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Regional ecosystem Cradle2Cradle maturity analysis Bavaria

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Executive Summary

This deliverable documents the results of the analysis of the ecosystem for the region of Bavaria with respect to circular economy in general and the cradle to cradle principles in particular.

The analysis has been performed in the 3 dimensions covered by the Cradle-ALP project:

- Policies and business support
- Technologies
- Business models

With the aim to take stock of the status quo, identify gaps and barriers for the circular transformation of the economy, as well as opportunities for fostering this transformation.

In each region, the analysis focused on the industrial sectors to be involved later in the project in industrial transformation pilot activities. In the case of the region Bavaria, those sectors are primarily: chemistry and polymers. For the packaging and textile sector CCB will partially contribute providing contact to relevant Bavarian companies.

Contents

1. Introduction to the Cradle-Alp project

Cradle-ALP aims for mainstreaming cradle to cradle (C2C) approaches, circular design and circular substitutions (from the alpine region) for linear products in industrial processes, in different industrial sectors. The Alpine Space is abundant in natural resources and possesses the technology necessary to replace fossil raw materials and toxic substances in production with sustainable, eco-friendly alternatives. This transformation facilitates the reintegration of materials and products into a healthy, closed-loop cycle after use. The focus of this project shall be on the substitution of chemical and fossil based/unsustainable materials with more circular, sustainable and bio-degradable ones.

First, the partners will build a broad awareness and understanding in the public, the relevant industries as well as among stakeholders from policy and innovation intermediaries, for the opportunities, barriers and mechanisms of the transformation of industrial products towards higher circularity by means of C2C approaches, circular design and circular substitutions. Business support providers shall be trained to accompany the transformation of businesses along more circular value chains.

In a second step, the partners will explore in details and test opportunities for implementing C2C approaches, circular design and circular substitutions along specific value chains in the chemistry/plastics and wood/forestry sectors supported by digital technologies. Building on a thorough multidimensional (technology, policy, economy, etc.) roadmapping exercise, transnational groupings of stakeholders – including businesses – will be installed, with the aim to transfer the C2C roadmaps into industrial practice along exemplary value chains.

Finally, the partners will work towards ensuring a transnational policy convergence towards transnational S4 strategies in the priority sectors of the project and initiate common cross border funding instruments for the industrial C2C transformation.

2. Objective and scope of the regional ecosystem Cradle2Cradle maturity analysis

The regional ecosystem maturity analysis performed in each project region is part of a larger set of activities, building together a transnational ecosystem Cradle2Cradle maturity analysis. The latter comprises:

- A regional ecosystem maturity analysis, performed in each project region,
- A transnational survey on the consumers' perspective on Cradle2Cradle in the Alpine Space,
- A transnational comparison/benchmarking in the dimensions policies/business support, technologies and business models.

The overarching aim of the transnational ecosystem maturity analysis is to is to understand the relevance of circular economy and more specifically the Cradle 2 Cradle principles in each of the project region within the triangle: policies/business support, technologies/knowledge, and business models/practices.

Practical implementation in the context of the Cradle-ALP project

In order to ensure a high relevance of the regional ecosystem maturity analysis for a successful implementation of the Cradle-ALP activities, the partners decided to focus the analysis on the industrial sectors to be addressed in the roadmaps to Cradle2Cradle transformation. Those sectors are: polymers/plastics, wood/furniture, chemistry/materials, fibres/textiles, packaging.

The results of the analysis shall provide the basis for the development of sectoral Cradle2Cradle industrial transformation roadmaps in the five selected sectors (WP2), thus ensuring a smooth transition between WP1 - Capacity building for Cradle2Cradle transformation and WP2 - Roadmaps to Cradle2Cradle transformation.

Remark: this practical approach represents a deviation from the Application Form, where the analysis was described as more generic and meant to provide input for capacity building activities to performed in WP1.

Scope of the analysis in the Cradle-ALP project

The analysis integrates status quo, gaps and barriers, potentials for transformation, as well as good practices and failures to learn from within the triangle policies/business support, technologies/knowledge, and business models/practices.

It has been performed through a combination of desktop research, building on the knowledge already available among project partners and the previously performed identification of good practices, and interviews/workshops with regional experts and representatives of companies.

- **Status quo and good practices analysis**

The scope of the status quo and good practices/failures analysis in the dimensions policies/business support, technologies/knowledge, and business models/practices was aligned with the topics identified as a result of the identification of good practices and lessons learned (D.1.1.2) and the capitalisation workshops (D.1.1.3).

The following table shows the scope of the status quo analysis for the transnational ecosystem maturity analysis:

Policies and business support	Technologies	Business models and practices
▪ Bavarian strategies/ policies fostering circular economy and bioeconomy ▪ Common European and national strategic documents (e.g., technology roadmaps) with relevance for CE in Bavaria	▪ Technology and knowledge providers, e.g. non-academic research organisations, technical centers, pilot infrastructures, innovation platforms located in Bavaria	▪ Companies (pioneers, best practice/role models) within the CCB network and Bavaria ▪ Relevant industrial clusters and networks in Bavaria

▪ Current funding programs available for SMEs in Bavaria and Germany		

The partners performed a mapping for each project region according to the items listed here above.

- **Gaps and barriers – potentials for transformation**

At project level, the identification of gaps and barriers for a better uptake of the C2C principles in industrial practices, as well as the identification of potentials or opportunities for such a transformation is a core result of the transnational comparison/benchmarking in the dimensions policies/business support, technologies and business models.

The partners collected input for the transformation ecosystem analysis by collecting such gaps and barriers as well as potentials for transformation at the regional level. This was done through a series of direct interaction with regional experts and representatives of companies, either in bilateral discussions (interviews) or in the context of event, such as workshops, group discussions and fairs. The partners in each region organized those activities according to their local context. For example, industrial fairs could be used to interview several companies on the same day, cluster board meetings or awareness could be used to have a group discussion with the participants.

Scope of the regional analysis in the region Bavaria

The analysis in the region of Bavaria focused primarily on the following sectors: chemistry, polymers, packaging. The results of the analysis are displayed in the following chapters of this deliverable.

3. Policies and business support

Policies

Regarding circular economy, in the region of Bavaria most of the legislation is adopted from the national legislation such as basic waste legislation and waste management requirements. In addition, individual EU directives, such as the Packaging Directive or the Single-Use Plastics Directive are implemented via national law, e.g., for packaging in the Packaging Act (VerpackG) since 2019 or Chemikaliengesetz (ChemG) on chemical substances.

For the areas of waste management which are not regulated by the federal government, the Free State of Bavaria has enacted an own waste law. In Bavaria, the Bavarian Waste Management Act (BayAbfG, Abfallwirtschaftsgesetz) applies, which was amended with effect from 2021. In addition, the Bavarian Waste Management Plan (Abfallwirtschaftsplan Bayern) and Bavarian Waste Responsibility Ordinance (Abfallzuständigkeitsverordnung) regulate and specify the responsibilities for the enforcement of waste legislation. The responsible bodies for waste disposal are the counties and the municipalities.

The following relevant policies were identified:

Generic level	**Regional** ▪ **Abfallwirtschaftsgesetz BayAbfG, 2021** (Link) The Bavarian Waste Management Act (BayAbfG) implements the federal Circular Economy Act (KrWG) at the state level. It sets targets based on the waste hierarchy and emphasises the promotion of waste prevention, reuse and recycling. The law obliges individuals and the state to contribute to the implementation of these goals. It aims to reduce waste quantities, increase the useful life of products and develop waste recovery processes. ▪ **Abfallwirtschaftsplan Bayern AbfPV , 2015** (Link) The Bavarian Waste Management Plan lays down binding requirements for Bavarian waste management, including the ban on waste shipments for disposal and the GSB's responsibility for hazardous waste disposal. This affects the circular economy by regulating waste movements and clearly defining responsibilities. ▪ **Abfallzuständigkeitsverordnung AbfZustV, 2022** (Link) The Bavarian Waste Responsibility Ordinance (AbfZustV) regulates the responsibilities for the enforcement of waste legislation. It specifies which authorities are responsible for certain tasks. This influences the circular economy, as the efficient management and monitoring of waste streams in the circular economy is crucial to effectively use resources and minimize environmental impacts.

