ShapingBio

The bioeconomy of the future

D1.4 Report on macro-regions

Mapping of initiatives, structures, instruments and key challenges for EU's macro-regions

Submitted version

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List of Abbreviations

Abbreviation	Full name
APRE	Agency for the Promotion of the European Research
ART	Agriculture Research Troubsko, Ltd
BBEPP	Bio Base Europe Pilot Plant
CBE-JU	Circular Bio-Based Europe Joint Undertaking
CEE	Central and Eastern Europe
ESIF	European structural and investment funds
EU	European Union
FBCD	Food & Bio Cluster Denmark
Fraunhofer ISI	Fraunhofer Institute for Systems and Innovation Research
GDP	Gross domestic product
GDP	Gross domestic product
GERD	Total expenditure on research and development
ICT	Information and communication technology
NA	Not available
NGO	Non-governmental organization
NMPB	The National Medicinal Plants Board
R&D	Research and development
R&D&I	Research, development and innovation
SUBNET	SUBMARINER Network
TRL	Technology Readiness Level
TTE	Tech Tour Europe
TTG	Tech Tour Global
TTO	Technology transfer office
WP	Work Package

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Executive Summary

The **ShapingBio project** aims to support and accelerate bioeconomy innovation and the deployment of new knowledge in the EU and its member states. The project seeks to provide evidence-based information, guidelines and recommendations for better policy alignment and stakeholder actions to realize the cross-sectoral potential of the bioeconomy and to reduce the fragmentation across bio-based sectors, the food system and policies across regions, domains and governance levels.

This Deliverable provides a **mapping** of the bioeconomy activities, structures, actors, policy strategies and instruments as well as challenges for selected topics for four EU macro-regions[1] covering total EU-27, based on stakeholders' information needs that had been identified in the ShapingBio project. Moreover, for every Member state a **Country Fiche** with main strategies, collaborative structures and policy instruments is provided in the Appendix. Based on this mapping comparative insights across four macro regions are drawn. Overall, the mapping provides an initial overview. It forms the basis for selecting further analyses that will be made later in the project. These analyses will focus on solutions to EU bioeconomy challenges and good practice examples.

The Deliverable shows that the **bioeconomy landscape** differs across the EU and the four macro-regions show specific profiles regarding type of biomass available, value chains and policy developments. Within the macro-region profile, macro-regions are to a certain extent heterogeneous on a country level. In many countries at least some relevant actors in the bioeconomy as well as key activities (e.g. cross-sectoral projects, relevant R&D funding programs, clusters, hubs and platforms) could be identified and the bioeconomy contributes significantly to value added and deployment in the different member states. The value chains and potentials differ between the macro-regions, with a forestry/wood focus in Scandinavian countries instead of agricultural biomass, while there opportunities for valorising agricultural biomass, which are not yet fully exploited in CEE and southern MR countries.

Strategic policy activities differ between member states in their maturity stage, but also in their approach. he mapping yielded a broad spectrum of approaches that EU member states pursued towards a national ioeconomy policy. Ten member states have a dedicated bioeconomy strategy, but differ in the point of time when such a strategy was developed (early to late adopters), whether the strategy is with/without action plan, differ in scope and sectoral foci. Those member states without a dedicated bioeconomy strategy, they either are in the process of developing strategies, or have dedicated policy initiatives, an action plan or a roadmap, or only address selected bioeconomy aspects in the context of other policy fields. While most advances in strategic policy development have been made in the Western macro-region, also countries in the Southern and Baltic Sea Region have made considerable progress. **Cross-country** strategic activities dedicated to the bioeconomy exist in the Baltic Sea Region and the CEE macro-region (EU strategy for Baltic Sea region; BIOEast Initiative) and strategic activities related to the bioeconomy in the Southern macro-region exist (e.g. Public-Private Partnership PRIMA).

Policy coordination within the Member States is of crucial importance, because of the cross-sectoral character of the bioeconomy and its linkages to different policy fields. All countries with strategies have involved several ministries covering different domains such as environment and climate change, R&D&I, agriculture or economics. While the countries have established informal and formal networks level, still challenges for joint decision making and integrated bioeconomy policies remains.

The **actual practical implementation of bioeconomy strategies** is of key importance for the transition to a bioeconomy. The implementation is, however, difficult to map as the countries differ whether they have

[1] The 4 macro-regions included in the report are: Baltic Sea macro-region (DK, EE, FI, LV,LT, SE), Western region (AT, BE, DE, FR, IRL, NL), Southern region (ES; GR, IT, PT) and Central-Eastern region (BG, CZ, HR, HU, PL, RO, SK, SL)

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action plans and what kind of instruments are implemented (e.g. dedicated to the bioeconomy or bioeconomy as part of horizontal programmes). Countries with strategic approaches to the bioeconomy seem to be more active in implementation. However, the measures implemented do not yet cover fully the high ambitions and goals that the bioeconomy strategies claim. Therefore, implementation of the bioeconomy strategies by appropriate policy mixes is an ongoing issue in many Member States.

There are significant difference in **bioeconomy innovation**. The Western Region takes a leading role and acquires approximately 50% of the bioeconomy funding provided by Horizon Europe Cluster 6, or the CBE funding, respectively, participated in application of 75% of the EU bioeconomy-related patents and runs more than the half of the open access pilot plants in the EU. It has a robust, well-developed infrastructure of universities, research centres and industries, and active associations for bioeconomy research. While in the Southern and Baltic Sea region, some countries (e.g. Spain, Italy, Denmark, Finland, Sweden) also show significant innovation activities and are partly strong in raising EU funding, other Member States are more in follower stage with limited innovation capabilities and lack of R&D infrastructure and networks. Also the CEE countries face many challenges to innovations in the bioeconomy, although there some signs of improvement.

The Western macro-region is also at the forefront with **industrial activities**, with e.g. significant shares of biorefineries and strong presence of industry and clusters. The Scandinavian countries show economically strong forestry and wood-based value chains with established industry actors, clusters, networks and significant contribution to value added in the bioeconomy. While the CEE countries have a high amount and quality of agricultural biomass, they often lack smart, value-adding, and sustainable value-chains to valorize this resource domestically. The Baltic Sea region bioeconomy is dominated by the forest industry and the products created by the forest as raw materials. Other important sectors are agriculture and food, biotechnology, chemicals, bioenergy industries as well as the overall blue bioeconomy as an emerging field. While the value-added. The Scandinavian countries (Denmark, Finland and Sweden) generate rather high value-added and show strong cross-sectoral collaboration especially related to wood, agriculture, food, and fisheries sectors, while in the Baltic countries bioeconomy is rather emerging.

Therefore in the final **cross-conclusion chapter** specific topics that need further investigation are highlighted, comprising policy coordination, cross-sectoral collaboration, applied R&D and technology transfer, as well as financing issues in the bioeconomy.

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1 Introduction

The current fossil-based economy has reached its limits and needs radical transformation towards new bioeconomy-based socio-economic model with more sustainable and circular use of resources. Over the last decade this transition process has become one of the EU's core objectives. In 2018 the European Commission, updated its bioeconomy strategy and reaffirmed the five original goals: (i) ensure food and nutrition security, (ii) manage natural resources sustainably, (iii) reduce dependence on non-renewable, unsustainable resources, (iv) mitigate and adapt to climate change and (v) strengthen European competitiveness and create jobs. (European Commission, 2022). These objectives are in line with the targets of the EU Green Deal and become more relevant than ever before, following the Russian invasion of Ukraine and the need to speed up EU's independence on energy and strengthening food security (European Commission, 2022). However, a need is seen to translate the high-level EU and national strategies to regional or even local activities, and to strengthen regional and local participation. But there is a very high heterogeneity between different macro-regions and sectors in the EU's bioeconomy. The macro-regions (and countries within them) often share common potentials and fields of activities (e.g. use of similar primary resources and/or strengths in certain application sectors), in some relevant activities to coordinate and develop bioeconomy potentials are taking place already (for example BioEast Initiative and BalticSea region). Even though the urgency of the development of bioeconomy and its importance to the economy across all EU macro-regions has been recognized both on the EU and national level, different gaps and inequalities remain, ranging from, for instance, policy coordination and harmonization to the level of R&D activities, actor engagement and awareness and to having access to financing. Therefore further efforts are necessary to harmonize the bioeconomy scene across Europe and improve the performance of all the member states. Insights on these aspects in the four macro-regions and comparative insights within them are further elaborated in the following chapters of the current report. It provides a mapping of an inventory of the bioeconomy activities, policy strategies and instruments and conditions for each macro-region, based on the prior identified information needs in the project. This report (Deliverable 1.4) complements the EU bioeconomy mapping (Deliverable 1.2) and will be accompanied by a more detailed analysis of specific topics (i.e. policy coordination, R&D transfer, collaboration and financing) in Work Package 2 of Shaping Bio.

This report contains 4 sections with an identical outline for four Macro-Regions covering the EU-27. In section7 a cross-conclusion for all macro-regions is provided.

In addition this Deliverable contains in the Annex country fact sheets, covering all the 27 member states of the EU. Those fiches summarize the main strategies, collaborative structures and policy instruments per member state.

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2 Approach

In the following the thematic and geographical scope as well as the used sources are presented.

Geographical scope

The reports cover different dimension of activities in the bioeconomy across the EU. As indicated in the introduction, to map and assess the very heterogonous regions and sectors in the bioeconomy, we differentiate between macro-regions. Those regions often share common potentials and fields of activities (e.g. use of similar biogenic resources and/or strengths in certain application sectors). Moreover, in some macro-regions relevant activities to coordinate and enhance activities in the bioeconomy already exist, such as the BioEast Initiative or the EU Strategy for the Baltic Sea Region. This focus on macro-regions enables us to specify key geographical issues of the bioeconomy.

Moreover this approach has the advantage that in those cases where gaps for country-specific information arise, we were able to focus either on the macro-region in general or on certain countries in the macro-region to provide relevant information about the bioeconomy. The macro-regions and respective countries are listed in the table below.

Table 1 Macro-regions and countries

Macro-Region	**Countries**
Central and Eastern Europe	Bulgaria, Czech Republic, Croatia, Hungary, Poland, Romania, Slovenia, Slovakia
Baltic Sea Region	Estonia, Denmark, Finland, Latvia, Lithuania, Sweden
Western Europe	Austria, Belgium, France, Germany, Luxemburg, the Netherlands, Ireland
Southern Europe	Cyprus, Greece, Italy, Malta, Portugal, Spain

Thematic scope and outline of Macro-Region chapters

For all 4 macro-regions the same activities and outcomes in the bioeconomy were analysed with the aim to cover all respective member-states. It contains

- **State-of play**, containing review of production and industrial use of biomass in the macro-region, as the economic relevance of the bioeconomy. The goal here is to characterize resources as well as activities in the bioeconomy for the MR, but also highlighting differences between the respective countries (see limitations below regarding sources).
- Describing the **actor landscape** in the MRs in the bioeocnomy. Please note that taking a wide perspective including the whole agri-food system the bioeconomy contains a very high number in the whole bioeconomy. A full coverage even on one single actor group level is out of scope, but the aim is to provide examples and to collect where existing insights about the presence of certain group in the Member states.

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- Characterization of the **national and macro-regional policy landscape** for the bioeconomy, mostly from the strategic level, but also as far as information available regarding policy instruments (see box 1 for typology).

Box 1: Typology of Policy Instruments

For the mapping of policy instruments we used the conceptual framework Edler/Georghiou (2007) proposed for supply-side and demand-side measures. This taxonomy is built on the observation that demand-side orientation is central for innovation system that include a high number of innovation actors, but that demand for innovation is still less reflected in conceptual framework. In the figure that follows, supply-side measures and demand-side measures are conceptually brought together for a taxonomy of innovation policy tools. Important to note is that demand measures are differentiated in the same way as supply-side measures.

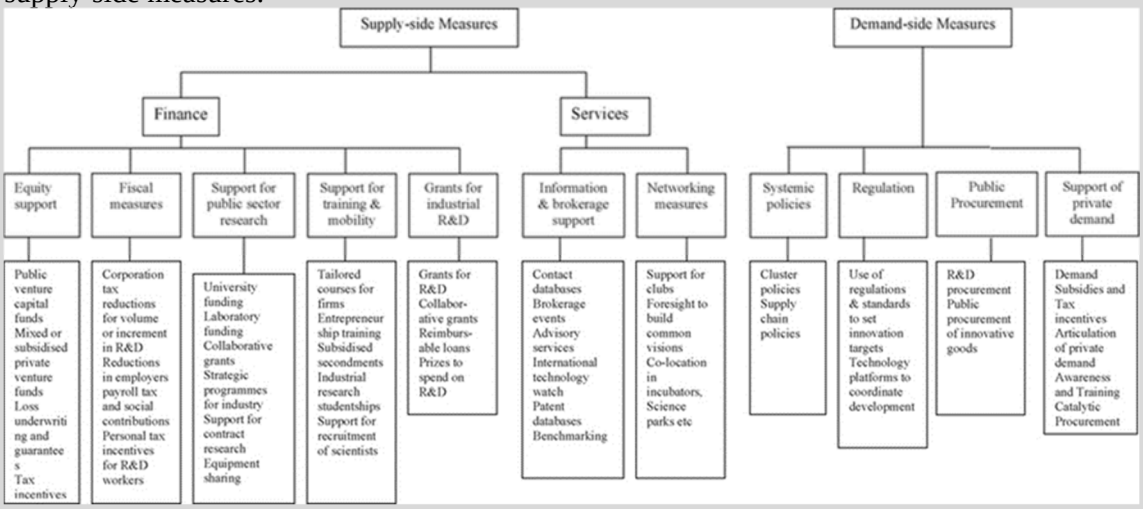

Figure 1. Taxonomy of innovation policy tools
Source: Edler/Georghiou (2007)

In the realm of supply-side measures, the conceptual taxonomy is structured into two levels: (1) Finance (2) Services. The finance dimension consists of diverse measures that include for example grants for industrial R&D, Equity support or support for public sector research. Along the dimension of services, network measures and information & brokerage support are displayed, which include tools, such as benchmarking, brokerage events or foresight. Demand-side on the other side consist of systemic policies, regulation, public procurement and support of private demand.

In addition, we investigated for **selected countries in each-macro-region** additional items, as here a full coverage of all countries is out of range of this study. Namely we analysed Italy and Spain in Southern Europe), Denmark (Baltic Sea), Germany, Ireland and Belgium (Western Europe). For Central and Eastern Europe an inclusion of more countries was partly possible based on earlier work of the BioEast network, and for some aspects a respective relevant country was chosen. For all these named countries we analysed the current situation for

- **Bioeconomy policy process coordination**: The box 2 below explains why policy coherence and coordination have a very high importance in the bioeconomy and needs specific attention. The section explores for each MR how horizontal coordination between different ministries/

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departments takes place, to which extent stakeholders are integrated in policy making processes and which are the prevailing goal conflicts and how they are governed. Regarding the goal conflicts, we aimed to identify by desk research, which goal conflicts are specifically discussed. Moreover, there is wide general discussion in the EU about potential goal conflicts, often without geographical specification, these are summarized in box 3.

- **Applied R&D and effective technology transfer** including the interaction of relevant stakeholders (research, industry and policy for different important activities, e.g. scaling up): The sub-chapter contains a review of policy instruments targeting these activities in the bioeconomy as well as review of structures and challenges.
- **Collaboration across all stakeholders**, in particular cross-sectoral and cross-country collaboration: The sub-chapter contains a review of policy instruments targeting these activities in the bioeconomy and a mapping of selected structures and examples.
- Financing, including the interplay of the (public and private) financial institutions community, research and industry at various stages of bioeconomy innovation developments and value chains. The sub-chapter contains a review of policy instruments targeting these activities in the bioeconomy and its mapping.

The macro-regional sections close with a SWOT-analysis that is based on all insights gained during the information gathering phase as well.

