elements. Furthermore, an improved information flow between research, economy, and society are key priorities of the Baden-Württemberg research strategy bioeconomy. Against this background we would like to know if you are involved in any co-operations apart from the meetings of the thematic cluster and status seminars.

Are you involved in any co-operations ...	Yes	No	If yes, with which organizations and/or players?
within the thematic cluster?			
within the overall research program?			
with research institutions which do not participate in the research program bioeconomy ?			
with companies in the fields of biotechnology and chemistry?			
with companies in the food industry			
with companies in the field of renewable energies?			
with companies in other sectors?			
with companies and institutions of the BioPro network?			
with farmers or agricultural associations?			
with non-governmental groups like environmental and consumer protection associations?			
with potential users?			

In which way do you cooperate?	Yes	No	If yes, with which organizations and/or players?
Regular meetings to exchange information			
Discussion, exchanging and/or passing on of results			
Joint definition of research questions			
Joint use of equipment and infrastructure			
Agreement on raw materials to be used			
Agreement on the research methods			
Sounding out common interests			
Discussion of a common marketing strategy			
Development of new business models (e.g. start-ups, public-private partnerships)			