National

- **Kreislaufwirtschaftsgesetz (KrWG), 2012/2023** (Link & BMJ)

The Circular Economy Act (KrWG) regulates waste management for the entire value chain and affects waste producers, owners, traders and disposers as well as manufacturers and distributors of products. It emphasizes the hierarchy of waste recovery, which begins with prevention and ends with disposal, and helps to promote sustainable resource use and environmental protection.

- **Abfallverbringungsgesetz AbfVerbrG, 2023** (Link)

The Waste Shipment Act (AbfVerbrG) regulates the transboundary shipment of waste in Germany and serves to implement European regulations. It affects persons who arrange, transport or receive waste shipments. The Act promotes the circular economy by establishing regulations for the recovery and disposal of waste and controlling cross-border waste trade. Violations of the law can have criminal and financial consequences.

- **Elektro- und Elektronikgerätegesetz ElektroG 2015/2023** (Link)

The Electrical and Electronic Equipment Act (ElektroG) regulates the placing on the market, taking back and environmentally sound disposal of electrical equipment by ensuring the proper disposal and recycling of old equipment, minimizing electrical waste and holding manufacturers accountable.

- **Ersatzbaustoffverordnung ErsatzbaustoffV 2021 / 2023** (Link)

The Substitute Building Materials Ordinance regulates the use of mineral substitute building materials in structures. It aims at a more sustainable use of resources by setting requirements for the production, use and recycling of such building materials.

- **Umwelt- und Klimapakt, 2020** (Link)
- **Batteriegesetz BattG 2009 / 2020** (Link)
- **Altholzverordnung AltholzV 2002/2020** (Link)
- **Gesetz über die Umweltverträglichkeitsprüfung UVPG 2010/2023** (Link)

The Environmental Impact Assessment Act (UVPG) requires a comprehensive assessment of environmental impacts for certain projects before they are implemented. It contributes to environmental protection in the circular economy by ensuring that environmental impacts are included in decisions on environmentally relevant projects, which helps to promote sustainable practices.

Chemistry	▪ **ChemG – Chemikaliengesetz Chem G 2013/2021** (Link & BMJ) The Chemicals Act regulates the handling of hazardous chemicals and biocides to protect humans and the environment. It transposes European regulations such as REACH and CLP into national law and sets criteria for hazardous substances. **European Union** ▪ **REACH - Registration, Evaluation, Authorisation and Restriction of Chemicals 2007** (Link) The EU's REACH regulation aims to protect health and the environment from the risks of chemicals and to promote the competitiveness of the chemical industry. It affects all chemical substances, from industrial processes to everyday products. The regulation indirectly promotes the circular economy, as it encourages the replacement of hazardous substances with more environmentally friendly options and promotes the use of safer alternatives in products such as clothing and electrical appliances. ▪ **Classification, Labelling and Packaging Regulation CLP 2006/2015** (Link) The CLP (Classification, Labelling and Packaging) Regulation governs the classification, labelling and packaging of chemical substances and mixtures in the EU. Its main objective is to protect health, the environment and the free movement of goods. It influences the circular economy by ensuring that hazardous chemicals are appropriately labelled and packaged, which supports safe use and disposal in circular processes.
Polymers	▪ **Einwegkunststofffondsgesetz EWKFondsG 2023** (Link) The Single-Use Plastic Fund Act (EWKFondsG) stipulates that producers of certain single-use plastic products must pay annual levies. These funds are used by municipal waste disposal companies. The law is part of the implementation of the EU Directive to reduce the environmental impact of plastic products and promotes the Circular Economy by strengthening product stewardship and recycling efforts.
Packaging	▪ **VerpackG – Verpackungsgesetz 2017/2023** (Link & BMJ) The Packaging Act (VerpackG) regulates the placing on the market, the return and the high-quality recycling of packaging. It promotes waste-avoiding measures and sets requirements for packaging. It contributes to the reuse and recycling of packaging by imposing deposits on disposable beverage packaging and avoiding harmful materials. ▪ **Einwegkunststofffondsgesetz EWKFondsG 2023** (Link) See above.

	<u>European Union</u> ▪ **Regulation on recycled plastic materials and articles intended to come into contact with foods (EU) 2008/2022** (Link) ▪ **Single-use plastics Directive (EU) 2019/904** (Link) The goal of the Single-Use Plastics (SUP) Directive is to prevent and reduce the impact on the environment of certain plastic products and to promote a transition to a circular economy. In particular, the Directive aims to tackle marine littering and plastic waste through a harmonized legislative framework across the EU.

National/regional strategic documents

On a generic level, several strategic documents on topics related with circular economy and C2C were identified, both from regional and national public institutions. Those include general strategies on innovation as well as specific strategic documents on bioeconomy to foster the use of biomass, on the use of resources, their consumption and resource efficiency as well as on sustainability. Currently, an expert group lead by the Chair of Wood Science, Technische Universität München, analyzes the availability and potentials of bio-based renewable raw materials, residues and waste flows for their material and energy utilization as a basis for a Bavarian Biomass Strategy (Link).

All national strategies listed have an influence on the Bavarian activities to establish a circular economy. Looking at individual industry sectors only statements, recommendations and reports of associations of expert committees such as the Bavarian Expert Council for Bioeconomy (Sachverständigenrat Bioökonomie Bayern) were identified.

The following relevant European and national/regional strategic documents were identified:

Generic level	**Regional** ▪ **Bavarian Bioeconomy Strategy 'FUTURE.BIOECONOMY. BAVARIA.', 2020** (Link) The Bavarian Bioeconomy Strategy aims at a sustainable, bio-based economy that conserves natural resources and promotes the circular economy. It emphasises the use of residual and waste materials, resource efficiency and the link between the bioeconomy and the circular economy. ▪ **Bavarian Innovation Strategy ,Innovationsland.Bayern - Bayerische Innovationsstrategie 2021-2027', 2019** (Link) The Bavarian innovation strategy "Innovationsland.Bayern" aims to strengthen Bavaria's position as a leading innovation location in Europe. One focus area of the strategy promotes innovations in the areas of recycling, biologisation of material sciences and use of nanotechnologies in order to increase resource efficiency and promote the circular economy. ▪ **Bavarian Resource Strategy, 2018** (Link) The Bavarian Resource Strategy comprises a 7-point plan to promote the efficient use of resources in Bavaria's economy. The aim is to reduce raw material consumption and increase resource efficiency. Measures include strengthening a resource efficiency centre, promoting recycling technologies, using digital processes to save raw materials, increasing the acceptance of recycled building materials and promoting Bavarian companies in this field. ▪ **Bavarian Sustainability Strategy, 2022** (Link) The Bavarian Sustainability Strategy is oriented towards the UN Sustainable Development Goals (SDGs). Based on SDG 12, the strategy

promotes resource efficiency and the recycling of products. Companies should also assume social and environmental responsibility in the supply chain (cf. SDG 8). The strategy emphasises the role of consumers in promoting sustainability, which supports the implementation of several SDGs.