Box 2: Policy Coordination and stakeholder involvement in policy processes in the bioeconomy

Policy coordination is essential to create a coherent and integrated approach to the development of the bioeconomy. This includes creating policy frameworks, regulations and institutions that support the transition to a sustainable and inclusive bioeconomy. Governments play a central role in setting direction and priorities for bioeconomy strategies, as well as coordinating and aligning efforts across different ministries and agencies.
In addition to political coordination, the participation of various stakeholders is essential for the success of bioeconomy strategies. Stakeholders from the industrial sector, including large companies and SMEs, can contribute their expertise and resources to the development and implementation of innovative biological technologies and products.
Research organizations can provide scientific expertise, conduct studies and work with industry and government to support research and development in the bioeconomy.
Some environmental organizations can play a role in ensuring that bioeconomy strategies are environmentally sustainable and do not harm ecosystems. They can provide information on biodiversity conservation, sustainable land use and conservation of natural resources. Farmers and agricultural organizations are important stakeholders in the bioeconomy as they can provide input and expertise on sustainable agricultural practices, crop diversification and biomass production for bioenergy and bioproducts.
Local communities must also be involved in the development and coordination of bioeconomy strategies. Their involvement ensures that the bioeconomy benefits local economies and addresses the specific needs and aspirations of local communities. Local communities can contribute knowledge and insights about their local resources, traditions and needs to help shape the bioeconomy strategy in a way that is culturally and socially acceptable.
Different mechanisms can be used to facilitate the coordination and participation of different stakeholders. These may include regular meetings and consultations, stakeholder workshops, public

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hearings and the establishment of task forces. These mechanisms provide a platform for stakeholders to discuss and contribute their views, share best practices and collaborate on the development and implementation of bioeconomy strategies.
In addition, on a macro-regional greater collaboration and cooperation among countries may be beneficial. This can include sharing best practices, harmonizing policies and standards, and jointly developing regional bioeconomy strategies. Governments and regional bodies can also play a crucial role in providing financial support and incentives for bioeconomy projects, as well as facilitating public-private partnerships and cross-border investments.

Box 3: Goal conflicts in the bioeconomy in the EU
Conflicting objectives in the bioeconomy have been a controversial subject of the public discourse since the overall concept of bioeconomy have emerged. These conflicting objectives and the proposed solutions, which are necessary, are differently perceived by bioeconomy actors. Particularly, civil society organizations (NGOs) and nature protection agencies criticize existing strategies for not addressing social, economic, and ecologic goal conflicts in the same way. They criticize that the current visions of the bioeconomy reflect mainly the interests and propositions of influential economic, political and scientific actors. Instead, others see great opportunities in the bioeconomy and regard a "Level-playing-field" as needed to develop and then further direct the bioeconomy to achieve sustainable goals. In the following, the general debate over bioeconomy goal conflicts in the EU is very shortly summarized to obtain an understanding how these topics are discussed among different political and societal actors and which solutions are proposed by these actors.
This summarization provides the basis for the more in-depth analysis in the MR where only specific aspects per MR, but not the general partly geographically-unbounded discussions, are repeated.
While Table 2 summarizes key issues of potential goal conflicts, three highly relevant discussions in the context of ShapingBio are the following
One conflicting goal that have been subject of public contestation are **land use conflicts.** As green biomass need to be produced at agricultural and forestry land areas, conflicts between the objective to provide nutrition security on the whole planet and to generate renewable energy emerged. Especially civil society organizations have claimed that the bioeconomy is therefore not able to contribute to a sustainable future, in which food security and equity of all actors along the value chain is guaranteed. A further challenge lies in the degradation of nature and its negative impacts on biodiversity, carbon stocks or freshwater, which are increasingly pressured through bioeconomic sectors (Többen et al., 2022). Especially the expansion of agricultural land for more biomass production leads to further degradation of nature and means losses of carbon sinks and higher CO2 emissions in the atmosphere (Hoff et al., 2018). In addition, a major challenge of the bioeconomy is to find solutions for the continuing specialization and intensification of agricultural production and its negative implications for species, genetic and ecosystem biodiversity.

Table 2 Mapping of selected goal conflicts in the bioeconomy

Goal Conflict	Description
Land use conflicts	Food security vs. energy production Sustainable energy vs. finite biomass Land grabbing
Intensive agricultural production	Intensive livestock farming Expansion of agriculture

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Modern vs. traditional sectors	Ousting of fossil-based industries and its labour-market political implications
Biomass use vs fossil-based products	High prices of bio-based products Social division through societal disadvantaged people
Justice and ethical conflicts	Distribution of ecological, economic, and social implications of the bioeconomy Procedural justice (inclusion of societal actors) Rural-Urban inequalities
Genetically modified crops and plants vs social acceptance	E.g. plant breeding technologies
Socio-ecological conflicts	Economic relationship with nature (nature capital) Profit-oriented forestry vs. natural heritage (culture capital)

Source: Own table.

Although new emerging bioeconomy sectors pose a lot of potential for a sustainable future, also pitfalls of labour-market political implications must be considered by stakeholders. Particularly, this aspect relates the question how workers from traditional, fossil-based industries can be adequately integrated in these new green bioeconomy sectors without losing their overall labour perspective (Banse et al., 2020). **Structural change** is therefore one of the key goal conflicts the bioeconomy has to cope with. Furthermore, conflicting goals in this context can also emerge if new adopted bioeconomy strategies are not well suited for local, traditional bioeconomy regions and if bioeconomy pathways differ between actors and regions. It is therefore important to adopt a coherent and well suited framework for the bioeconomy, which take into account the several peculiarities of existing bioeconomy regions.
New innovations in the bioeconomy opens up new technological opportunities to reach the high ambitious goals of the bioeconomy. One ambition to end hunger and to provide food security is linked to genetically modified plants, genome editing (e.g. plant breeding technologies). These techniques offer great potential to develop new crop varieties and help to overcome food insecurity (Lassoued et al., 2018). However, a major obstacle for the legal-adoption of these technologies in Europe are public concerns and overall missing social acceptance by consumers and civil society organizations (NGOs) that hinder the development of a legal framework. Currently the plans to modify regulations are a major topic of debate.

Sources
The following sources have been used

- **JRC-Data:** Very recently, the Joint Research Centre for the European Commission has published or updated various databases or information collections for the bioeconomy covering bioeconomy supply and use, biorefineries, economic relevance as well as partly policy strategies and measures. This data is collected and presented on a macro-regional level. Here, the limitation arises that most available especially for the supply and use of biomass is 2017; moreover, comparable country level data on residues was not available at the time of data collection.
- **Literature and Desk Research:** A wide range of documents, such as research articles, bioeconomy studies, but especially internet desk research to identify policy instruments and activities has been done.

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- **Databases:** For mapping of private financing and open-access pilot plants, additional analysis of databases has been performed (see Box 4 and 5 below)
- **Interviews:** As in particular for policy coordination hardly written information is available, interviews have been performed with policy makers from the different countries.
- **Validation workshops:** For each macro-region a dedicated online workshop has been performed at the end of the data collection phase, to validate the findings, especially in the sense that the conclusion that were partly drawn based on info for some countries are valid for the whole macro-region or not. At each workshop experts with different background and from different countries of the macro-region were present.

Box 4: Private financing

Private investments in the bio-based industry are limited, pushing companies in bioeconomy to rely on their own resources or seek equity from specialized investors or corporate partners as they grow in size and technological sophistication. While the European Union offers grants through specific bioeconomy programs like EIC, Eurostars, EIT, these grants are limited for companies, favouring those that are technologically advanced. As companies in the bioeconomy industry scale up their projects to more advanced development stages, they encounter a diminishing availability of grants due to the larger project sizes – also confirmed by the respondents in the ShapingBio D1.1 Stakeholder Needs Report (ShapingBio project, 2023). Additionally, the presence of public funding does not always attract sufficient private capital, primarily because sector-specific risks often exceed the risk absorption capacity of public funding instruments (EIB 2017).

Mapping of the financing landscape in the EU is based on information on available sources of private investment (e.g., for specific types of companies (size), size of tickets, countries they invest in, etc.) by means of desk research focusing on diverse relevant sources. The data relates to investment in bioeconomy present status and to some extent future trends. A more detailed ShapingBio analysis on bioeconomy financing will be implemented in ShapingBio WP2 Analysis of mapped information and involvement of stakeholders. Here are presented only schematic findings to present the regional situation as a whole and for regional comparison purposes. ShapingBio used as starting point three main types of sources:

- Online sharing data platform Dealroom.co (https://dealroom.co/) was used for the research as our main source of data on private investments in the EU. Dealroom is one of the most prominent data providers on start-ups, growth companies and tech ecosystems in Europe and around the globe. It obtains data from the world's most active investors, entrepreneurs and government organisations and helps investors and tech companies connect and share data.
- In brief, the Dealroom research included 3822 bioeconomy and biotech funding rounds in various stages of growth and respectively size in the EU and Norway from the beginning of 2021 till 13.04.2023. The investors are of EU and global origin and include private investors and EU schemes that may participate in a financing round in syndicate. That is why the research also includes Horizon Europe financing and its sub-programs like EIC, EIT, BBI-JU, as well as investments from EIB and other private but to some extent related to EU funding. The sectors researched were agriculture, including forestry; food and feed, and biofuels. It is based on reported data which may exclude some deals that have taken place but not reported, or deals that were reported but the investment amount was not disclosed. Such is the case with deals in Malta in the South Macro-region. The data presented here include deals that are approximately relevant to all TRL tiers, and it is worth noting that we compare the financing as a whole related to the maturity of the companies and the ecosystems.

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Box 5: Open-Access PilotPlants

Innovators' success hinges largely on their ability to effectively transition from lab to pilot and eventually full-scale production. However, the piloting phase demands substantial time and often entails significant investments in infrastructure. At the EU, national, regional, and local level, initiatives, structures and infrastructures have been established to support the development of innovations, their testing and demonstration, training of qualified staff, as well as investing in infrastructures. Nonetheless, these high investments still represent a significant barrier to accelerating bioeconomy growth and when it comes to the creation of new successful ventures. As a proxy indicator for the existence and diffusion of pilots plant, data from Pilots4U network is used. The Pilots4U network sets up a free online database that lists European pilot and demonstration infrastructures and their scale-up equipment for various bio-economy processes. This equipment is operated by several companies and institutes that work in an open access mode (shared facility). The Pilots4U database currently contains 500+ entries from 100+ organisations present in all EU countries. These entries are Open access pilot and demonstration infrastructures that allow industry to bring bio-economy innovations from the laboratory into industrial practice. They are open to all companies and research institutes and offer a wide range of innovative, state-of-the-art equipment and expertise.

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3 Macro-Region Southern

Authors and Affiliations:

3.1 State of Play of the Bioeconomy in Southern Macro-Region

The southern macro-region is composed of six countries: Spain, Portugal, Malta, Italy, Greece, and Cyprus.

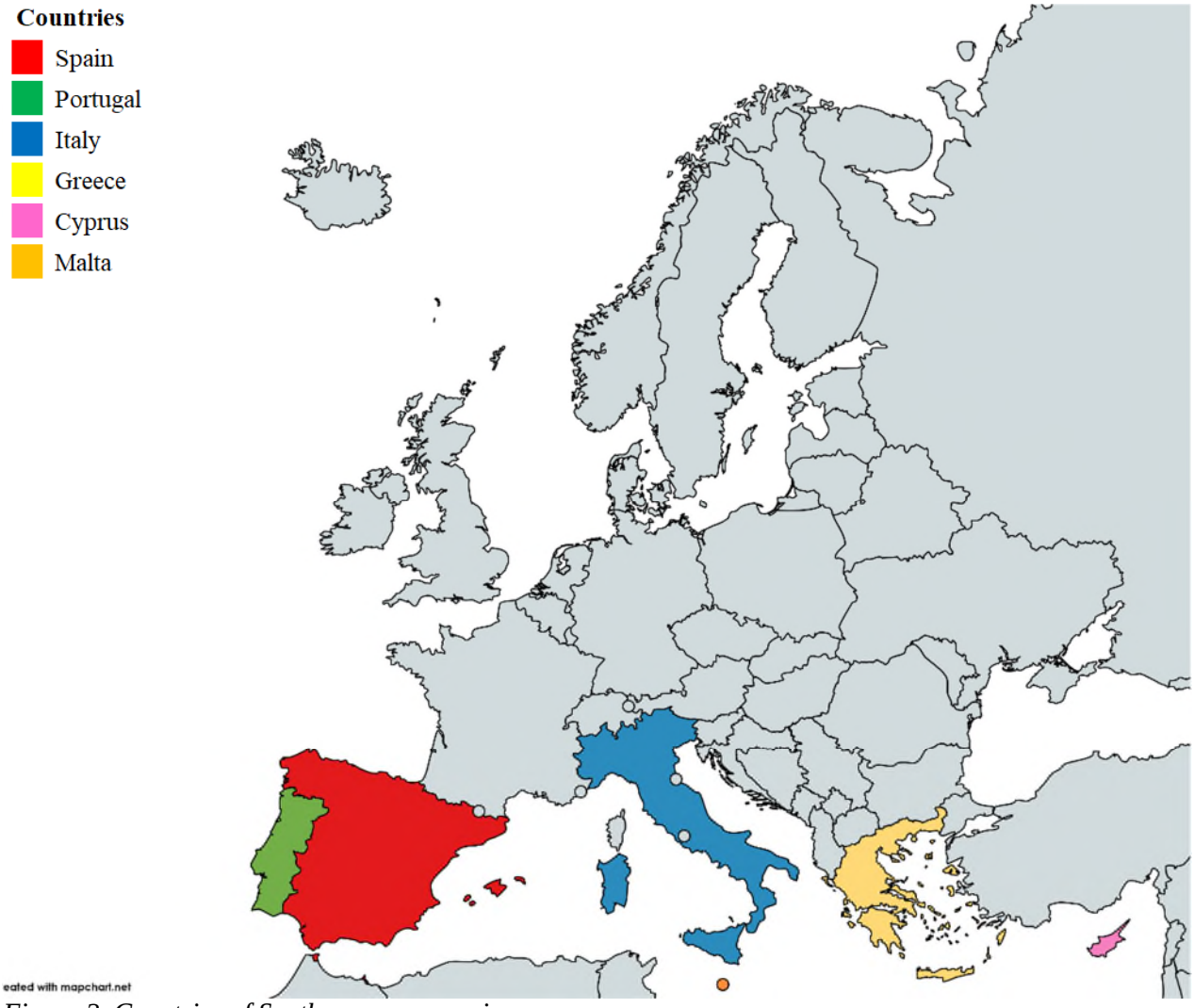

Figure 2. Countries of Southern macro-region.
Source: mapchart.net (2023).

The countries of the southern macro-region represent 25.12% of the total area of the EU-27. Spain is the second largest country in the EU; however, Cyprus and Malta are placed in the last positions compared to the rest of the countries.

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Regarding the number of inhabitants, the southern macro-region accounts for 28.81% of the total population of the EU-27. Italy and Spain are ranked at the top, only surpassed by Germany and France. However, Cyprus and Malta, despite its area, are placed in the last positions in terms of the number of inhabitants.

Table 3 Area and inhabitants of southern macro-region

Country	Area (sq. km)	Share of EU-27	Inhabitants (2022)	Share of EU-27
Cyprus	9,213	0.22%	904,705	0.20%
Greece	130,048	3.17%	10,459,782	2.34%
Italy	297,825	7.26%	59,030,133	13.21%
Malta	313	0.01%	520,971	0.12%
Portugal	90,996	2.22%	10,352,042	2.32%
Spain	502,654	12.25%	47,432,893	10.62%
Total MR	1,031,049	25.12%	128,700,526	28.81%
Total EU-27	4,103,987	100%	446,735,291	100%

Source: Eurostat.

3.1.1 Production and industrial use of biomass

Primary Production

In the primary sector (agriculture, fishing, and forestry), agriculture is the most important sector in the economy of the countries that make up the southern macro-region.

According to data from the Food and Agriculture Organization (FAO) of 2020, in the countries belonging to southern Europe, there is an area of 21,665,334 hectares of arable land (FAO, 2020). However, as observed in Figure 3, there is a progressive decrease, more significant in recent years, in the cultivable land area. This situation is since poor agricultural practices can lead to land fertility loss. Also, the increasing population and the demand from other sectors put growing pressure on the available resources.