National

- **National Circular Economy Strategy – NKWS, 2023** (Link)

The National Circular Economy Strategy aims to protect the environment, reduce pollution, and enhance climate protection by facilitating circular value chains. It targets key industries to cut greenhouse gas emissions and energy use through recycling. Additionally, NKWS seeks a resilient economy by securing raw materials, including critical ones like rare earths, reducing import dependence.

- **National Raw Materials Strategy, 2019** (Link)

The raw materials strategy of the German Federal Government emphasizes the importance of mineral raw materials for industry. It aims to ensure the secure and sustainable supply of raw materials, especially in the face of technological challenges such as electromobility. The strategy promotes recycling and lightweight construction to strengthen the circular economy and optimize the use of raw materials.

- **German Resource Efficiency Program 2020-2023, 2020** (Link)

The German Resource Efficiency Programme (ProgRess) was launched in 2012 to combine ecological necessities with economic opportunities and promote resource efficiency. ProgRess III, from 2020-2023, emphasizes the decoupling of economic growth and resource use, the use of digitalization and the closing of material cycles, thereby advancing the circular economy.

- **National Bioeconomy Strategy, 2020** (Link)

The Federal Government's National Bioeconomy Strategy promotes the sustainable use of biological resources and the combination of economy and ecology. It aims to make Germany the leading innovation location for the bioeconomy and emphasizes the importance of research and biological knowledge. The strategy supports the circular economy by focusing on the cycle-oriented use of renewable raw materials.

- **National Biomass Strategy – NABIS, 2022** (Link)

The German National Biomass Strategy (NABIS) aims to use biomass sustainably, primarily for materials rather than energy, in order to promote climate protection and environmental goals. The strategy emphasizes the multiple use of biomass and prioritizes the use of

	biomass fractions in biogenic waste materials. This strategy is to be closely linked to the National Circular Economy Strategy in order to utilize the potentials of the circular economy. ▪ **German Circular Economy Roadmap, 2021** (Link) The German Circular Economy Initiative outlines a roadmap for the development of a circular economy. It emphasises the importance of circular business models, standardisation, transparency and regulatory measures. This strategy aims to combine economic, environmental and political goals and promote the circular economy in Germany to increase sustainability, competitiveness and resource efficiency. ▪ **National Sustainability Strategy, 2021** (Link) The German Sustainability Strategy addresses the implementation of the Agenda 2030 of the United Nations. This also includes the area of the circular economy. The aim is to decouple economic growth and resource consumption through measures such as resource efficiency, circular economy and sustainable supply chains. Political incentives are to promote the responsible use of resources in order to strengthen sustainable economic activity and protect the environment. ▪ **Bioeconomy in Germany, 2022** (Link) The bioeconomy offers sustainable economic growth opportunities while striving for a circular economy that minimises waste and efficiently uses renewable resources along the value chain. ▪ **National Waste Prevention Programme, 2020** (Link) The German waste prevention strategy addresses waste reduction and aims to minimise various waste streams, including food waste and e-waste. It promotes measures such as public procurement, repair and product service systems to reduce waste, increase resource efficiency and minimise environmental impacts. ▪ **National Strategy for Food Waste Reduction, 2019** (Link) The German National Strategy for Food Waste Reduction aims minimize waste along the entire supply chain. It includes measures such as data analysis, process optimisation, behavioural change and digital innovation to facilitate circular economy by minimising resource waste and promoting sustainability in the food supply. ▪ **National Research and Innovation Strategy, 2023** (Link) The National Research and Innovation Strategy aims at technology leadership, research transfer and openness to technology in order to make the economy sustainable and climate neutral. It emphasises the importance of societal resilience, diversity, and cohesion. This strategy influences the circular economy through innovation to ensure resource efficiency, food security and environmental protection.

Chemistry	▪ **SVB (2022) - Circular Economy in the context of bioeconomy** See below. ▪ **Agora Energiewende (2023) - Chemicals in transition** (Link) Key strategies for the chemical industry to reach the goal of climate neutrality by 2040 include electrification, a circular economy and the replacement of fossil raw materials with renewable ones. These measures require policy support and incentives to ensure competitiveness and promote the circular economy in the industry. ▪ **VCI (2023) - Chemistry4Climate** (Link) In a two-year process, the climate protection platform Chemistry4Climate explored ways to achieve greenhouse gas neutrality in the German chemical industry. The conclusions emphasise the importance of plastics circular economy, biomass, CO2 use, renewable electricity and hydrogen. These strategies aim to reduce carbon demand and promote the circular economy by focusing on recycling, sustainable raw material use and CO2 reduction. ▪ **EU Commission (2023) - Transition Pathway for the Chemical Industry** (Link) The EU has developed an updated industrial strategy to drive the green and digital transformation of industry. In this context, a transition strategy for the chemical industry is being developed. This strategy includes measures to promote innovation, clean energy supply and diversification of raw materials.
Polymers	▪ **SVB (2021) - Substitution of fossil raw materials - materials for a bio-based way of life and economy** (Link) The recommendations focus on the use of bio-based polymers from sustainable sources and promoting their use in various applications. They emphasise the importance of recycling, biodegradable products and education to reduce the environmental impact of polymers and support the circular economy. The strategy calls for regulatory incentives, recycling options and sustainable raw material supply for successful implementation. ▪ **European Environment Agency & European Topic Centre on Circular Economy and Resource Use (ETC CE) (2023) - Pathways to circular plastics in Europe** (Link) The report emphasizes three ways towards an improvement of the plastics system: intelligent use, increased circularity and renewable materials. Examples for approved practices are named, but need to be implemented more extensively. Among the three routes, the increase of circularity is developed best. The objective is to reduce use of plastics, promote circularity and use renewable materials.

Packaging	▪ **SVB (2022) - Circular Economy in the context of bioeconomy** (Link) The Bioeconomy Expert Council addresses the need for a sustainable bioeconomy in the context of the circular economy. They highlight the challenges of disposing of short-lived products such as packaging and show ways in which bio-based plastics such as polylactic acid (PLA) can be recycled more efficiently. This has the potential to improve the circular economy for polymers and packaging and increase resource efficiency.

Funding schemes and further business support measures

In Germany, a variety of different funding schemes at national, federal and regional level addressing circular economy are available. Several generic funding programs relate to circular economy as a long-term goal of the funded actions without establishing circularity as a eligiblity requirement. However, at a sectoral level, circularity becomes a more common prerequisite for project applications. Nevertheless, Cradle-to-Cradle approaches have not yet found their way into the German funding system but rather need to be funded under the general term of circular economy.

The following relevant funding schemes were identified:

Generic level	▪ BMBF – Federal Ministry of Education and Research: Funding program **KMU-innovativ/innovative SME**, funding area Ressourceneffizienz und Klimaschutz/resource efficiency and climate protection (federal funding scheme) ▪ BMBF – Federal Ministry of Education and Research: Fona³ - **Rahmenprogramm Forschung Für Nachhaltige Entwicklungen/Framework program Research for Sustainability** (federal funding scheme) ▪ BMWK – Federal Ministry for Economic Affairs and Climate Action: **Förderaufruf Ressourceneffizienz und Circular Economy**/ Call for funding Resource Efficiency and Circular Economy (federal call for funding) ▪ DBU – **Deutsche Bundesstiftung Umwelt**: Thematic and open project funding (national funding scheme) ▪ FNR – **Fachagentur Nachwachsende Rohstoffe**: Project funding (national funding scheme) ▪ StMWi – Bavarian Ministry of Economic Affairs, Regional Development and Energy: **Innovationsgutschein** Bayern/Innovation Voucher Bavaria (regional voucher) ▪ StMWi – Bavarian Ministry of Economic Affairs, Regional Development and Energy: **Regionalförderung/Regional funding** (regional funding scheme) ▪ StMWi – Bavarian Ministry of Economic Affairs, Regional Development and Energy: **BayTP+ - Bayerisches Technologieförderungs-Programm Plus**/Bavarian Technology Promotion Program plus (regional funding scheme) ▪ StMWi – Bavarian Ministry of Economic Affairs, Regional Development and Energy: **BayVFP - Bayerisches Verbundforschungsprogramm**/Bavarian Bavarian Collaborative Research Program
Chemistry	▪ BMWK – Federal Ministry for Economic Affairs and Climate Action: **Förderprogramm Industrielle Bioökonomie/Funding**

	program Industrial Bioeconomy (federal funding program) ▪ SPRIND – **Circular Biomanufacturing** (private national funding program) ▪ StMWi – Bavarian Ministry of Economic Affairs, Regional Development and Energy: **Bioökonomie-Scale-Up/Bioeconomy Scale-Up** (regional funding scheme)
Polymers	▪ FNR – Fachagentur Nachwachsende Rohstoffe: **Förderprogramm Nachwachsende Rohstoffe**/Funding program Renewable Raw Materials (national funding scheme) ▪ StMWi – Bavarian Ministry of Economic Affairs, Regional Development and Energy: **Neue Werkstoffe in Bayern**/New Materials in Bavaria (regional funding program)
Packaging	▪ BMEL – Federal Ministry for Food and Agriculture: **Programm zur Innovationsförderung**/Program to Promote Innovation (federal funding program) ▪ FNR – Fachagentur Nachwachsende Rohstoffe: **Förderprogramm Nachwachsende Rohstoffe**/Funding program Renewable Raw Materials (national funding scheme)

Bavaria offers a unique support structure for businesses, universities and research institutions. In 2006, the Bavarian Cluster Initiative established 16 state-wide platforms ("clusters") in high tech industries and traditional key sectors of the Bavarian economy. These clusters set out to foster collaboration between industry and academia, identify, increase and optimize synergies between companies, accelerate market success of research results and thus, strengthen the entire value chain from research to the end-product by increasing the overall innovation dynamics in Bavaria. This wide-spread support structure is complemented by initiatives specialized in patent issues, start-up support, funding applications, knowledge transfer, consulting, education as well as training, internationalization, and circular economy.

The following relevant business support measures were identified:

Generic level	▪ **Cluster Initiative Bavaria** The Cluster Initiative Bavaria was formed in 2006 by the Bavarian Ministry for Economy with the objective of fostering innovation in Bavaria. The focus lies on providing support alongside the complete value chain from research to the final product, strengthening the competitiveness of the Bavarian market by cooperation and improved science transfer. The Cluster Initiative consists of 17 clusters with specific fields of expertise. The clusters support SMEs with finding suitable partners of all sizes in the industry and research. Several clusters (Cluster Neue Werkstoffe, Cluster Umwelttechnologie, Cluster

	Energietechnik, Chemie-Cluster) are very active in projects regarding circular economy. Cluster-Offensive Bayern ▪ **BayPat** BayPat works in IP Consulting, market analysis, business development and commercialization of new inventions by utilizing their network. BayPAT ▪ **planB Gründerwettbewerb** The PlanB Start-Up Competition has been supported by the Ministry of Economy and partners in industrial biotechnology, green chemistry, agriculture and forestry since 2014. Start-Ups with business ideas aimed towards a more sustainable future and biobased concept are invited to submit their ideas to the competition. PlanB supports the further development of the business ideas by coaching and workshops while also providing a network reaching from partners in finance, business support and technology providers. Additional to a money prize the winner start-up gets 1 year of rent-free office. Plan B Wettbewerb ▪ **BayStartUP** BayStartUP is an independent Bavarian network for start-ups financed by two supportive associations. They provide a large network of investors, players of the industry, research facilities and co-working spaces. Additionally, they organize business plan competitions and events like the Start Up Demo Night which gives founders an opportunity to present their ideas. BayStartUP ▪ **BayFOR** BayFOR provides advisory services for EU-funded research and innovation. This includes support during the application and finding suitable project partners. Their services not only apply to research institutions, but are also directed towards SMEs looking for EU-funding, e.g., by Horizon-projects. BayFOR ▪ **Bayern Innovativ** The Society for Innovation and Knowledge Transfer focuses on the support of SMEs in their innovation management. They provide a strong network consisting of companies, universities and research institutes and a variety of networks. Furthermore, they give insights to funding opportunities and advise on business models, international projects and property rights. Bayern Innovativ ▪ **Chamber of Commerce – IHK** The IHKs are regional consortia comprising SMEs to advocate for

	their interests. They are also involved in innovation consulting, eduction and further training as well as they offer counselling for founders. BIHK ▪ **Invest in Bavaria** As the business location agency of the Free State of Bavaria, Invest in Bavaria supports companies from Germany and abroad and from a wide range of industries in finding the optimal location in Bavaria so that they can act successfully right from the start after settling here. https://www.invest-in-bavaria.com/ ▪ **Circular Republic** This is a platform aimed at decoupling value generation from resource use. It is directed towards start-ups and corporates and supports the development of circular business models by connecting stakeholders from corporates, start-ups and science. CIRCULAR REPUBLIC
Chemistry	▪ **Chemie-Cluster Bayern (CCB)** CCB is a network focused on chemistry and industrial biotechnology respectively. Addressing start-ups, SMEs, corporates, universities and research facilities the focus is on accelerating innovation in the field of circular economy by providing connections through their networks, offering consulting services and organizing events for their stakeholders. https://chemiecluster-bayern.de/ ▪ **Cluster Nanotechnologie** The cluster nanotechnology provides a network for stakeholders in the nanotech field. Cluster Nanotechnologie ▪ **TUM Venture Labs** TUM Venture Labs provides support for start-ups from the idea to the generation of seed-capital. Besides their network and consulting they offer laboratories and co-working spaces for TUM-students. TUM Venture Labs
Polymers	▪ **Cluster Neue Werkstoffe** The Cluster Neue Werkstoff is affiliated to Bayern Innovativ. They provide a platform for information and communication about technology and innovation in the field of new materials. Cluster Neue Werkstoffe ▪ **Kunststoffnetzwerk Franken** A platform for exchange in the plastics industry of Franconia. The network consists of companies active in plastic processing, tool construction, technology- and material focused companies.

	Kunststoff-Netzwerk Franken e.V.
Packaging	▪ **Umweltcluster Bayern** The Umweltcluster Bayern is a network of the Bavarian environment economics. Their focus lies on science transfer to SMEs, education and enhanced cooperation. They are competent in waste and recycling, alternative energy generation, remediation, air pollution control, resource efficiency and material flow analysis, water and wastewater. Umweltcluster Bayern ▪ **Kunststoffnetzwerk Franken**: see above

4. Technologies and knowledge providers

Technology and knowledge providers

For the further development of a circular economy R&D organisations, technology and knowledge providers are important stakeholders to drive the development of novel and innovative processes and technologies. Next to universities and non-academic research organisations, this includes technical centers, pilot infrastructures, innovation platforms too.