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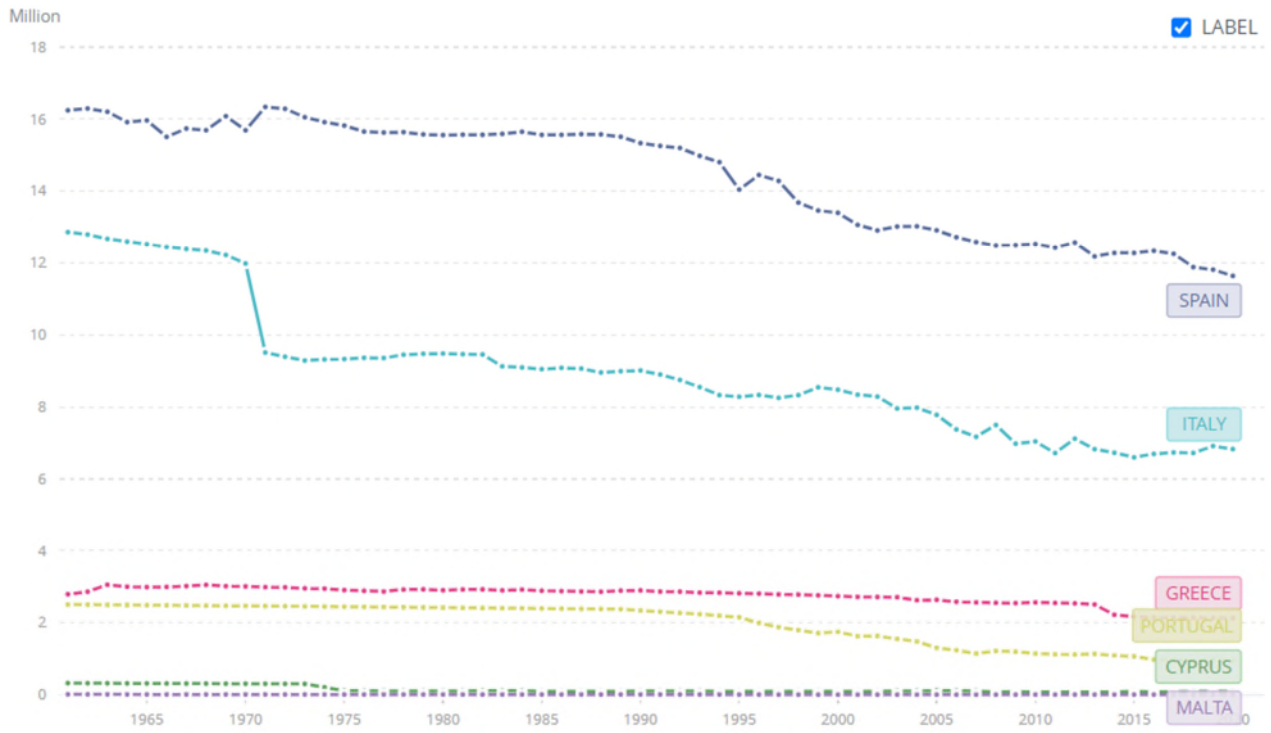

Figure 3. Arable land (hectares) in Southern Europe (2020).
Source: Food and Agriculture Organization (FAO).

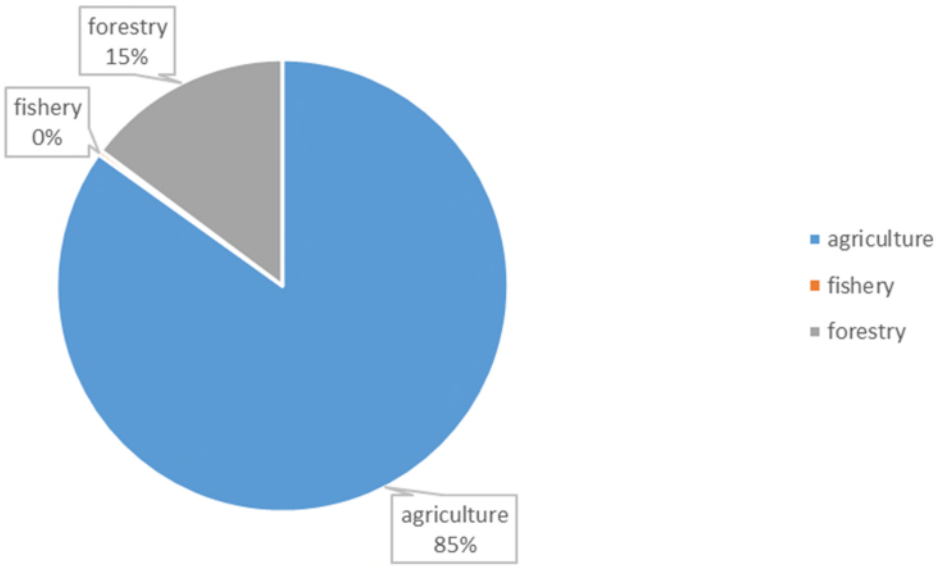

Figure 4. Biomass Production from Primary Production Systems in Southern Europe (2020 for agriculture, 2016 for fisheries and 2017 for forestry).
Source: Datam JRC, European Commission.

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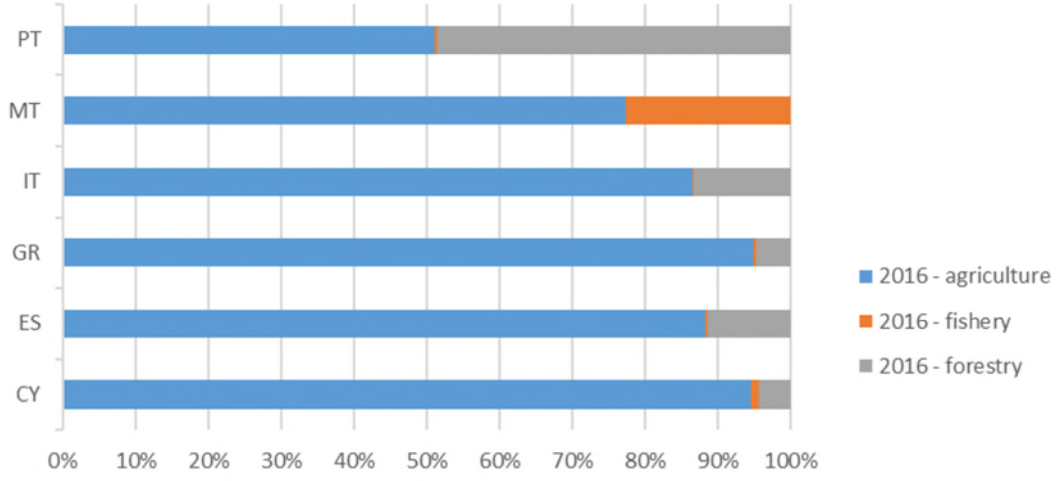

	CY	ES	GR	IT	MT	PT
2016 - agriculture	94,45%	88,16%	94,80%	86,38%	77,35%	50,98%
2016 - fishery	1,12%	0,40%	0,32%	0,17%	22,65%	0,35%
2016 - forestry	4,43%	11,44%	4,88%	13,44%	0,00%	48,67%

Figure 5. Biomass Production from Primary Production Systems in Southern Europe (2020 for agriculture, 2016 for fisheries and 2017 for forestry).
Source: Datam JRC, European Commission.

Figure 4 and Figure 5 refer to the Biomass Production from Primary Production Systems (agriculture, fishery, forestry). In the Southern MR, almost all the biomass comes from the agriculture sector. Currently, the countries in the southern macro-region are focusing on the blue bioeconomy since as countries like Portugal, Malta, or Cyprus basing their economies on the marine sector. Therefore, it is foreseeable that the percentage of biomass production from marine and aquaculture sources may increase in the coming years to certain extent.

Use of Biomass

In the southern macro-region, during 2017, a total of 182,431 tonnes of biomass (dry matter) from agricultural and woody sources were consumed to produce energy, materials, and food. This data represents 22.58% of the total biomass consumption in the EU-27.
Clearly, the highest demand among the countries in the southern MR coincides with those that have a larger area and a higher population. In these countries, biomass is primarily used for food and feed production (76.6%), but there is also significant use for energy production (13.51%) and biomaterials (9.88%).

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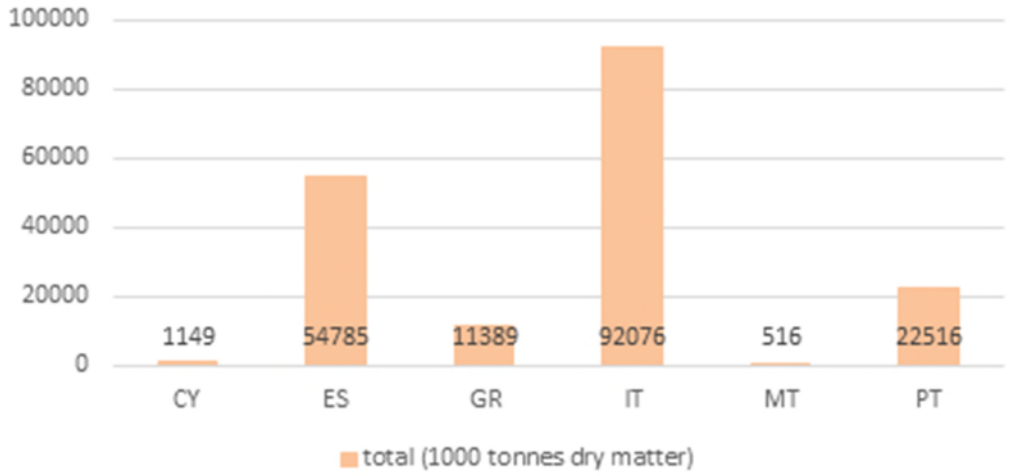
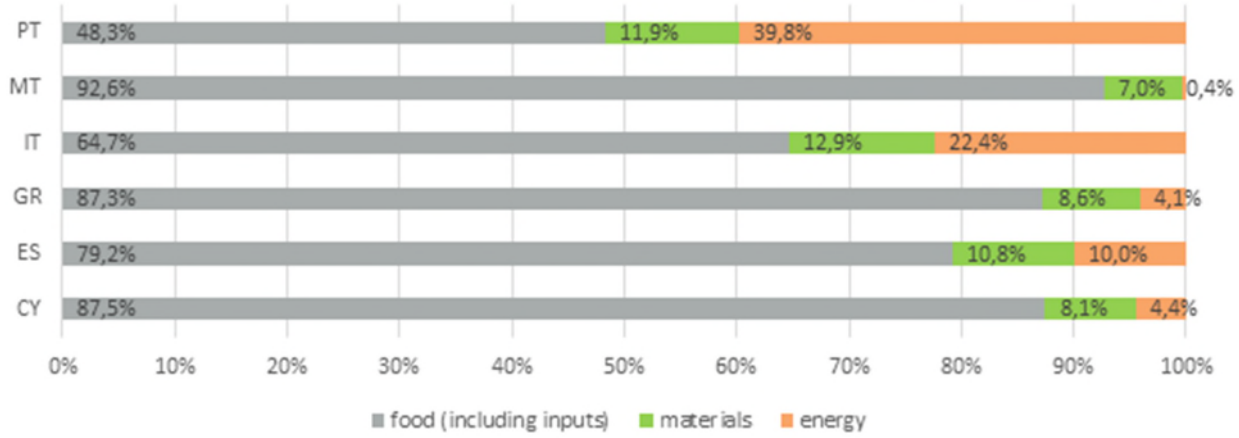


Figure 6. Total biomass consumption in Southern Europe (2017).
Source: Datam JRC, European Commission.

Figure 7.Total biomass consumption in Southern Europe (2017).
Source: Datam JRC, European Commission.



Biomass Flows

Figure 8 shows a summary of the latest biomass flow data for Southern Europe.[2] As previously indicated, the biomass supply comes from the agriculture, forestry and fisheries sectors and is converted into products related with food and feed, bioenergy and biomaterial.

[2] Slight deviations to the figures above are possible, due to partly different reference years and additional attribution steps of data

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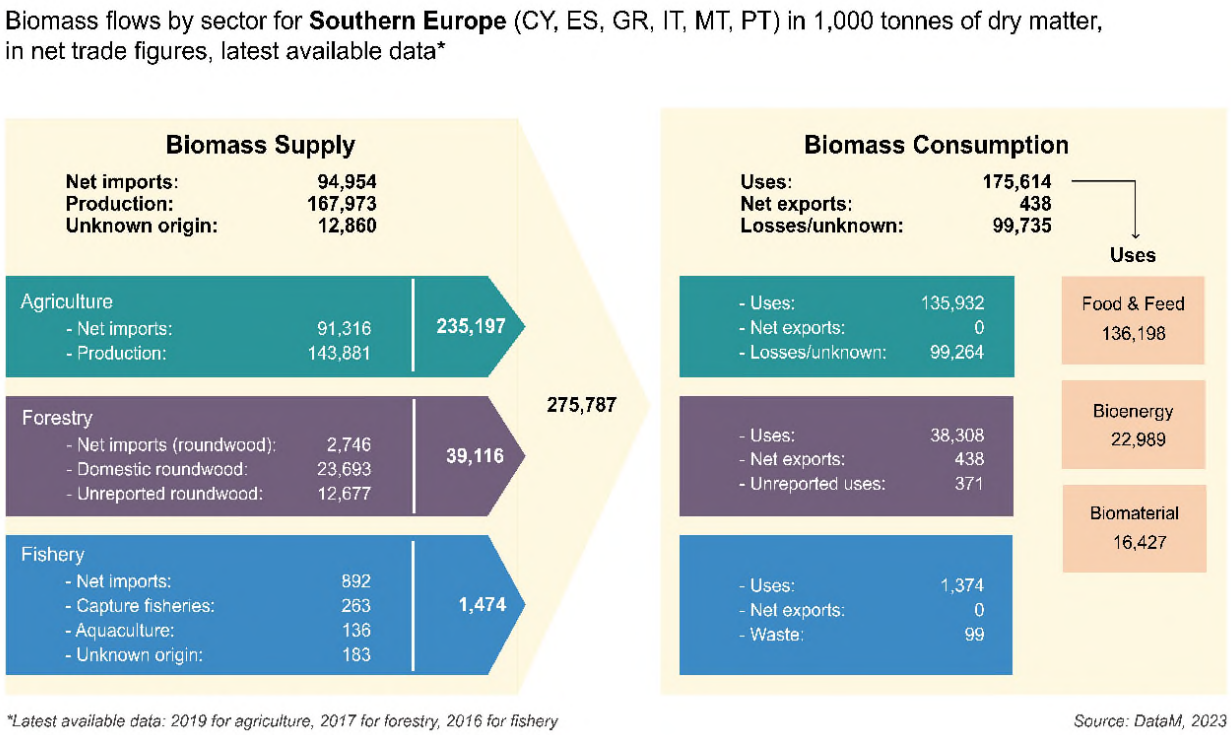

Figure 8. Biomass Flows in Southern Europe.
Source: Datam JRC, European Commission.

3.1.2 Industrial deployment of bioeconomy and economic relevance

3.1.2.1 Industrial deployment

Open-Access Pilot Plants
Regarding open-access pilot and demo facilities, the Pilots4U network database shows a rather even (distribution of such facilities. All of the countries have a rather medium number of such facilities, even the countries differ considerably in size.

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Figure 9. Distribution of number of open access pilot plants in Southern Europe (2023).
Source: Pilots4U network.

Biorefineries

The EU bio-based industry is quickly evolving, but in the countries of southern Europe, the number of biorefineries is less concentrated than in other areas of the continent. In the southern macro-region, there are 379 facilities, which account for 16% of the total 2,362 biorefineries in the EU-27.

Italy ranks 4th in terms of the number of bio-based industries compared to other EU countries, with most of the biomass feedstock used coming from agriculture, as does Spain, which ranks 7th, followed by Greece, which ranks 12th in the EU. Portugal, Cyprus and Malta are ranked 20th, 25th and 27th respectively.

In Figure 10 we can realize that in Italy there are almost twice as many bioindustries as in Spain. In both countries there are a notable number of biofacilities where the pulp and paper bioindustries predominate (Figure 11), this last also happen in Portugal. Besides, in Greece the liquid biofuels industries stand out. In Malta and Cyprus there are not bioindustries.