The following list will give an overview on the organisations most active in circular and bioeconomy:

Generic level	▪ Ressourceneffizienz-Zentrum Bayern (REZ) Center for Resource Efficiency Bavaria: Founded in 2016, REZ is a central contact point providing information on the topic of resource efficiency. The regions of Untermain, Augsburg, Bayreuth and Oberpfalz-Nord collaborate and organize the exchange of experts and companies. ▪ Bifa Umweltinstitut GmbH, Augsburg, is an application-oriented research, development and consulting institution offering environmental services including process engineering, technical chemistry, energy management and life cycle assessment. Regarding CE the institute offers material flow management, development of recycling processes and waste management concepts. ▪ University of Augsburg, Resource Lab: works on the development of resource strategies for future-oriented technologies, implementation of a sustainable bioeconomy and circular economy with a focus on criticality assessments, Life-Cycle-Assessments and Social-Life-Cycle-Assessments. ▪ Technische Hochschule Deggendorf, Research Focus ‚Sustainable Materials', research on bionic and biomimetic materials, sustainable plastics and resource efficiency.
Chemistry	▪ Fraunhofer IGB, Straubing Bio-, Elektro- und Chemokatalyse BioCat focuses on the development of catalytic processes (new chemical catalysts and biocatalysts) for the use of renewable raw materials and CO2. ▪ University of Bayreuth, Faculty of biology, chemistry & earth sciences: the Department of Chemistry focus on polymers, biomolecules, novel natural substance synthesis. Development of synthetic spider silk, biobased chemicals from orange peels and effects of microplastics are three well-established examples. ▪ Technical University Munich (TUM): research activities relevant for circular economy comprise bioprocess engineering, synthetic biotechnology, wood technology, fungal

	biotechnology in wood science, and many more. ▪ TUM Campus Straubing for Biotechnology and Sustainability: development of sustainable technologies based on green chemistry and biotechnology. Offers study programmes in Bioeconomics, Chemical Biotechnology, Technology of Biogenic Resources and Sustainable Management & Technology ▪ Hof University of Applied Sciences, Institute for Circular Economy of Bio:Polymers (ibp) has its research focus set on bioplastics, biogenic additives, processing of biopolymers as well as recyclability of biopolymers and conventional plastics ▪ TH Rosenheim, Faculty of Chemical Technology and Economics Campus Burghausen: next to a research focus on forest-based bioeconomy and wood technology the Campus Burghausen does research on green chemistry, polymers and additives. ▪ FAU University Erlangen-Nürnberg, at the Faculty of Engineering and the Faculty of Natural Sciences researchers work on novel materials and bioprocess engineering. ▪ BioCampus MultiPilot: The BioCampus MultiPilot (BMP) is a multi-purpose demonstration plant being built at the Straubing-Sand port. In the BMP, customers will be able to further develop, test, scale and optimize their industrial biotechnology processes up to pre-industrial scale, validate their economic viability and manufacture product samples. ▪ Fraunhofer UMSICHT in Sulzbach-Rosenberg is a Pioneer of the energy and raw material revolution contributing to a sustainable energy and raw material supply through research in energy/plant technology, biological process engineering and recycling management. The focus is on the conversion of biogenic residues into valuable, storable products (e.g. synthetic fuels, biochar) and for the recycling of composite materials.
Polymers	▪ Fraunhofer Institute for Silicate Research (ISC) in Würzburg focuses on the use of renewable and environmentally friendly raw materials as well as intelligent and sustainable processes. Optimization and refinement of polymers and their manufacturing processes through multifunctional coatings and additives for environmentally friendly (also biodegradable) packaging or smart surfaces. ▪ Fraunhofer IGB: see above ▪ University of Bayreuth: see above ▪ TUM & TUMCS: see above ▪ Technische Hochschule Nürnberg Georg Simon Ohm is a university of applied sciences with faculties for applied

	chemistry, material and process engineering. ▪ Technology Centre Weißenburg (Kunststoffcampus Bayern), combines expertise in research and development in the field of plastics and their value chain.
Packaging	▪ Fraunhofer Institute for Process Engineering and Packaging IVV is a R&D institute in the area of process engineering and packaging developing high-quality foods and packaging materials from renewable raw materials and waste materials. ▪ SKZ - German Plastics Center, Würzburg, is non-academic research organization in the field of plastics and packaging with large expertise in the development of polymer compounds, functional fillers, additives, recycled materials and biopolymers. ▪ Zentrum für Lebensmittel- und Verpackungstechnologie e.V. (ZLV) has its focus on the entire value chain for factory made and packaged food stuff from the raw materials to the retail trade and circular economy.

5. Business models and practices

Role model companies

Especially in the chemical sector it is not easy to identify companies that use the C2C certification for their products. However, to our knowledge there is a growing number of companies developing, manufacturing and applying biobased chemicals replacing fossil-based materials. Others are intensively looking into recycled materials and material streams for future recycling, and at the same time developing new processes for advanced recycling.

Next to a few big players we identified companies in Bavaria and within the cluster network that offer chemical recycling processes, develop non-fossil based chemicals, use biotechnology for biobased additives or manufacture bio-composites.

The following role model companies are listed here in more detail:

Chemistry	**Enterprise** ▪ Wacker AG, Burghausen is a manufacturer of a wide range of chemicals for the chemical, polymer, textile, energy, food industries. ▪ Clariant Produkte (Deutschland) GmbH, is a Swiss specialty chemical company producing a diverse range of chemicals für polymer and packaging industry targeting the circular economy (catalysts and adsorbents for recycling) and bioeconomy markets (biobased additives for polymers, bioethanol) with their solutions. ▪ Baerlocher GmbH is an additive supplier with expertise in the production and use of additives for plastic materials supplying the plastics industry with metal soaps, fatty acids, glycerol, lubricants and stabilizers for polymers and PVC. **SMEs** ▪ SWC Südwest Chemie GmbH produces thermosetting resins for phenolic resins and melamine resins for the manufacture of temperature-resistant products. ▪ LXP Group GmbH, the LXP Technology makes a broad range of biomass waste viable for second-generation (2G) bioconversion in biogas plants and results in the production of LXP Lignin and LXP Cellulose which can be converted in higher-grade chemical products such as sugar and chemical derivatives. ▪ PRUVIA GmbH has developed a pyrolysis technology to recover Naphtha from plastic waste. ▪ APK AG specializes in the production of plastic granulates using an efficient recycling process called Newcycling® to produce,

	pure granulates with properties similar to virgin plastics from complex waste streams, e.g. mixed plastic waste and multi-layer packaging. ▪ Biolog Heppe GmbH develops applications of biopolymer technologies and products, with a specialization in chitosan. The natural biopolymer chitin and its derivative chitosan can be used in paper, textile industry and others. **Start-ups** ▪ Mk2 Biotechnologies GmbH develops, produces and investigates peptides & proteins using a revolutionary synthesis technology. Peptides with antimicrobial activities could be used in packaging materials. ▪ ESY-Labs GmbH uses the technology of electrocatalysis/electro-synthesis to produce high-quality chemical compounds (fine chemicals, metal compounds, etc.) ▪ Treemera GmbH, has developed a highly efficient and economical process to manufacture furandicarboxylic acid (FDCA), the building block for high purity PEF. PEF is a 100% recyclable bio-based polymer derived from plants. ▪ Additional start-up companies: Circular Carbon (pyrolysis), Carbonauten (pyrolysis), Lignopure (lignin) Global Sustainable Transformation (sustainable oleaginous materials)
Polymers	▪ Südstärke GmbH produces potato starch for technical applications ranging from food, feed, paper, adhesives to chemical applications. ▪ HP-T Höglmeier Polymer-Tech GmbH & Co. KG specializes in grinding , regranulating and compounding of engineering plastics and develops individual recycling concepts ▪ Biofibre GmbH manufactures natural fibre-reinforced biomaterials and products that can be further processed into end products using standard thermoplastic processes such as injection moulding and extrusion.
Packaging	▪ Weimako GmbH produces biobased and biodegradable packaging for the cosmetics and food supplements industry ▪ Landpack GmbH manufactures sustainable thermal packaging for cold chain distribution to replace common polystyrene packaging with high-performance alternatives made from renewable raw materials ▪ pacoon is an agency for packaging design and sustainable packaging.

	▪ Treemera: See above ▪ LIFOCOLOR is a manufacturer of polymer compounds and colorings for packaging taking circularity into consideration. **Start-ups** ▪ Fungarium develops mycelium-based material to replace styrofoam packaging ▪ Proservation GmbH develops sustainable and plastic-free cushioning packaging made from plant residues
Textile	▪ Kelheim Fibres GmbH is a manufacturer of speciality viscose fibres with applications in hygiene and body care, filtration, insulation and textiles industries. The basis for viscose fibres is cellulose. ▪ Pulcra Chemicals GmbH manufacturers of innovative specialty chemicals for the fiber, textile and leather industries including products for process auxiliaries for primary and secondary spinning to sizing, pretreatment, dyeing, printing and finishing of textiles. ▪ Rudolf GmbH offers a portfolio of textile chemicals covering every aspect of textile production, from pretreatment to dyeing, digital printing, finishing and coating including water repellent finishing based on natural plant extracts and fluorin-free/holgen-free. ▪ Carl Weiske GmbH develops and manufactures fibres, yarns and textile systems for technical applications in automotive, transportation, sportswear and interior industries.

Relevant industrial groupings and networks

A major role in promoting bioeconomy and circular economy approaches in Bavaria plays the Bavarian Expert Council for Bioeconomy (Sachverständigenrat Bioökonomie Bayern) founded in 2015. The Chambers of Commerce are institutions representing and supporting all companies in their region.

The following industrial groupings and networks were identified:

Generic	▪ **Bavarian Expert Council for Bioeconomy (Sachverständigenrat Bioökonomie Bayern)** The SVB advises the Bavarian state government on bioeconomy issues. It carries out the evaluation of the Bavarian Bioeconomy

	Strategy, develops recommendations for future development of the strategy and for the successful implementation of a bio-based economy in Bavaria. The Council also promotes the social dialogue on the bioeconomy. ▪ **Chamber of Commerce – Industrie- und Handelskammer (IHK)** The IHKs are regional consortia comprising SMEs to advocate for their interests. They are also involved in innovation consulting, education and further training as well as they offer counselling for founders. ▪ CirculaTUM - TUM Mission Network Circular Economy Is an interdisciplinary research network for circular economy. Their focus topics are industrial value generation, the built environment and natural cycles and bioeconomy. ▪ Fraunhofer Circonomy Hub With Circonomy Hubs Fraunhofer is building an innovation network as an agile instrument for cooperation between industrial partners, research, politics and society. The aim is the establishment of souvereign value chain cycles, climate neutrality, circularity and bioeconomy.
Chemistry	▪ VCI Bayern **- Bavarian chemical associations** Is an association representing the interests of the bavarian chemical and pharmaceutical industries towards policy makers, agencies and the public. They ellaborate position papers on relevant topics.
Polymers	▪ Kunststoffnetzwerk Franken A platform for exchange in the plastics industry of Franconia. The network consists of companies active in plastic processing, tool construction, technology- and material focused companies.

6. Gaps and barriers – potentials for transformation

To identify challenges, gaps and barriers for SMEs in Bavaria regarding circular economy we invited companies of the cluster network to participate in a short questionnaire on circular economy and C2C. We asked for the general understanding and knowledge of terms and concepts, the perception of circular economy initiatives in Bavaria, the implementation within the companies, Bavarian funding opportunities and barriers encountered.

We collected answers from 21 Bavarian companies/stakeholders of which the majority has less than 500 employees, five companies are larger.

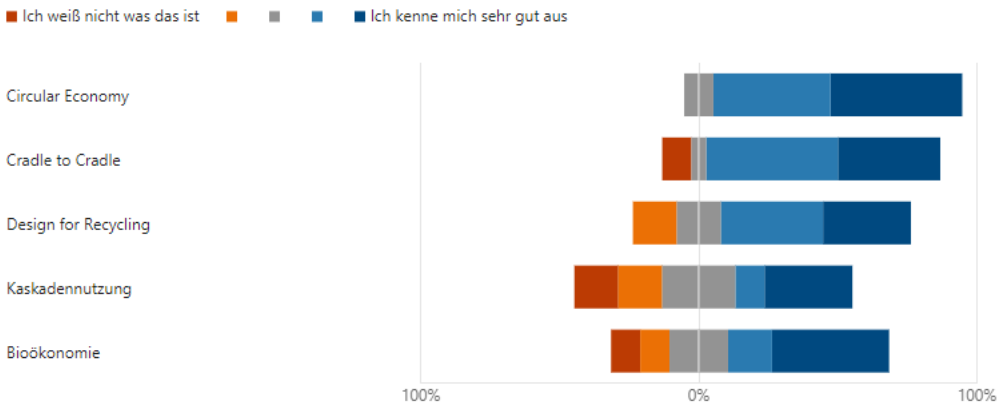

Table 1: Knowledge of certain key terms in circular economy/bioeconomy

The terms ‘circular economy’ and ‘C2C’ are familiar to most, whereas ‘design for recycling’ and ‘bioeconomy’ are less well known. The term ‘Cascading use’ (Kaskadennutzung) is not well understood by half of the participants.

The current progress in the development of a Circular Economy in Bavaria is rated with 3 out of 5, where 1 marks no and 5 large progress. Accordingly, numerous barriers and challenges affecting an efficient circular economy were given by the interviewees (See table 8 and table 9 below). Major given reasons for little progress comprise the influence of the legal framework and regulations providing a clear and detailed frame for companies to act, technical reasons (sorting, sensors, …), economic factors such as high costs, low profitability, missing business models as well as not enough courage to innovate, lacking knowledge what circular economy means. According to one statement politicians have too little knowledge of the circular economy to guide in the right direction. The majority of interviewees views the legal framework and regulations as insufficient to establish and promote a working circular economy.

In addition, we asked for actions to take to increase the interest in Circular Economy/Bioeconomy approaches. Economic factors such as economic incentives, public funding and incentives for private investments were mentioned. Also regulatory requirements, mandatory quotas and the enforcement of laws and regulations were pointed out. Subsidies, tax reductions and the gradual increase of fees for economic activities not in line with circular economy practices were suggested.

Interestingly, most of the interviewees emphasize the importance of collaboration between

companies and research institutions within Bavaria but also across borders.

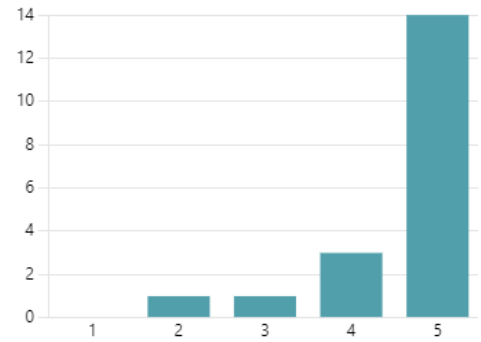

Table 2: Importance of collaboration in companies to advance circular economy

In a second part of the survey, we asked about circular economy in the companies. Almost half of the company representatives claim to have a company strategy for circular economy regarding e.g. the use of renewable resources, of side/waste streams or new business models. And two thirds plan to align the company more strongly in this direction.