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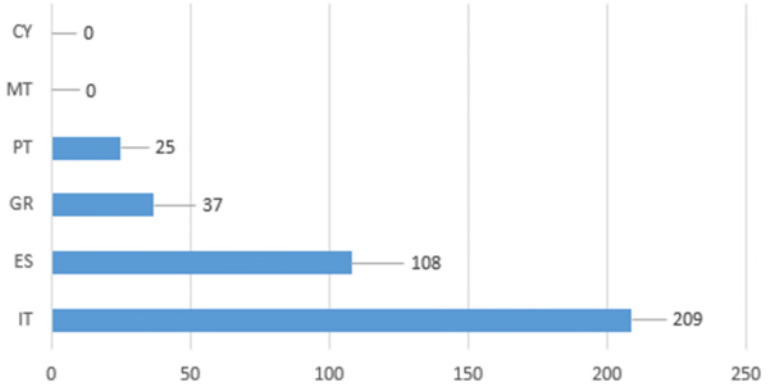

Figure 10. Number of bio-based industry facilities by country in Southern Europe (2020). Source: Datam JRC, European Commission.

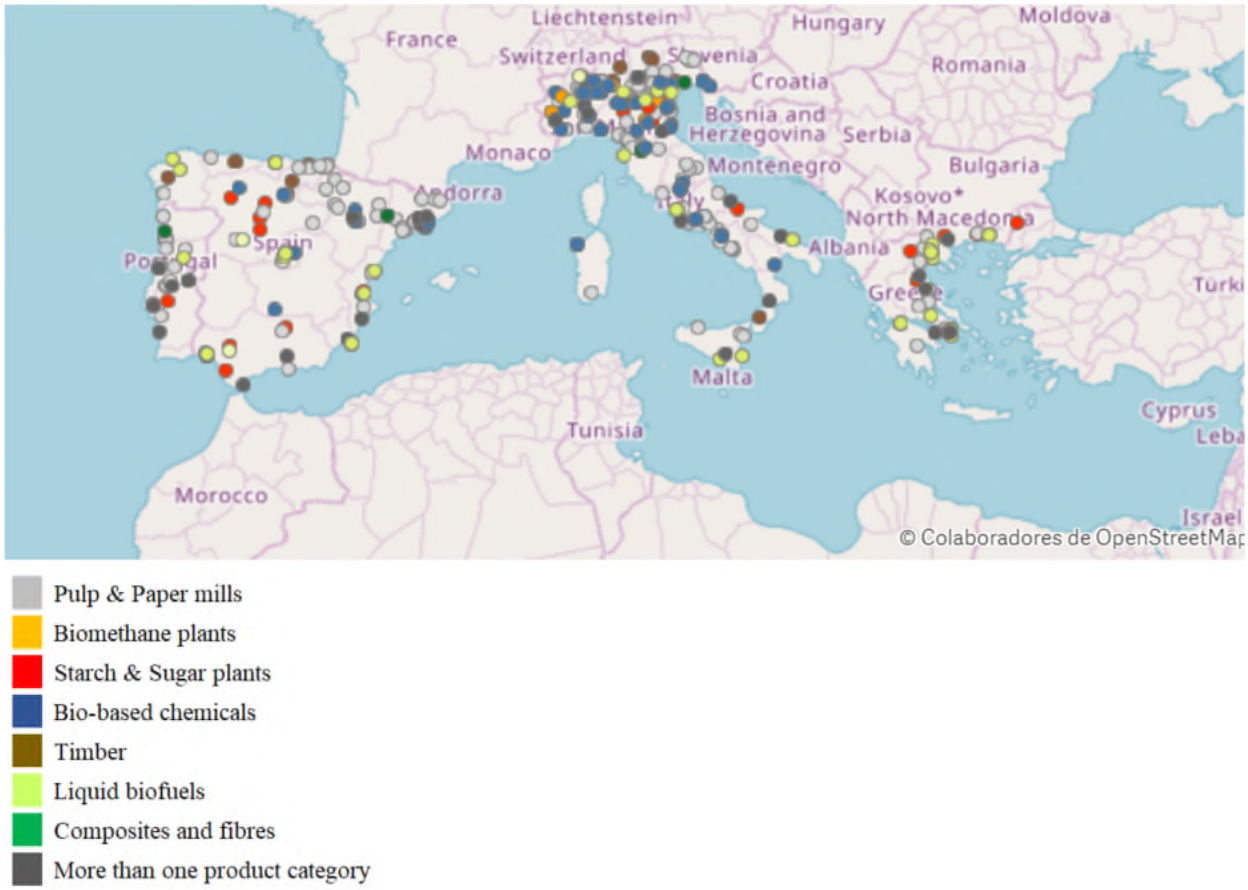

Figure 11. Distribution of bio-based industry facilities by country in Southern Europe (2020). Source: Datam JRC, European Commission.

If bio-based industry facilities are classified by feedstock origin, those using raw materials from the primary sector, specifically from forestry and agriculture, notably predominate. On the opposite side, the

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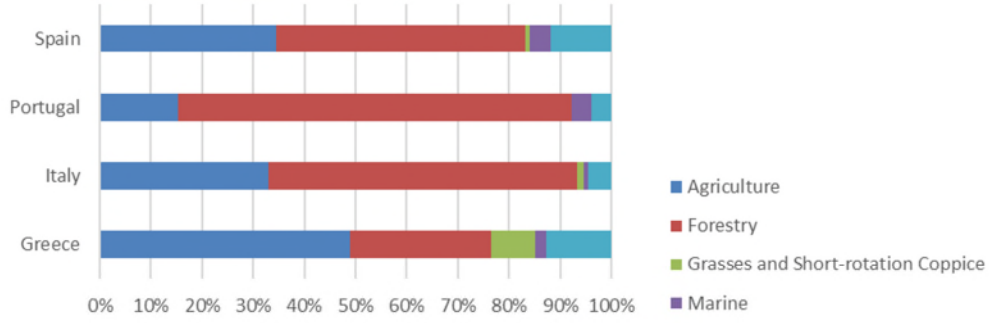
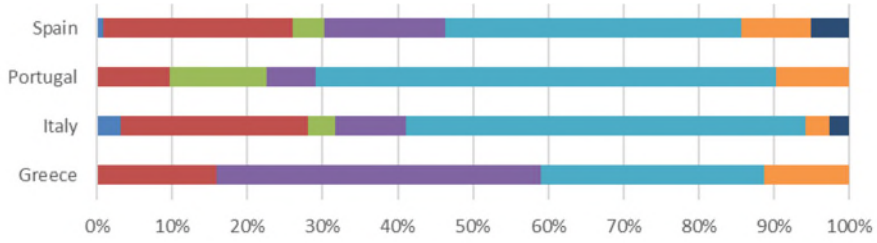
percentage of feedstock originating from the marine and grasses and short-rotation coppice industries is much lower (Figure 12). Portugal differs from the other countries, in fact forestry-derived feedstock dominates (i.e. is used in more than 50% of biorefineries in the country) as the same percentage of Finland and Sweden. Marine-derived feedstock (like fish oil and macro/micro-algae) is employed by a relevant number of facilities in Spain (5 plants), also waste-derived feedstock is especially represented in Spain (10 plants).



	Greece	Italy	Portugal	Spain
Agriculture	48,94%	32,88%	15,38%	34,45%
Forestry	27,66%	60,36%	76,92%	48,74%
Grasses and Short-rotation Coppice	8,51%	1,35%	0,00%	0,84%
Marine	2,13%	0,90%	3,85%	4,20%
Waste	12,77%	4,50%	3,85%	11,76%

Figure 12. Share bio-based industry facilities by feedstock origin in Southern Europe (2020). Source: Datam JRC, European Commission.

Figure 13 shows the percentage of bio-based industry facilities based on the product class they generate. There is a wide variety of products obtained from biomass, but the strongest industry is the pulp and paper sector following by chemical sector. On the other hand, the amount of biomethane produced in the bio-based industry facilities of the southern macro-region is low.



	Greece	Italy	Portugal	Spain
biomethane	0,00%	3,13%	0,00%	0,84%
chemicals	15,91%	25,00%	9,68%	25,21%
composites and fibres	0,00%	3,57%	12,90%	4,20%
liquid biofuels	43,18%	9,38%	6,45%	15,97%
pulp&paper	29,55%	53,13%	61,29%	39,50%
starch&sugar	11,36%	3,13%	9,68%	9,24%
timber	0,00%	2,68%	0,00%	5,04%

Figure 13. Share bio-based industry facilities by product class in Southern Europe (2020). Source: Datam JRC, European Commission.

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3.1.2.2 Economic relevance

In the southern macro-region, there are 4.6 million **people employed** in several sectors that contribute to the bioeconomy. They represent the 27% of the employed individuals in the bioeconomy within the EU-27. The sector with the highest number of employees is agriculture (2.35 million), followed by the food and beverage sector (1.19 million). Other relevant sectors include "bio-based chemicals, pharmaceuticals, plastics and rubber (excl. biofuels)" (111.99k).

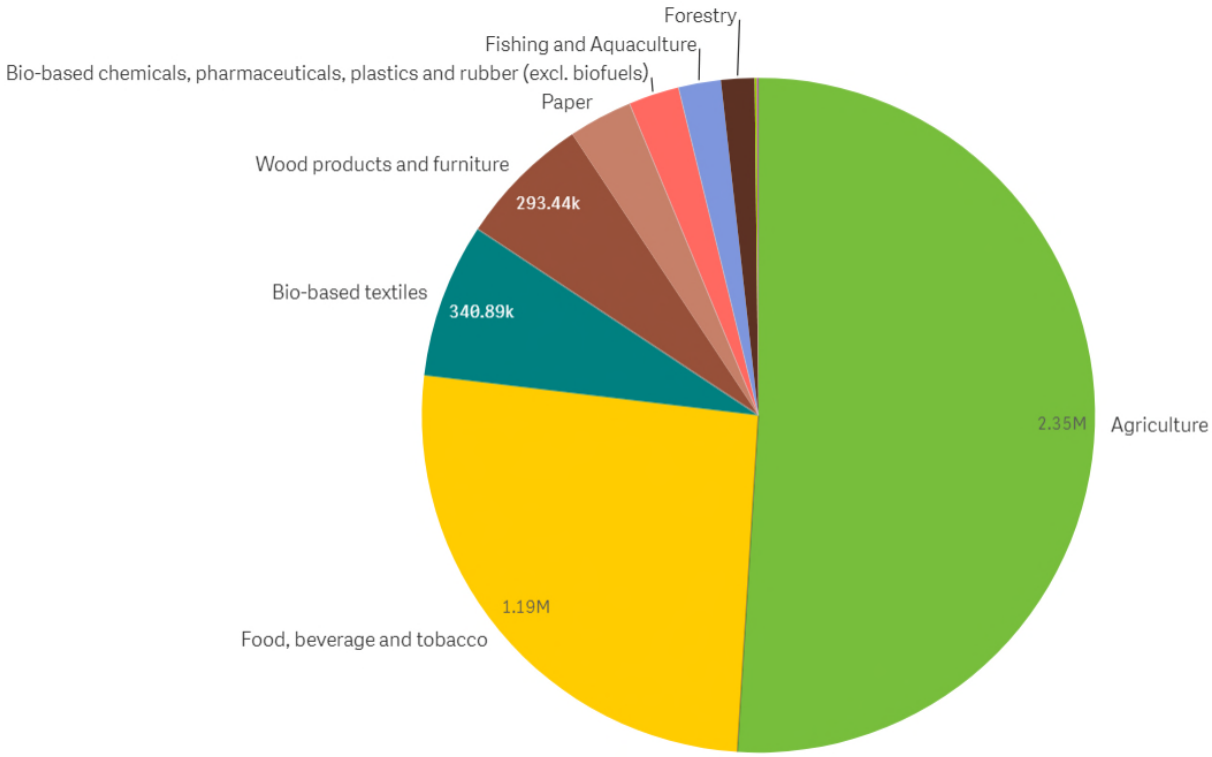

Figure 14. People employed per bioeconomy sector in Southern Europe (2020).
Source: Datam JRC, European Commission.

According to data from last years (Figure 15), the number of employees in these sectors remains constant.

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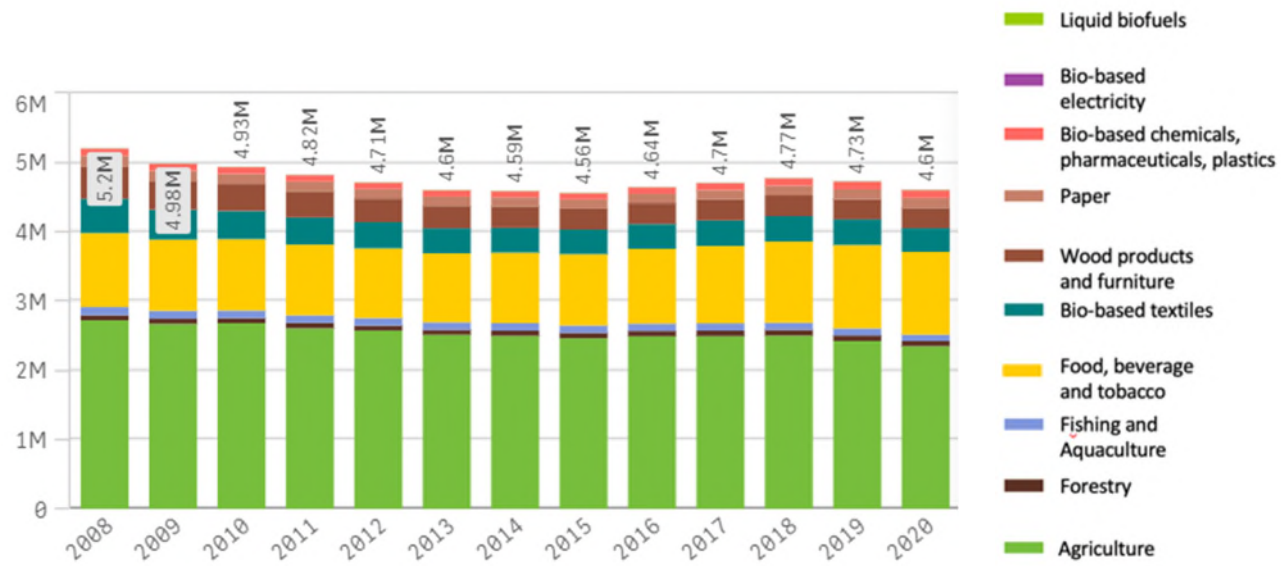

Figure 15. People employed per bioeconomy sector in Southern Europe (2008-2020). Source: Datam JRC, European Commission.