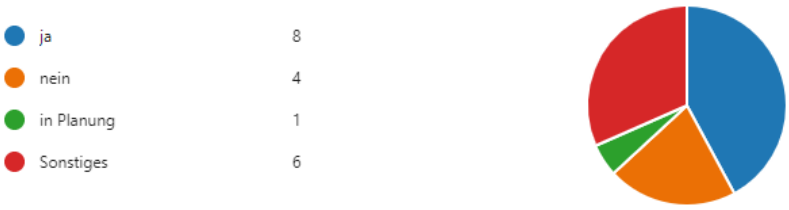

Table 3: Existing circular economy strategy in companies

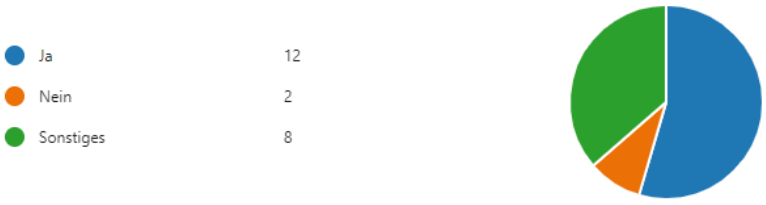

Table 4: Intention to implement more circular economy actions

In this context we asked for different circular economy activities that are already used by companies. Use of recycled and/or biobased resources and the consideration of sustainability in the selection of raw materials was selected by 50 percent (between 10 and 12 answers out of 20). A second important aspect for companies comprises sustainability certifications. Life Cycle analysis (LCA) and CSR/ESG reporting are not yet in the focus. Similarly, the concept of circular design and novel circular-based business models are not very prominent.

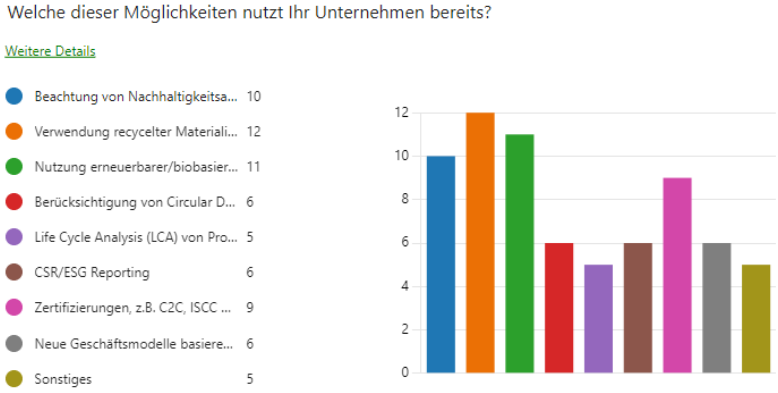

Table 5: Activities/Actions used by companies

Regulations and EU directives such as the Single Use Plastics Directive, the Packaging Waste Regulation, etc. are important regulations affecting companies from the chemical, polymers and packaging sector. Interestingly, a large majority of the respondents knows the REACH regulation on the registration and restriction of chemicals. In average about 50 percent are familiar with the regulations although we did not ask how detailed.

Table 6: Awareness of legal regulations

Most interestingly a high number answered that the economic added value for their company they see in a circular economy is the contribution to sustainability. There is nobody seeing no benefit while more than half think of an opportunity to reduce waste and for a future-oriented development of the company. Still 50 percent expect to attract new customers and a potential for new products and markets when focusing on circular economy principles.

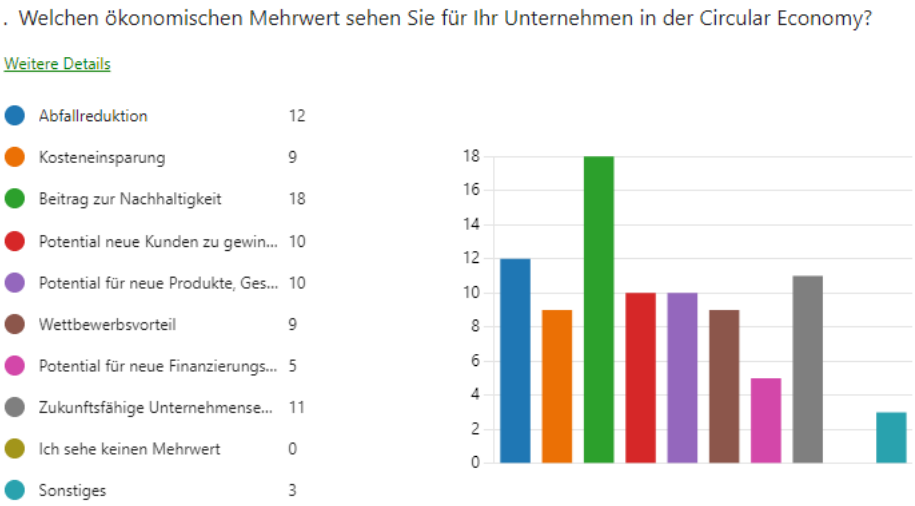

Table 7: Economic added value seen in circular economy

The following table summarises the gaps and barriers as well as potentials for an industrial transformation towards a circular economy in the addressed sectors for the region of Bavaria. Most of the answers given focus on non-technical gaps and barriers. The technological aspects were collected by the cluster experts based on their experience and exchange with companies during the last months.

Gaps and barriers	Drivers & Opportunities
• **Regulatory Challenges:** Existing regulations that favor linear economic models or lack incentives for circularity can pose obstacles to implementing circular practices. **Regulatory Hurdles:** Some regulations and standards may not align with circular economy goals, making compliance difficult, especially regarding material reuse and recycling. **Inconsistent Guidelines:** Inconsistent guidelines and regulations, particularly regarding material reuse and recycling opportunities, can create confusion and slow down implementation efforts. • **Economic Factors:** Short-term cost savings associated with linear production can discourage businesses from transitioning to circular models due to the initial costs involved. **High Investment Costs:** Implementing circular practices may require upfront investments in new technology or processes, deterring some organizations. **Limited Growth & Transition Opportunities:** Scaling up circular economy production and expanding geographically can be challenging. Issues with ecosystem members and collaborators may also hinder progress. **Lack of Business Models:** The absence of well-defined and proven circular business models can deter companies from making the transition. • **Supply Chain Complexities:** The complexities of global supply chains, with products crossing borders and involving various stakeholders, make it challenging to implement circular practices. **Fragmented Value Chains:** In industries where value chains are fragmented, it's difficult to coordinate efforts across different stages of production and consumption. • **Resource Availability:** Limited availability of recycled or reused materials can be a barrier, as businesses may struggle to secure a consistent supply of secondary resources. • **Lack of Awareness:** Limited awareness and understanding of circular economy concept among businesses and consumers hinder its adoption. No full awareness of benefits.	• **Environmental Concerns:** Growing awareness of environmental issues and resource depletion is a significant driver for the adoption of CE practices. The need to mitigate environmental impacts and preserve finite resources motivates organizations and governments to transition towards a circular economy. • **Regulatory Frameworks:** Governments and international bodies are playing a crucial role in promoting CE by implementing policies and regulations that encourage circular practices. These regulations often focus on waste reduction, recycling, and sustainability, creating incentives for businesses to adopt CE principles. Not adapting to foreseeable regulation may impair future economic performance motivating companies to be proactive. • **Resource Scarcity:** Depletion of finite resources and increasing raw material costs are pushing organizations to seek alternative, sustainable sources of materials. CE offers a solution by emphasizing resource efficiency and minimizing waste. • **Cost Savings & Economic Gain:** Many companies are driven to implement Circular Economy (CE) practices due to motivations like efficient resource utilization, cost savings through resource efficiency, and maximizing economic value. CE principles offer opportunities for cost savings by reducing waste generation, optimizing resource utilization, and improving operational efficiency, ultimately leading to reduced waste disposal costs and improved financial performance. • **Innovation and Technology:** Advancements in technology play a pivotal role in enabling the circular economy. Innovative processes for recycling, remanufacturing, and product design make circular practices more feasible and economically viable. • **Corporate Identity:** Implementing CE principles may enhance the reputation and recognition of companies improving their market position.

Consumer Behavior: Consumer preferences for new products and the culture of disposability can hinder the adoption of circular consumption patterns. • **Technological Limitations:** Inefficient disassembly and recycling processes for certain products can pose technological challenges to circularity. • **Resistance to Change:** Resistance within organizations, both from employees and management, can be a significant barrier, as some may be hesitant to embrace new circular practices. **Risk Aversion:** Companies may be risk-averse when it comes to investing in new, unproven circular technologies or business models. **Lack of External Support or Demand:** Companies pioneering in the circular economy space may struggle to build a market from scratch and deal with incompatible customer demands and expectations. • **Lack of Resources, Infrastructure, or Competencies:** Challenges include the cost and availability of circular economy raw materials, a lack of knowledge, and viable recycling solutions.	
Literature sources for the overview on generic barriers and drivers - Neves, S.A., Marques, A.C., 2022. Drivers and barriers in the transition from a linear economy to a circular economy. Journal of Cleaner Production 341, 130865. - Piila, N., Sarja, M., Onkila, T., Mäkelä, M., 2022. Organisational Drivers and Challenges in Circular Economy Implementation: An Issue Life Cycle Approach. Organization & Environment 35, 523–550. - Kirchherr, J., Piscicelli, L., Bour, R., Kostense-Smit, E., Muller, J., Huibrechtse-Truijens, A., Hekkert, M., 2018. Barriers to the Circular Economy: Evidence From the European Union (EU). Ecological Economics 150, 264–272.	

Table 8: Gaps, barriers and driving factors for a circular economy valid for all sectors based on literature research

Gaps and barriers	Drivers & Opportunities
• **Existing regulation and waste legislation:** - Uncertainty regarding legal requirements for declaration of recycled materials (e.g. for in-house recycling) - Existing waste regulations restrict use of residual materials due to declaration as waste preventing further by recycling - Lack of binding design specifications for products • **Technological limitations:** - Lack of effective mechanical recycling technologies for materials that cannot be recycled yet - Improved sensor technology for sorting processes (AI-based) - 'Design for recycling' is a clear concept but implementation is still limited - Precise analysis of components in recycled/waste materials - Material data sheets with sufficient information on recycled/biobased material • **Economic Factors:** - Virgin material cheaper than recycled; - More complex warehousing & production planning for recycling materials - Profitability is still too low - Lack of incentives for stakeholders of value chain - Insufficient public funding to quickly improve technology dev. and tech transfer - Material stream of biobased plastics to small for economically viable recycling (e.g. PLA) • **Lack of Resources, Infrastructure, or Competencies:** - Collection of post-consumer material not sufficiently adapted to high-quality recovery (e.g. food packaging) - Lack of infrastructure - Difference in waste collection by municipal institutions responsible for waste management (complex collection, return…) • **Misc aspects:** - Lack of innovation spirit - Low willingness to collaborate in value chain networks - Lack of understanding what Circular Economy means: focus on efficiency but resource efficiency is not the same as CE → no decoupling from resource consumption - Responsible politicians lack detailed knowledge - Intransparent, cumbersome certification for C2C	• **Economic Factors:** - Create economic incentives (e.g. as done for energy savings, tax incentives) - Incentives for private investments - Suitable funding programs for companies & university research - Advantages in the allocation of project funds for CE projects - Linking the promotion of digitization and circularity • **Policies and regulation:** - Increase gradually and predictably prices for undesirable economic practices - Strengthening the enforcement of waste regulations/laws (e.g. national implementation of organic waste garbage cans) - Mandatory quotas for recycling • **Infrastructure:** - Investments in waste disposal/process • **Technology:** - Improved processes for waste separation • **Misc aspects:** - Awareness raising/training in companies and among consumers - Networking opportunities for stakeholders along the value chain (suppliers, customers, …) - Engage policy makers in the design of the necessary and goal-oriented legislation for CE

Table 9: Gaps, barriers and driving factors given by the interviewees for the region of Bavaria

7. Conclusions

The regional maturity analysis for Bavaria focused primarily on the chemical and polymers sector. Partially, packaging and textile were addressed where similar/same aspects were valid for the focus sectors.

In Germany the responsibilities for waste management are inconsistent. National law and EU-directives which have to be implemented at the member state level are all valid for Bavaria. Only those parts in the legislation which are not addressed by national law are regulated by regional legislation. This mainly comprises the Bavarian Waste Management Act and Plan and regulates the responsibility of municipal institution to enforce the waste legislation. Regarding uniform systems and processes for an efficient circular economy this appears to be a big challenge as there are big differences form on municipality to the other.

On the regional level, the State of Bavaria has published or works on various political strategies targeting sustainability, bioeconomy, resource security and biomass resources. There is no specific Bavarian circular economy strategy published.
Moreover, no sector-specific official strategies for the chemistry, polymers or packaging sector regarding could be found. However, associations such as the VCI Bayern published the strategic paper 'Chemistry4Climate', the Think Tank Agora Energiewende published their impulse on 'Chemicals in transition' and the Bavarian Bioeconomy Expert Council released several publications on Circular Economy and Bioeconomy or the substitution of fossil raw materials.

In general, the landscape of public funding opportunities in Germany is well established. Bavarian companies have access to these funding offers. The state of Bavaria has set up several public funding programs such as the Bioeconomy Scale-Up program, Regional funding program, Innovationsgutscheine, BayTP+ - Bayerisches Technologieförderungs-Programm Plus and BayVFP - Bayerisches Verbundforschungsprogramm. These funding programs address SMEs, but with the exception of the Bioeconomy Scale-Up program all other programs are of a general character to boost innovation and technology development. The result of the survey showed that the SMEs do not profit from Bavarian funding schemes and do not see them as effective. Therefore, it is not surprising that more and better-suited less bureaucratic funding programs for the development of the circular economy are required.

Bavaria offers a unique support structure for businesses, universities, and research institutions. The Bavarian Cluster Initiative established networks ("clusters") in high tech industries and traditional key sectors of the Bavarian economy to foster collaboration between industry and academia, accelerate market success of research results and strengthen the entire value chain. This business support structure is complemented by specialized stakeholders to support start-ups, consult in funding applications, and help with knowledge transfer.

There is also a large number of technology and knowledge providers consisting of academic and non-academic renown research institutes which support their business partners/ customers with state-of-the-art processes, R&D development and expertise.

Similarly, there is a number of Bavarian companies ranging from start-ups via SMEs to large enterprises that are pioneering circular economy/bioeconomy technologies, processes and materials in their specific industry/business sector.

According to the results of the survey companies are quite well informed about regulations relevant for their sector. In general, companies regard circular economy as an important topic which increasingly affects their business. Accordingly, companies claim to already have implemented a specific circular economy strategy or intend to focus on it in the future.

A major barrier for companies is the uncertainty about legal requirements and the lack of binding specifications for recycled materials/products. In addition, the existing waste regulation restrict the use of certain residues/waste streams making it impossible to establish effective cascading processes.
Another challenge is the undefined composition of materials. This is the case for similar products which are made by different manufacturers but even more difficult across different sectors where, for example, different additives are added to polymers to realize the characteristics of each product. This means for recycling companies that two products which seem to be made of the same base material might not be recycled in one material stream. Better sorting technologies are necessary to separate waste streams into mono-materials and analytics have to be improved to define the precise composition of recycling materials. Accurate material data sheets with sufficient information on the material would be necessary. This could be saved in a digital product passport for example.

Finally, companies that intend to switch to recycled materials face the problem that many times virgin material is still cheaper. Replacing virgin, fossil-based materials by recycled and/or biobased materials often impacts their profitability. To motivate more stakeholders of the complete value chain to collaborate in a circular economy, incentives were suggested, such as, e.g., tax incentives or incentives for private investments. Additionally, public funding to improve necessary technology developments and tech transfer are seen as insufficient and to cause too high efforts for application and administration.

8. Annexes

- Results sheet of the survey carried out on circular economy in the region of Bavaria