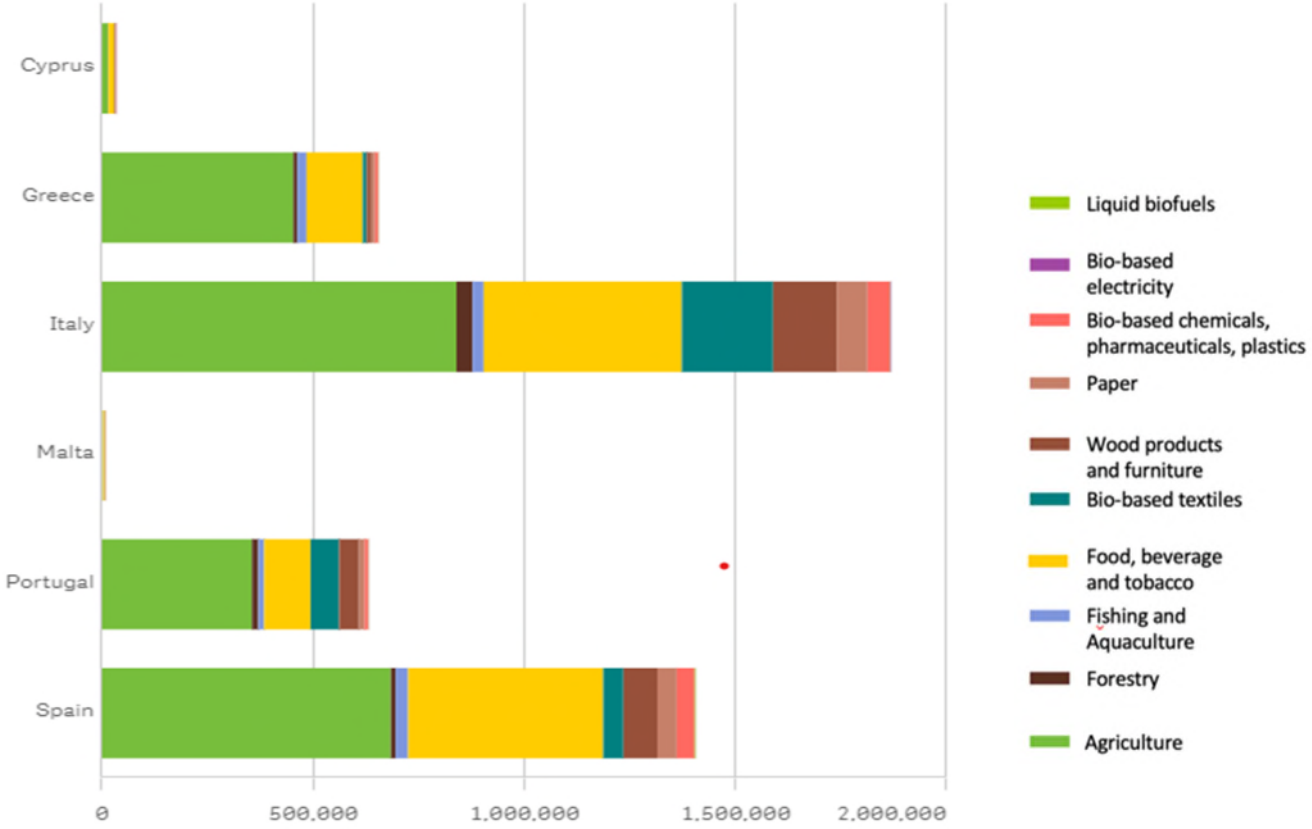

Figure 16. People employed per bioeconomy sector and per country in Southern Europe (2020). Source: Datam JRC, European Commission.

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Figure 16 shows the number of employees' per-sector in each country of the Southern macro-region. Obviously, the amount is proportional to the number of inhabitants of the country. However, it is noted that within the bioeconomy sector, in all of these countries the sector with the most employment is agriculture. Besides, the **added value of biomass** produced in Southern Europe it is EUR 183 million, higher than the European average. The sector with the highest added value of biomass is agriculture, followed by the food and beverage sector. Other relevant sectors include pharmaceuticals, plastics, and textiles.

Figure 17. Value Added in Southern Europe (2020).
Source: Datam JRC, European Commission.

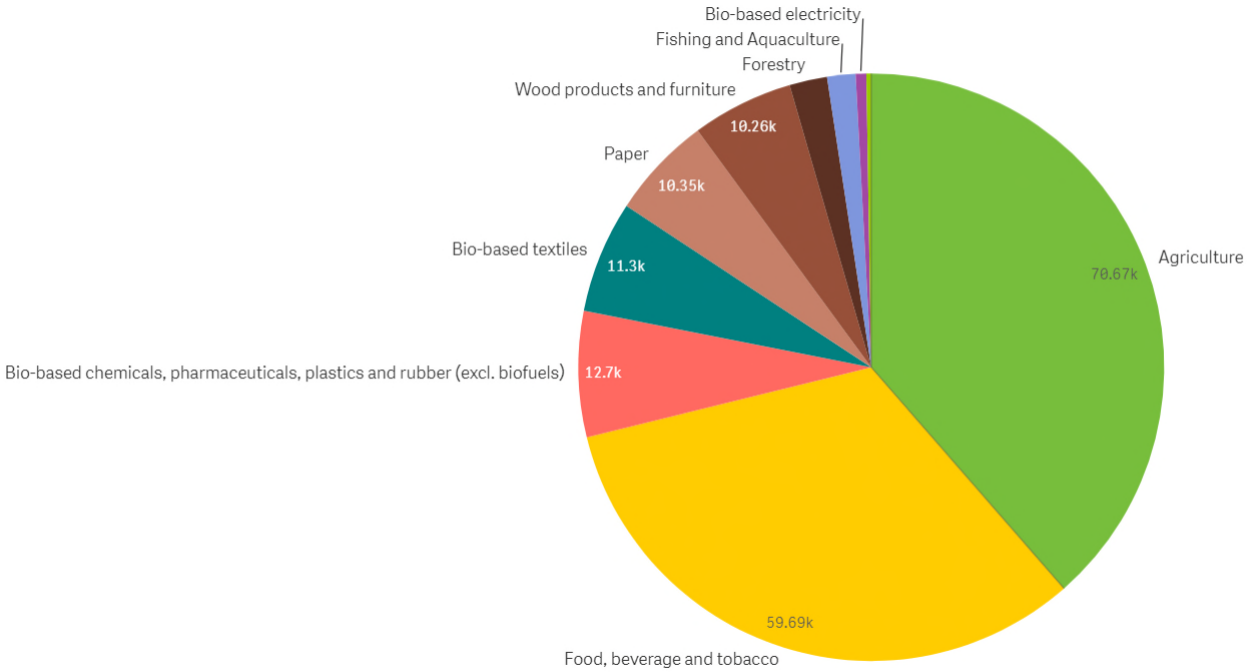

Figure 18. Value Added per bioeconomy sector in Southern Europe (million €) (2020).
Source: Datam JRC, European Commission.

According to data from last years (Figure 19), the value added data, while remaining almost constant, exhibit a brief upward trend thanks to the upward trend in the liquid biofuel and bio-based electricity sectors. However these sectors still represent a small percentage of the value added compared to sectors such as agriculture and food, beverage and tobacco.

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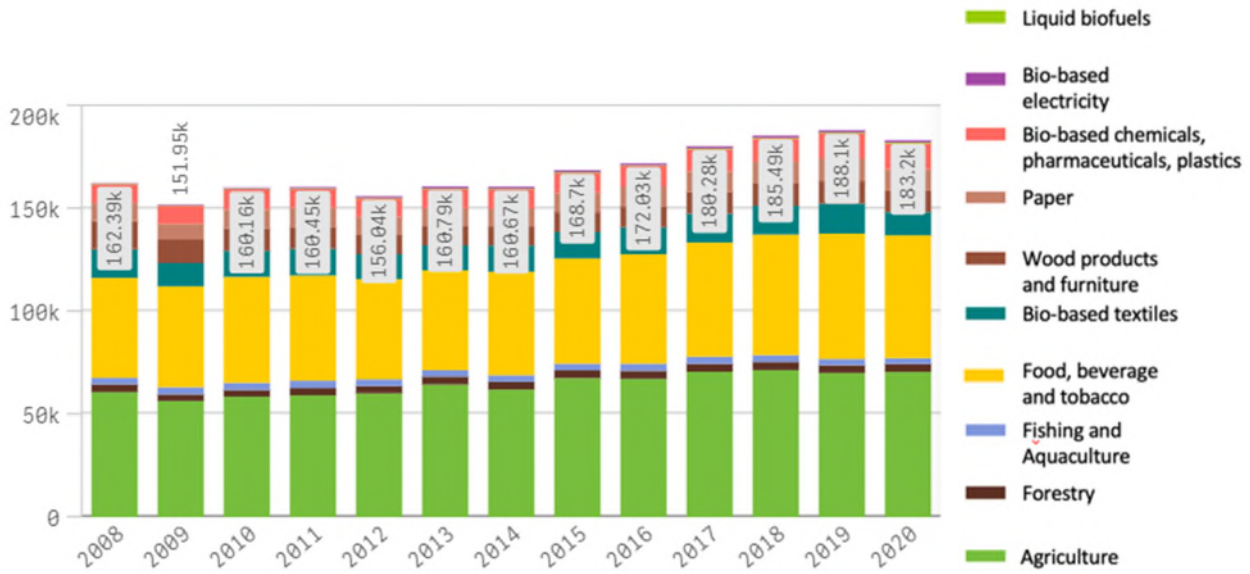

Figure 19. Value Added per bioeconomy sector in Southern Europe (million €) (2008-2020). Source: Datam JRC, European Commission.

- After having closed 2020 with a 2.6% drop in the value of output, in 2021 the Bioeconomy recorded a rebound in output of 10.6%, spread across all sectors, fully recovering the lost ground and positioning itself at levels higher than pre-pandemic levels of around EUR 26 billion. After a first quarter of 2022 still characterized by a good development, the outbreak of the war in Ukraine made the scenario much more complex. Rising costs and difficulties in supplying inputs, especially energy but also agricultural inputs, will have a significant impact on some sectors of the Bioeconomy (agriculture, fishing, paper and paper products).
- It is noted that within the bioeconomy sector, in all of these countries the first sector by relevance is agriculture followed by industry agri-food (food, drink and tobacco). This shows how the bioeconomy in Southern MR countries is more specialized in sectors that generate less added value (lower in agriculture than in the agri-food industry).
- However, the evolution is worse than the European average. Since 2008 a significant drop in the added value generated by bioeconomic sectors is also observed. These data show that it is required a greater effort in these sectors to be able to reach the pace of European growth.

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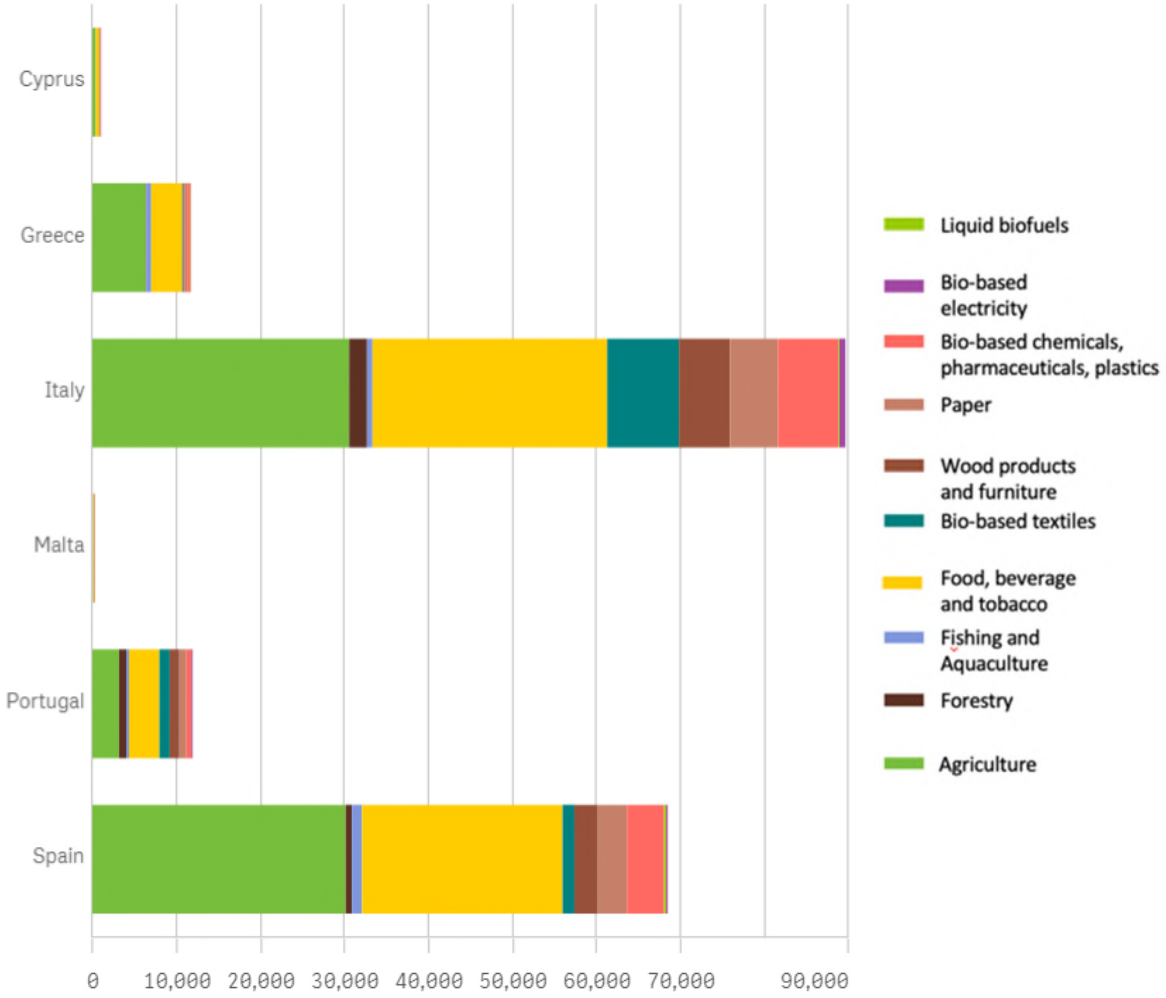

Figure 20. Value added created by bioeconomy sectors in Southern Europe per country in 2020 (in million €).
Source: Datam JRC, European Commission.

Concretizing in the SR countries, Italy and Spain created the most value added in the Region. They are followed by Greece and Portugal and finally, by Cyprus and Malta. So, the value added is directly influenced by the country's surface and the economic activity. Finally, in the selected countries the highlight sectors are agriculture followed by industry agri-food (food, drink and tobacco).

3.1.3 Actors

The overall framework of actors involved in the bioeconomy implementation and application in the countries of the southern macro-region is quite homogenous. Although there are differences between the countries analysed, the bioeconomy key players belong to the major sector, the industrial one.

3.1.3.1 Academia, Research and Development

There are several academic institutions (universities) or institutions well connected to the universities in Spain (e.g. BioEcouva), Italy (e.g. National Research Centre) but also in Greece (e.g. the iBO institute for

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Bio-economy and Agri-Technology) and Portugal (Interdisciplinary Centre of Marine and Environmental Research at the University of Porto (CIIMAR-UP)) that are relevant for research and development (R&D) in the field of bioeconomy. These institutions are known for their contributions to various aspects of the bioeconomy, including agriculture, biotechnology, environmental science, and more. Collaboration among these institutions, along with industry and government entities, plays a crucial role in driving innovation and technology transfer in the field of bioeconomy.
Research in bioeconomy, especially in Spain and Italy, encompasses both basic and applied aspects, reflecting the multidisciplinary nature of this field. Bioeconomy focuses on the sustainable utilization of biological resources for the production of food, energy, materials, and other products, and this breadth is reflected in the research approach.
Some of the notable academic institutions have active research in bioeconomy, but also R&I institutions with a dedicated area to the bioeconomy, some examples in Italy are the Department of Bioeconomy of CREA, The Council for Agricultural Research and Economics or the institute of Biology, Agriculture and Food Sciences Department CNR, the National Research Council of Italy. For instance, in Spain some examples are the CEDR (Renewable Energy Development Centre) and CDT (Centre for Technological and Industrial Development).
Moreover, due to the strong commitment with the agro-food sector, it has been developed a common vision of which could be the knowledge and skills to improve the employment in the bioeconomy sector as macro-region.
On that issue an interesting example of education model in bioeconomy promoted in this southern macro-region is the RELIEF Erasmus + project that involved Italy, Greece, Cyprus and Portugal that aims to develop and deliver an innovative approach for teaching bioeconomy in farming, by developing specific learning resources addressing HEIs (higher education institutions) students and farming practitioners. HEIs, VETs (vocational education and training), farmer consultants, research institutes, and social partners from Italy, Greece, Sweden, Cyprus and Portugal will deliver a high-quality network within the EU to advance bioeconomy in the farming agenda.
RELIEF will deliver a training needs analysis and develop two curricula in bioeconomy, for HE students, farming practitioners, and farmers to explore the key areas that are critical for the implementation of business models and strategies for bioeconomy in farming.

3.1.3.2 Industry

Both in Italy and in Spain, as the main target of the current bioeconomy strategy is the agri-food sector in terms of economic and rural development, most of the actors involved in promoting the bioeconomy are linked to this sector. Of particular note are the local actors who, in full agreement with the policies issued by the European Commission, manage to activate networks and activities in this area. For instance, some private companies have conducted activities closely related to the agricultural sector, supporting innovation and knowledge.
It can be confirmed the same situation for Greece. In spite of the lack of a strategy for the bioeconomy, the role of industry in bringing out possible directions of development and opportunities for innovation is definitely strong (Skordoulis et al. 2020). Moreover, the weight of industry is further amplified by the strong propensity to create cohesive clusters in all the countries of the macro-region such as CLUBE in Greece.

On the industrial association/cluster's issue there is not a common Southern macro-region actor besides EU institutions, but the main ones are limited to the country specific area.
In Italy it needs to be mentioned as influential bioeconomy industry/business associations Federchimica, Assobiotec, also a founding member of EuropaBio, the European Association for Bioindustries, and of the ICBA, the International Council of Biotechnology Associations. Moreover, Italy, through Federchimica, it

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is a founding member of ALISEI (the Italian National Cluster of Life Sciences) and of SPRING (the Italian National Cluster of Green Chemistry). It is also an ongoing and active participant in the work of the Blue Growth cluster and of CLAN (the Italian National AgriFood Cluster). An optimized tool in this direction is the Italian Circular Economy Stakeholder Platform.
In Spain the activity of clusters and association is aimed to push up the ambition of regional areas to national and European level. For example, the Spanish region of Navarra has a strong agri-food sector and competitive advantages on Biomass Processing, New Ingredients and Renewable Energy. For this reason, the AIN (Industrial Association of Navarra) endorses the regional government´s ambition of making Navarra the centre of the circular bioeconomy at national level (Spain). Moreover, there are also national centres such as the National Agrifood Technology Centre (CNTA) and the National Renewable Energy Centre (CENER) or AseBio (Spanish Bioiondustry Association), that promote industrial activity in the field of bioeconomy. Besides, “
The Biodiversity foundation” stands out for its role of dialogue with the private sector with the aim of promoting economic development that integrates biodiversity conservation.
In Portugal, the BLUEBIO ALLIANCE (BBA) is an association founded in 2015, which represents a wide variety of players in the marine bioresources and blue biotech value chain, ranging from raw material producers, R&D units, biotech SMEs, transforming centres and manufacturers, public sector & governmental entities, support companies and final consumer product developers. BBA does not directly supply marine bioresources but seeks to support and enhance the value chain of the latter and identifies four key areas of actions.

3.1.3.3 Civil Society

For civil society, bioeconomy issues are related to environmental protection and conservation activities. But, in the southern macro-region there is a lack of NGOs as the number of NGOs active in the bioeconomy area is really small especially for Cyprus and Malta.
Several NGOs existing in the southern macro-region have a special focus on the blue-bioeconomy. One example is Sea Shepherd Italy with mission on the hampering illegal fishing.
“SDG4MED – Sustainable Development Goals for the Mediterranean” is an NGO observatory of sustainable development goals (SGDs) for the Mediterranean.
It was established in early 2020 as a joint initiative of Fondazione CS MARE (Italy) and Fundacion Philippe Cousteau (Spain). It recently evolved into an Association and incorporated the managing staff and knowledge base of Fondazione CS MARE. As a result, its field of activities include maritime logistics, sustainable tourism at sea, shipbuilding, marine resources (fisheries, energy from the sea, biodiversity), agriculture and renewable energies, urban logistic and transport safety as well as digitalisation as a mean to achieve decarbonisation. Entirely financially supported by its members, its HQ are based in Catania (IT) and, as of as March 2020, it operates in Italy, Spain, Portugal in the macro-region analysed.
Finally Greenpeace and Sea Sheperd’s have a relevant role as policy maker over the world in the defence of environment even if are not directly involved in bioeconomy issue.
In Greece the majority of the NGOs are related to climate justice and green transition for instance, EKO Greece, has to be mentioned as the Entrepreneurship and Social Economy Group. EKO Greece is a Non-profit Organization seated in Athens, Greece, working in the field of youth empowerment, cultural integration and sustainable development. Also, Common Ground in Greece is an interesting reality as they build a community platform for the strategic cooperation to solve the issues related to green economy transition.
For what concern Malta and Cyprus no relevant or active NGOs in the bioeconomy have been detected.

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In general, in the southern macro-region there is a lack of awareness of the possibilities offered by the bioeconomy in implementing current systems on the part of civil society as well as industry, perhaps due to a lack of knowledge of the specific issues to be implemented. Many times the related data shared with civil society is fragmented or misleading, causing a misunderstanding of the context and an inability to guide activities.
In this sense, the role of NGOs is crucial in the dissemination and communication of both problems and solutions offered by the bioeconomy. There are some points linked to the education of citizens that still need to be implemented such as awareness of environmental challenges.

3.1.4 Bioeconomy Policies in the Southern Macro-Region

For Greece, Malta and Cyprus, there is a general lack of policy documents in the MR for the bioeconomy. This is in stark contrast to Italy and Spain, but recently also to Portugal, where have been produced several references and sources on the bioeconomy policies (the national strategies itselves). However, Greece, Malta and Cyprus have Plans on Circular Economy.
The bioeconomy strategies aims to boost economic activity and improve the competitiveness and sustainability of the productive sectors linked to use of biological-based resources. These strategies seek to promote the generation of knowledge and its use for the development and application of derived technologies, through collaboration within the science and technology system and both public and private entities.
The national bioeconomy documents are focused on the production and use of biological resources and actions related to primary sector are seen as the most significant ones. The primary sectors (especially agriculture) and bioindustry (in particular the food industry) are included in all strategies analysed, while other such as energy are present in a large majority.
In addition, most strategies include actions or measures specifically targeted at rural areas. Moreover, biorefineries are mentions in some of the strategies but it is not a priority issue.
A few countries emphasize additional specific strengths; for example, the Italian Bioeconomy strategy focuses on the valorization of secondary raw materials on a local basis with the involvement of all players in the supply chain to overcome current criticalities and design a more sustainable future (Fava et al.2021). Italy today boasts leadership in the field of the Circular Bioeconomy, which has been achieved through the integration of green chemistry and agriculture, with the construction of an integrated supply chain for bioplastics and biochemicals. This platform can boast world-first technologies capable of accelerating the ecological transition by replacing chemistry that is less and less economically and environmentally sustainable.
In Spain, agriculture and forestry are the most significant bioeconomy industries. The revaluation of agri-food industry derivatives allows the development of another economic sector. Using them as raw material and through biological, physical, chemical, or thermochemical processes, it could be produced various biomaterials (bioplastics, lubricants, etc.) as well as bioenergy (advanced biofuels or other energy uses of biomass). In addition to bioenergy, other sectors such as chemicals, pharmaceuticals and other materials of biological origin are gaining importance. (Esteban & Sanz, 2021).
Moreover, Spain and Italy have elaborated Bioeconomy Action Plans, based on the strategy, but current implementation appears to be limited.
Besides Portugal, Greece, Malta, and Cyprus have a high coastline surface so these countries give great importance to the marine sector.
Therefore, Portugal is focusing on the implementation of the blue economy. By the end of 2020, EUR 23.9 million of EMFF (European Maritime Fisheries and Aquaculture Fund) support was committed to 114 operations related to the blue bioeconomy which were financed under shared management. In Portugal were oriented to producing essential oils from marine plants.

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Policy Instruments

Several policy instruments focus on primary production sectors (agriculture, forestry, aquaculture) and consist of subsidies for the promotion of forestry bioeconomy or innovative projects in the agri-food and forestry sector. This in in line with key responsibilities and focal points of the national bioeconomy strategy in Spain, where the Spanish Ministry for Agriculture, Food and the Environment has the leading role for the bioeconomy in Spain and prioritizes food and primary production, encompassing agriculture, forestry, and fishery. On the other side, the national focal point include also policies on chemistry and bioenergy[3]. A national lighthouse example is the National Food and Agriculture and Forestry Innovation and Research Programme that has been set up by the Spanish government in 2015. This inititative was co-funded by the Spanish government and Horizon 2020. Moreover, with the Support Plan for Entrepreneurship in Local Bioeconomy in Depopulated Areas, the Spanish government, which primarily focus on bioeconomy development in rural areas between 2023 and 2026. Also on the Spanish regions different policy instruments have been established. Regions, such as Castilla y Leon or Andalucia have robust bioeconomy programs, including instruments like grants for research projects, services for knowledge transfer to SMEs or investment support schemes for entrepreneurs. As outlined in the national Italian bioeconomy strategy it is necessary to improve the integration of funding programmes in a common strategic framework, taking into account financial mechanisms to ensure prolonged stability of bio-investments[4]. Therefore, the Italian strategy outlines the combination of European, national and local funding programmes. On the European level it highlights the Cohesion Policy Funds or the European Agricultural Fund for Rural Development, whereas on the national level, different funding schemes have been developed. In Italy there has been an increasing shift towards demand-side policies. The Action Plan chase the ambition to grade better regulatory framework to the bioeconomy in Italy (e.g.development of legislative faremwork to promote certain bio-based products).

Moreover, already earlier some demand-side instruments have been implemented in the form of directives, orders or laws. For instance, the Ministry of Environment and Land and Sea Protection of Italy signed the law 145/2018-Tax credit for purchases of products from recycling. Although this regulation and fiscal measure is not directly dedicated to the bioeconomy, some relations exist, as it has a clear focus on waste and bio-materials. Portugal with its rich marine resources has invested recently much more in the blue bioeconomy. This is very much in line with the strategic focus of the Portuguese National Ocean Strategy and its action plan, which outline Portugal’s ambition to make Portugal one of the major and leading maritime nations.[5] The country has set up 2 programmes recently, which are directed to promote the sustainable development of the blue bioeconomy sector. Mar 2030 allocates a budget of 539.89 million euros that will be invested in fishery and aquaculture. For the modernization of the sector, the programme is built on four main areas: Sustainable fisheries, innovative aquaculture, processing of marine products, and protection of marine biodiversity. Furthermore, Compete 2030, the other programme, has a broader scope with a focus on boosting innovation and the digital transition as well as the climate transition, human capital and business competitiveness.[6]

In general, it can be summarized that in Southern Europe only few policy instruments exist that have a dedicated link to the bioeconomy, but many measures aimed at key environmental policy issues. In Spain and Italy, the most policy instruments have been implemented, but according to interviewed experts not much action has been taken in Spain and Italy to really implement the strategies. In countries of small size, such as Malta lack consistent and progressive bioeconomy development and have not yet developed pronounced bioeconomy instruments.

[3] https://biooekonomie.de/themen/laenderdossiers-weltweit/spanien
[4] https://cnbbsv.palazzochigi.it/media/1768/bit1_en.pdf
[5] https://biooekonomie.de/en/topics/in-depth-reports-worldwide/portugal
[6] https://b2e.pt/portugal-invests-in-support-for-the-blue-bioeconomy-sector/

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Table 4 Bioeconomy and circular economy policies in Southern MR

Country	Perspective	Bioeconomy Strategies (year of publication)	Strategy Goals	Target Sectors
Spain	Holistic Bioeconomy Development	Spanish Bioeconomy Strategy (2015)	Competitiveness, Economic growth , Bridging gaps between research and economic sectors, Cross-disciplinary education, Rural development, Biological resource management	Agriculture, Food industry, Forestry, Bio-based industry, Bioenergy, Research and Development
Italy	Holistic Bioeconomy Development	Bioeconomy in Italy (2019)	Economic growth, Bridging gaps between research and economic sectors, Alignment of EU, national and regional policies, Technology advances, Cross-disciplinary education	Agriculture, Food industry, Forestry, Bio-based industry, Marine bioeconomy
Portugal	Blue Bioeconomy	Strategic lines of primary production sectors in the context of the development of the national strategy for the sustainable bioeconomy 2030 (2021)	Climate neutrality, Digitalization, Cross-disciplinary education, Rural development, Biological resource management	Agriculture, Forestry, Fishery and aquaculture, Research and Development
Greece	Holistic Circular Economy Development	No, But: Plan on Circular Economy (2018)	Waste management	Waste management and recycling, Sustainable production and consumption
Malta	Blue Circular Economy	No, But: Malta's Sustainable Development Strategy for 2050	Competitiveness, Economic growth, Climate neutrality, Job creation	Green and blue bioeconomy, Digital transformation
Cyprus	Holistic Circular Economy Development	No, But: Plan for the transition to a circular economy (2021)	Waste management, Funding and collaboration opportunities	Waste management and recycling, Sustainable production and consumption

Source: Various national strategies.

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In general, it has been recorded improvements on building a strongest cooperation with Member States and demonstration projects have laid the basis for regional and national bioeconomy deployments, with a focus on less developed countries and understanding of ecological limits of the bioeconomy. However, gaps remain on how to better manage biosphere use to meet environmental and economic requirements in a climate neutral Europe, and how to promote more sustainable consumption patterns to guarantee environmental integrity.
The Spanish, Italian and Portuguese national documents aim to develop and promote horizontal and vertical cooperation at different stages and levels of the value chain. For this purpose, the elaboration process involved the participation of both private and public actors from different sectors related to the bioeconomy. But the approach of horizontal coordination between different institutions seems to be more theoretical than practical. Consequently, the regions of these countries have chosen to develop their own regional strategies to ensure better implementation of the bioeconomy policy.
Analysing the **responsible entities of the bioeconomy policies** in the southern macro-region, the main bioeconomy maker remains the Ministry of Environment in terms of policy making and implementation on the topic in cooperation with other ministries.

Table 5 Responsible entities of the bioeconomy policies in Southern MR

Country	**Institution responsible for bioeconomy policy development**	**Advisory bodies**
Spain	Ministry of Science and Innovation (But the Strategy was created by M. Economy + M. Agriculture)	Spanish Bioeconomy Strategy Management Committee (currently inactive)
Italy	Ministries of the University and Research, the Economic Development, the Agriculture, Food and Forestry Policies, the Environment, Land and Sea	National Biosafety, Biotechnology and Life Sciences Committee
Portugal	Ministry of the Environment	Operationalization Unit of each strategic axis (Consultive Council)
Greece	Ministries of Environment and Energy, Interior, Economy and Development, Governmental Economic Policy Council	Circular Economy Committee of the SBC GREECE
Malta	Minister for the Environment, Energy and Enterprise	Lead Ministry for each target
Cyprus	The Ministry of Energy, Commerce and Industry, Rural Development and Environment	Not develop yet

Source: Own compilation.

Going down to a deeper level of analysis, we can see how in Italy, despite the territorial fragmentation on a regional basis that connotes it, there is a strong management at the ministerial level that has led to the creation of a responsible body, from an arm of the Presidency of the Council of Ministers, the CNBBSV –

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Comitato Nazionale per la Biosicurezza, le Biotecnologie e le Scienze della Vita, (National Biosafety, Biotechnology and Life Sciences Committee).
The frame changes as we move to Spain, where bioeconomy strategy remains in the hands of Ministries. However, there is a strong presence of regional governments.
In Portugal, is led by The Portuguese Environment Agency, although there are also regional coordinators.
For the other countries of the Southern Macro-region, lacking a dedicated bioeconomy strategy, the main bioeconomy maker remains the Ministry of Environment in terms of policy making and implementation on the topic in cooperation with other ministries.
In relation to **regional policies**, in Table 6 there are some examples in Spain, Portugal and Italy. Nevertheless, there are other strategies additional to the bioeconomy plan such as the "Forest Biomass Regional Strategy" in the Spanish region of Castilla La Mancha.

Table 6 Regional Strategies in Southern MR

Country	**Region**	**Strategy Goals**
Spain	Castilla-Leon	Competitiveness Innovative territory Free of carbon emissions Regenerative model Efficient use of natural resources
Spain	Andalucia	Economic growth Sustainable exploitation of resources Promotion of renewable energies Production of new value-added products
Spain	Catalonia	Economic growth Sustainable development Promotion of biological resources Promotion of renewable processes
Portugal	North Region	Agri-food sector
Portugal	Lisbon and Tagus Valley Sector	Preservation of local biodiversity and natural resources Responsible production and consumption Reducing the extraction of material and energy resources Life cycle of products
Portugal	Alentejo	Access to funding resources Competitiveness Sustainable and cohesive development
Italy	Puglia	Primary production (agriculture) Circular Economy Innovation Waste management
Italy	Veneto	Sustainable agriculture Energetic efficiency New materials Bioenergy

Source: Own compilation based on regional strategies.

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Regarding policy instruments, some grants are available for bioeconomy related projects, but there is a disparity of financial support depending on the geographical size of the country or population density as the main factors. In addition, EU grants is the mainly financial resource for cross-sectoral collaborative projects among EU countries.
An example of a policy instruments to develop bioeconomy action is the "Support Plan for Entrepreneurship in Local Bioeconomy in Depopulated Areas" between 2023 and 2026 in Spain. Besides, Spanish regions like Castilla y León or Andalucia have a robust Bioeconomy program that includes featuring instruments such as grants for research projects, the provision of services related to knowledge transfer to SMEs looking to carry out pilot projects or obtain prototypes that involve research valorisation or transfer of results. Additionally, there are investment support schemes for entrepreneurs, as well as accelerators or financial launchpads serving as platforms for project funding. Something similar happens in other Spanish regions.
In Greece an incentives law has been established that includes incentives and aid to SMEs to promote the green economy and digital transitions. However, Portugal gives fiscal incentives for foreign investors to invest in the national blue bioeconomy. Moreover, there are also incentives for promoting circular economy processes in SMEs.

3.2 Policy process and policy coordination in selected MR countries

This section will address the political coordination and participation of different stakeholders in the development and coordination of bioeconomy strategies in the countries of the southern macro-region.
As already highlighted in the analysed several countries in the macro-region still have not a dedicated policy for the bioeconomy.
However, the main challenge to implement the bioeconomy development process and coordination among the countries can be addressed to the overall macro-region.
This concern, ensure coordination by a dedicated body to identify and mitigate divergences between sectoral priorities and policies, including external and internal policies, and promote mutually supportive actions across policy and institutional sectors.
In this sense, the Spanish stakeholders interviewed agree that the elaboration of the Spanish bioeconomy plan was carried out in a coordinated manner with several stakeholders from different areas and sectors related to the bioeconomy. However, its implementation is not progressing as planned due to a lack of interest and proactivity among stakeholders, as well as the bad coordination among the institutions responsible for strategy development. In 2016, for the development of the bioeconomy strategy launched by the Ministry of Economy, there was good coordination among various ministries, institutes, technological centres, and private companies. However, in 2018, there was a change of Government, and the Bioeconomy Plan became the responsibility of the Ministry of Science, for which the plan is not a priority, causing its development to stagnate. Nevertheless, in response to this situation, some Spanish regions have decided to implement their own Bioeconomy plans. However, their development is carried out individually in each region without considering the actions of the rest of the country.
In this term, an example of good practice is Italy, because it has demonstrated that integrate decision-making processes are valuable. In 2016, the Italian Bioeconomy Strategy was prepared though a wide stakeholder consultation. Two years later, the Presidency of Council of Ministers asked for an update, so different Ministries and other institutions (see Table 5) have worked in a coordinated way to improve this strategy (Bieconomy in Italy (BIT II)).

3.2.1 Characterization of horizontal coordination between different ministries/departments

In the countries of the southern macro-region, there is no single organization responsible for the development and implementation of bioeconomy measures. Therefore, cooperation and coordinated efforts among different actors are essential. Ministries and public institutes selected to participate in related matters

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play a significant role in the country's bioeconomy. In fact, the Ministry of Economy and the Ministry responsible for the primary sector stand out in each country.
Both in Italy and Spain, previously to the development of the National Bioeconomy Strategy, the government initiates a process to form a working group composed of ministries, national innovation institutes, and public administrations closely involved in bioeconomy-related tasks. Subsequently, a coordinating ministry is determined, which is supported by other ministries and agencies.
The group responsible of developing the National Strategy is complemented by the participation of experts from the public and private sectors, primarily related to the primary sector and R&D tasks. The goal is to integrate their opinions and interests.
For instance, in Spain, the information was obtained from 240 stakeholders form different regions and sectors. After that the document was writen by the commission headed by the National Institute for Agricultural and Food Research and Technology (INIA).
In Italy and Spain, different regions of the country use this national strategy as a framework to develop their own contextualized plans: more specific to the needs of each region with designed initiatives. Some regions directly reference the national legislation.
To ensure the proper development of the national strategy and to improve the social, political, and administrative environment of the bioeconomy, support, promotion, and cooperation structures were organized. This applies to both central and regional administrations and their relationships with various stakeholders in science, economics, and society as a whole. The main objectives are[7]:

1. Establishment of a Monitoring Group for the Strategy with representation from Ministries and regions: its goal is to monitor the strategy, coordinate the implementation of new measures in this field, and promote cooperation among different administrations. For instance, the Italian Strategy has been updated by a group integrated by the Ministry for Economic Development, Ministry of Agriculture, Food, Forestry and Tourism, Ministry of Education, University and Research, Ministry of the Environment, Land and Sea, XI Committee of Italian Regions and Autonomous Provinces and the Italian Technology Clusters for Green Chemistry SPRING, Agri-Food CLAN and Bluegrowth BIG.
2. Proposing new measures and actions to improve the bioeconomy system.
3. Implementing and coordinating international initiatives to boost the bioeconomy in Mediterranean basin. An example is the initiative Blue Bio Med. It forms a group of 13 European countries on the northern shore of the Mediterranean, working together for sustainable growth in the region with a focus on the blue bioeconomy.
4. Guaranteeing the policy coordination among public authorities, with particular attention to the implementation of European policies addressed to waste prevention and minimization, in order to encourage full exploitation of the resources and circularity.
5. Technological Networks Group responsible for continuous market analysis and identifying potential opportunities for bioeconomy and public-private collaboration for innovation.

Unfortunately, horizontal coordination among Ministries and political departments results in the blurring of responsibilities and tasks of each one in the development of the bioeconomy strategy. As a consequence, even if the document is coherent, the expected measures and objectives are not put into practice, and therefore, the progress of the bioeconomy remains blocked.

[7] Information from Spanish Bioeconomy Strategy, Italian Bioeconomy Strategy and interviewee.

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3.2.2 Role of stakeholder involvement in bioeconomy policy making

In order to encompass the interests of all stakeholders involved in the country's bioeconomy, the working groups responsible for drafting and developing the Bioeconomy Plans of Italy and Spain respectively promotes the integration of experts from both the public and private spheres.

The participants were:

- In Italy: Presidency of Council of Ministers, Ministry of Education, University and Research, Ministry for the Economical Development, Ministry of Agriculture, Food and Forestry, Ministry of the Environment, Committee of Italian Regions, Agency for territorial cohesion, Italian Technology Clusters for Green Chemistry and Italian Technology Cluster for AgriFood.
- In Spain: Ministries of Economy and Agriculture, Food and Environment; State Secretary for Research, Development and Innovation (SEIDI) and dependent entities (INIA, CDTI, CIEMAT, CSIC); Industry associations such FIAB, AseBio, CEOE; Institutes such a IDAE and other societies such a SEBiot.

Moreover, public consultations were held in both countries. Proposals were received from various actors and different regions of the country: companies and organizations representing agricultural, forestry, fisheries, food, chemical, and energy sectors, consumer organizations, unions, and NGOs related to the objectives, opportunities, and challenges of the bioeconomy.
The establishment of clusters and interest groups among companies, cooperatives, communities, and research groups in specific areas aims to promote multidisciplinary collaboration in the search for innovative solutions, as well as the contribution and collection of suggestions from any citizen for evaluation and, if appropriate, incorporation into the system. Within the public realm, consideration is given to businesses and institutes of research and innovation, agriculture and environment, and industry. On the other hand, in the private sphere, participation is ensured from a representative of the food industry and the business sector, as well as representatives from technological platforms and associations.
The participation of several stakeholders involved in the bioeconomy has ensured that the interests of both the public and private spheres have been taken into account in the development of the strategy. This factor was necessary to achieve stability in the sector that would not be threatened by changes in government or legislature.
However, in reality, it seems that the bioeconomy strategy have remained more in theory than in practice.
A good proposal to follow up the bioeconomy strategy and to ensure that the different actors express their interests and influence policies is the one proposed by Spain. When the strategy was published in 2016, a group known as the "Spanish Bioeconomy Observatory" was created to brought together representatives of the Ministries involved and the regions. At the same time, a social dialogue programme was designed around the bioeconomy in which representatives of productive sectors, business groups, research groups, consumers, trade unions, NGOs and other stakeholders could expressed their views and proposals. Unfortunately, this initiative was only carried out for a short time and is currently stalled, as is the implementation of the bioeconomy strategy.
An example of good practice is the fact that some regions have their own bioeconomy strategy, based on the national one but adapted to each context. This fact facilitates the implementation of actions more effectively.

3.2.3 Dealing with goal conflicts

Despite the high potential Southern Europe is showing for the bio-based economy, the region is also confronted with many challenges. As Southern Europe has shown strong population growth and urbanization in the last century, these trends needs to be taking into account by stakeholders who shape the

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bioeconomy in these countries. Further challenges the region shows are scarcity of natural resources, changing consumption patterns or weak competitiveness. Key natural resources that are necessary for new emerging bio-based sectors, such as water resources are limited and unevenly distributed between regions (Martinez de Arano et al., 2018). All of these challenges might create conflicts of goals, as the perception how to cope with these challenges varies among stakeholders, regions and countries (Martinez de Arano et al., 2018).
The discussion about conflicting goals in the Southern macro-region remains limited as less countries are explicitly addressing them in their strategies. For instance, the Italian bioeconomy strategy is outlining the multiple benefits the bioeconomy could provide for agricultural land. Although it is highlighting the importance of the agricultural sector for rural development, it is not addressing the huge urban-rural inequalities, which can emerge through the bio-based transformation of rural areas. However, competition of energy and food from agricultural products on regional level exist (Gissi et al., 2011). Besides the numerous benefits the bioeconomy can offer, negative implications or environmental and/or social conflicts have not been at the focus. According to experts, conflicts exist, however, on the development of rural areas, poorly forestry exploitation or abandonment of lands (ShapingBio, 2022).

Another interesting observation is that in Spain the media coverage is very limited regarding bio-based sectors, such as forest bioeconomy. The media seems to have little interest in forest resources as a potential solution for sustainable energy production (Sanz-Hernández, 2020). This lack of interest can be seen as a sign that bioeconomy in the public is not very much debated and therefore conflicting issues certainly not really communicated. However, some associations and lobbying organizations warned about mismanagement of forests and the need for reforms in the forest sector with public participation (Sanz-Hernández, 2020). Negative media perceptions on the bioeconomy remain therefore scarce. It can be also stated that the private sector and civil society organizations (NGOs) are not really participating in the public discourse about the bioeconomy.
Moreover, as chapter 3.1.3.3 on civil society have shown, less civil society organizations (NGOs) exist, which could question and criticize existing strategies for not addressing these goal conflicts. And the existing are very much focused on blue bioeconomy in the Mediterranean and seem not to be addressing bioeconomy and related goal conflicts.

3.3 Applied R&D and Technology Transfer

In the context of the bioeconomy, technology transfer is particularly relevant and currently in the southern macro-region is promoted and support mainly by Spain and Italy.
Spain and Italy have a range of institutions, organizations, and programs that promote the transfer of knowledge and technologies in this field.
In the field of Research there are many universities and research centres that are involved in studies related to the bioeconomy, developing technologies and knowledge that can subsequently be transferred to industry and other sectors. For example, BioEcouva in Spain is the Bioeconomy Research Institute of the University of Valladolid and it has different research lines based on bioeconomy. In Greece stand out IBO (Institute for Bio-economy and Agri-Technology) which is focused on the scientific field of agri-technology and sustainability assessment of bio-production activities.
But companies and industry play a crucial role in technology transfer, as they are the main beneficiaries of the application of new knowledge and technologies in the production and marketing of bioeconomic products.
There are technological platforms which encourage technology transfer and collaboration among different stakeholders in the sector, including businesses, research centres and public administration. An example from Italy is SPRING, a national platform which brings together over 100 of the main stakeholders of the

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value chain in bio-based chemistry, from farmers to entrepreneurial associations. In Spain, The National Centre for Technology and Food Security (CNTA) is a private non-profit association whose purpose is to contribute to improving the competitiveness and quality of the food sector.
It has been noted that technology transfer is driven primarily by collaborative projects, both at national and European level, between different actors in the value chain. In fact, Spain and Italy participate in international projects and collaborations in the field of bioeconomy, which can also contribute to technology transfer on a global level.
Funding for these projects comes mainly from the European Union, but there are national entities such as the Centre for Technological and Industrial Development (CDTI) in Spain or Rete Nazionale Acceleratori and other governmental organizations providing funding and support programmes for bioeconomy research and development projects, facilitating technology transfer.
In summary, in Italy and Spain technology transfer in the bioeconomy is moving forward, with diverse actors and mechanisms involved in the dissemination and application of knowledge and technologies related to the sustainable use of biological resources but there are still several challenges for both countries for the implementation and for the transition to bioeconomy systems. For example, the majority of these platforms are private non-profit, so it is missing the participation of institutions.
In the other countries of the southern macro-region the frame is different because technology transfer and applied R&D are still an area to be defined.
In Greece, faculties dedicated to the bioeconomy have been springing up only in recent years, while in Cyprus and Malta, bioeconomy-related topics are dealt with marginally within other degree courses mainly dedicated to agriculture and biotechnology.

3.3.1 Policy Instruments for Applied R&D and Tech transfer in selected MR countries

In all Southern MR countries there are initiatives to implement Technology Transfer and R&D. These initiatives are focused on solving the poor translation of knowledge generated in research organizations into the productive fabric.
The following map (fig.18) of Europe shows how R&D investment increased above the European average in Portugal, Spain, Cyprus, and Malta between 2020 and 2021. In addition, Greece and Italy also show an increase in investment.

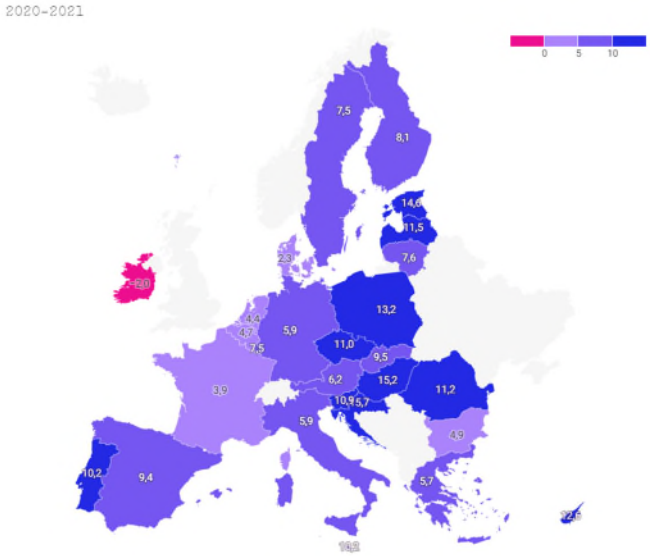

Figure 21. Evolution of R&D investment in Europe (2020-2021).
Source: COTEC Foundation.

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In Spain, the INNVIERTE **funding program** promoted by CDTI stands out. It is framed in the Spanish Science, Technology and Innovation Strategy 2021-2027 because is an initiative whose aim is to promote business innovation by supporting venture capital investment in technology-based or innovative companies. In its first programme, more than EUR 390 million was committed to 20 investment vehicles that have invested in more than 240 companies.
Portugal's Agency for competitiveness and innovation (IAPMEI) promotes a wide range of programmes, initiatives and services focus on supporting entrepreneurship, on boosting business innovation and innovation management and promote and on monitoring dynamics of collective efficiency, in particular clusters, collaboration networks and technology transfer. In the field of bioeconomy, the Energy Challenge program stands out, which finances start-ups with innovative projects in the energy sector that help solve existing challenges.
In addition, in Spain, Italy, Portugal and Greece **tax exemptions** are also chosen as a financial tool to enhance the private participation of companies in the implementation of Research and Development projects and/or Investment Plans. For example, there are tax deductions to R&D activities, or, in Greece, the Angel Investor is entitled to an income tax deduction equal to 50% of the capital contributed to eligible start-ups.
Moreover, in order to promote advances in scientific research at the University, it is essential to promote technology transfer centres and incubators.
Technology Platforms are "strategic projects on issues of regional or supra-regional" that fall in a specific area of technological innovation and have the objective of promoting a coordinated and organic set of industrial research and experimental development put in place by different subjects - companies, institutions, universities – and aimed at the pursuit of industrial objectives of short to medium term. Some relevant technology platforms are: the EATIP (European Aquaculture Technology and Innovation Platform), or at regional level the Bioeconomy Technological Platform developed by Piemonte in Italy or BIOVEGEN (Green biotechnology technology platform) or BIOPLAT that includes all the agents involved in the Bioeconomy in Spain.
In Italy, one of the most operational and efficient accelerators is the offer of Consorzio Italbiotec, which forms a cutting-edge start-up innovation ecosystems, companies, universities in biotechnology were cooperation and knowledge exchange trigger growth and sustainable innovation. In addition, there is another interesting accelerator managed by CDP, "Rete Nazionale Acceleratori" (National Network of Accelerators). It is an accelerator called Terra Next that incubates and launches innovative start-ups and SMEs that offer solutions in the sectors of Bioeconomy with attention to the segments of Nutraceuticals, Circulars and Biomaterials and Regenerative Agriculture.
Another best practice in Italy is the Science Park Area of the main initiative in technology transfer and applied R&D for the development of the blue bioeconomy.
It is the national public research organization responsible for managing the campuses of the Science Park Area - the main multi-sectoral Science and Technology Park - in Italy. It continues its mission to contribute to the development of the business sector through innovation and technological research.
They are now part of a coherent territorial model called the "OIS - Open Innovation System", which aims to create a permanent open territorial innovation system that connects all actors and stakeholders operating in a territory. Given its geographical position, the Area Science Park actively collaborates with the Western Balkans (also Greece) in the field of innovation and technology transfer.
Innovation poles are clusters of SMEs, large companies and research organisations active in a particular application or technology that respond to the widely disseminated national and international model of "Innovation clusters" and/or "Centres of Innovation". They want to promote technology transfer, the exchange of facilities and the exchange of knowledge and skills, according to the approach of the Public-Private Partnership (PPP).

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An interesting case study is in Portugal, the BLC3 Association - Campus of Technology and Innovation, a non-profit association with the role of incubator of ideas and companies. It also supports the development of a Bio and Circular Economy, with a particular focus on the concepts of Biorefineries.
In addition, in Portugal in 2022, The BlueBio Value was born, a new business acceleration and incubation program dedicated to the marine bioeconomy sector. Its aim is to create the right conditions to make Portugal a world leader in the marine biotechnology industry. It supports entrepreneurs with commercially viable projects that use marine resources in a sustainable manner and help address today's major social challenges.
In Greece, the EUR 30 million "Competence Centres" initiative is co-financed by the European Regional Development Fund (ERDF) and national resources. They are structured public-private partnerships aimed at bridging the gap between demand and supply of specialized innovation and technology transfer services in one or more value chains.
Initiatives also exist in the Universities of Cyprus and Malta. For example, in Malta, in 2009, the Office of Knowledge Transfer was created. There, the process of commercialization of research is analysed and the collaboration of the University with industry is addressed. In addition, they have also created the TAKEOFF incubator.
Finally, in recent years, the **Technology Transfer Offices (OTC)** have been an effective tool for improving academic performance in the process of valorization and industrialization. OTC is a real link and often arises directly in the universities themselves. They are also present in the other countries of the macro-region and their activity is not limited to the national level.
However, even though most of the research done at Southern MR is carried out in public research organisations, most of these entities have not yet established structured mechanisms for the commercial exploitation of research results.
The Cyprus University of Technology (CUT) recognizes the need for an intellectual property rights policy. CUT recognizes that the registration and commercial exploitation of intellectual property is often a long and costly process that is justified once a commercial argument for such registration and exploitation is established. In practice, only a small number of works can be commercially exploited in a viable manner, depending on the nature and marketability of the work in question.

3.3.2. Structures and Challenges for Applied R&D and Tech transfer in selected MR countries

There are several clusters, associations and centres along southern MR that promote technology transfer such as the Spanish Bioeconomy Technology Transfer (BIOVEGEN). But these entities are mostly private non-profit.
Currently, there are only a few testimonies concerning study programmes or exchange opportunities for students on the topics of the bio-economy and practical applications of related technologies, but these stop at the educational level.
Moving on critical aspects that disadvantage the development of tech transfer, TTOs as one of the main instruments of support and information in this area needs to be analysed deeply.
At present, even though they are throughout the country, TTOs are subject to numerous criticisms, including the fact that they are undersized, except for a few major universities. Another critical point to highlight is that the level of skills is, on average, inadequate for the challenges required by the role, and that there is a lack of technology transfer managers who are able to be recognised as suitable interlocutors to speak both the language of research and that of business.
And in any case, even when these structures succeed in attracting and training the best talent, the chronic lack of stable resources to devote to technology transfer issues and the lack of long-term vision in terms of career growth, means that there is a very high turnover of personnel and a dry loss of skills to the advantage of the private manufacturing world.

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From the point of view of marketing the activities carried out in universities and research centres it can be mentioned that in Italy, something has been moving. There is, for example, the Knowledge Share Web Platform that can function as a 'showcase' and gateway for the intellectual property of Netval associates. The research university network Netval is a key actor in tech transfer in Italy. Netval brings together 61 universities and 10 public research institutes (including CNR, ASI, Enea, IIT, INFN), whose mission is 'to enhance university research vis-à-vis the economic and entrepreneurial system, public bodies and institutions, entrepreneurial associations and companies, venture capitalists and financial institutions'. Challenges of technology transfer in the bioeconomy in the southern macro-region include:

- **Complexity of Research**. The bioeconomy involves multidisciplinary research spanning areas such as agriculture, biotechnology, and environmental science. Translating complex research findings into practical applications can be challenging.
- **Lack of Collaboration**. Effective technology transfer requires collaboration between research institutions, industry, and government. Ensuring effective communication and cooperation among these diverse stakeholders can be difficult.
- **Intellectual Property Issues**. Determining ownership and protecting intellectual property rights can complicate technology transfer agreements, especially in cases involving joint research efforts.
- **Regulatory Hurdles**. Bioeconomy technologies often intersect with regulatory frameworks related to agriculture, environment, and health. Navigating these regulations can delay or complicate the transfer process.
- **Limited Funding**. While funding programs exist, securing sufficient funding for technology transfer initiatives can be a challenge. Adequate resources are necessary to support the development, protection, and commercialization of new technologies.
- **Cultural and Mindset Differences**. Bridging the gap between academic research and commercial application requires a shift in mindset. Academics may prioritize publication over practical applications, while industry focuses on profitability.
- **Risk Aversion**. Businesses may be risk-averse when adopting new technologies due to uncertainty about their performance and market acceptance. This can hinder technology adoption and transfer.
- **Skill Mismatch**. Translating research into market-ready products often requires different skill sets. Ensuring that researchers have access to business development and entrepreneurship skills can aid in technology transfer.
- **Fragmented Ecosystem**. The bioeconomy landscape involves various actors such as universities, research centres, start-ups, and established companies. Coordinating these entities and streamlining the transfer process can be challenging.
- **Long Development Cycles**. Many bioeconomy technologies have long development cycles due to the complexity of biological systems. This can discourage investment and hinder timely technology transfer.
- **Awareness and Communication**. Stakeholders may lack awareness of available technologies and the potential benefits of collaboration. Effective communication strategies are necessary to bridge this gap.
- **Sustainability Concerns**. In the bioeconomy, sustainability is paramount. Ensuring that transferred technologies align with environmental and social sustainability goals can be a challenge.

Addressing these challenges requires a comprehensive approach involving policy adjustments, improved collaboration mechanisms, enhanced funding opportunities, and educational initiatives to promote a culture of innovation and technology transfer in the bioeconomy sector.

3.4 Cross-sectoral Collaboration

3.4.1 General overview of cross-sectoral collaboration

Intersectoral collaboration in the field of bioeconomy is essential to address the complex and multidisciplinary challenges involved in this field. The main countries of the macro-region are working to foster collaboration across different sectors to promote innovation, sustainability, and development in the bioeconomy. Fundamentally, this collaboration occurs through the formation of associations, clusters, funding programs, and academia-industry partnerships. This allows for the leveraging of knowledge and resources from various sectors to comprehensively tackle the challenges and opportunities of the bioeconomy.

- **Clusters and Technological Platforms**. They bring together stakeholders from different sectors such as agriculture, chemical industry, and research. These platforms facilitate collaboration and knowledge exchange to promote innovation in bioeconomy.
- **Funding Programs**. They encourage collaboration among companies, research institutions, and government agencies in research and development projects related to the bioeconomy.
- **Academic and Industrial Collaboration**. Universities, research centres, and businesses work closely together to develop bioeconomic solutions. Technology transfer and co-creation of innovative solutions are promoted.
- **Participation in European Networks and EU research programs** that foster cross-sectoral collaboration in the bioeconomy at an international level.

There are sectors where greater cross-sectoral collaboration is observed due to the multidisciplinary nature of the bioeconomy. Aligning with the main economic activity in southern European countries, the key sectors are:

- **Agriculture and Agri-food Industry**. Fundamental for developing sustainable agricultural practices, improving food and bio-based material production, and promoting efficient management of natural resources.
- **Biotechnology and Biochemistry**. These sectors are crucial for developing innovative technologies and processes based on living organisms. Collaboration between biotechnology companies, research centres, and industrial sectors drives the creation of bio-based and sustainable products.
- **Renewable Energies**. Collaboration between the renewable energy industry and other sectors such as agriculture and forestry can lead to the production of biofuels, biomass, and other sustainable energy sources from biological resources.
- **Chemical Industry and Sustainable Materials**. Development of bio-based materials, bioplastics, and sustainable chemicals, reducing dependency on fossil resources.
- **Research and Development**. Collaboration among universities, research centres, and businesses is key to bioeconomy innovation. Knowledge transfer and collaboration on interdisciplinary research projects can accelerate the development of bioeconomic solutions.
- **Forestry and Timber Industry.** Promotion of sustainable use of forest resources and the development of timber and non-timber products.

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In summary, cross-sectoral collaboration in the bioeconomy is evident in a wide range of sectors spanning from food production to biotechnology research and renewable energy. Collaboration across these sectors allows for a comprehensive approach to addressing challenges and seizing opportunities in the bioeconomy. However, actions related to agriculture and the food sector stand out, as both sectors contribute the most to the bioeconomy in the southern macro-region, as indicated in chapter 3.1.1.
Both Spain and Italy are countries with significant agricultural and agri-food production. A significant amount of biomass is produced in the form of crops, agricultural by-products, and organic waste. Some of this biomass is used for various purposes, such as biofuel production, renewable energy generation, and the production of bio-based materials.
The objective of cross-sectoral collaboration in the field is to leverage the expertise, resources, and perspectives of different sectors to address the complex challenges and opportunities presented by bioeconomy. The countries recognize that bioeconomy encompasses a wide range of industries and disciplines, and collaborating across sectors is crucial for achieving sustainable development, innovation, and economic growth. Some of the key objectives of cross-sectoral collaboration in bioeconomy include:

- **Innovation.** By bringing together expertise from various sectors such as agriculture, industry, research, and academia, cross-sectoral collaboration fosters innovation. This can lead to the development of new technologies, products, and processes that contribute to a more sustainable and resource-efficient bioeconomy.
- **Sustainability**. Collaborating across sectors allows for a holistic approach to addressing sustainability challenges. By integrating environmental, economic, and social perspectives, cross-sectoral collaboration aims to create bioeconomic solutions that are both environmentally friendly and economically viable.
- **Resource Efficiency**. Bioeconomy is based on the responsible and efficient use of biological resources. Cross-sectoral collaboration helps optimize the use of these resources by sharing best practices, knowledge, and technologies for resource management.
- **Value Chain Integration**. Bioeconomic value chains are interconnected and often span multiple sectors. Collaborating across these sectors ensures a seamless integration of processes, from raw material production to final product development and distribution.
- **Skills and Knowledge Sharing**. Collaboration allows for the exchange of skills, knowledge, and expertise among sectors, enhancing the collective understanding of bioeconomic challenges and potential solutions.
- **Economic Growth**. Bioeconomy has the potential to create economic opportunities and new markets. Cross-sectoral collaboration aims to capitalize on these opportunities by connecting various industries and driving economic growth.

However, there are several barriers that hinder the promotion of intersectoral collaboration. The most relevant ones are:

- Each sector has its own culture, goals, and ways of working.
- Competition for resources, such as funding, skilled personnel, and time, can create conflicts and impede cooperation.
- Lack of clear agreements on intellectual property ownership of outcomes.
- Incentives for collaboration can differ across sectors. Some sectors might be more profit-oriented, while others focus on scientific or social objectives.
- Intersectoral collaboration might require additional time and resources. The lack of these resources can limit stakeholders' ability to participate effectively.

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- The absence of pre-existing connections and networks between sectors can hinder the establishment of collaborative relationships.

Specifically, in the agricultural sector, difficulties primarily arise from resistance to change among farmers, as well as the need for investment. The utilization of agricultural waste and by-products requires suitable infrastructure and management systems that are not yet in place.
On the other hand, regarding biorefineries, investments in these facilities are costly and economic viability is not guaranteed, as it depends on biomass prices and market demand.

3.4.2 Policies supporting Cross-sectoral Collaboration in selected MR countries

To overcome these barriers, a holistic approach involving various stakeholders, such as governments, industries, research, and society at large, is required. Specific policies, regulations, and strategies can play a fundamental role in addressing barriers and promoting the sustainable development of the bioeconomy in these sectors.
In the southern macro-region, various instruments of policy and financing have been implemented to enhance intersectoral collaboration in bioeconomy projects. Some of these instruments include:

- State R&D programs
- Technological platforms for public-private collaboration
- Tax incentives and financial support for innovation and technological development projects involving intersectoral collaboration.
- European programs for international cooperation.

However, these instruments are not specific to the bioeconomy but are intended for projects in different sectors such as agriculture, marine or forestry. The actions resulting from some of these intersectoral projects are those related to the bioeconomy.

3.4.3 Mapping cross-sectoral collaborative structures

The projects have been selected for three reasons:

- Promotion of a bioeconomic model
- Biodiversity conservation
- Valorization of waste. Biomass generation and conversion.

The different actors play a role within the project that facilitates data exchange and the utilization of technologies to achieve the set objectives. However, during the project development, participants encounter various challenges in line with what is outlined in section 3.4.2.

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Table 7 Examples of cross-sectorial collaboration projects

Name	Objectives/Roles	Sectors	Actors	Type	Countries	LINK
BIOSOST	Promote the exploitation of R&D activities in the field of biotechnology, renewable energy, and water	biotechnology, renewable energy, and water	Technological centre	Project	National (Spain)	BIOSOST
ALGARED+	Promote sustainable aquaculture of marine microorganisms for the production of bioproducts, such as food, cosmetics and pharmaceuticals	Marine Food Cosmetics Pharmaceutical	Universities, technology centres and research institutes	Project	European (Spain and Portugal)	ALGARED+
LUCRA	This project will use the EU's abundant and underutilised organic municipal solid waste and wood waste to produce bio-based succinic acid, a chemical for which is significant demand in industry	Forestry Chemical	Universities Research Centres SMEs	Project	European (Greece, Spain and Italy)	LUCRA
Agro2circular	Extract products that could be used in the production of novel foods, cosmetics, and nutraceuticals.	Agri-food	Research centres Public institutions Clusters Technological centre Universities SMEs	Project	European (Spain and Italy)	Agro2Circular
BIOVALOR	More resilient forests and valorising bioproducts and by-products from native species	Agri-food	Associations Research centres	Project	National (Spain)	BIOVALOR
BIOrescue	Develop biorefinery concepts for the valorization of agricultural residues, with a focus on fruit and vegetable waste.	Biorefinery Agro	SMEs National and international associations Universities Research centres	Project	European (Spain, Italy, Ireland, UK, Belgium, Finland, Germany)	Biorescue
BIOWAYS	This project aims to raise awareness and promote public understanding of bioeconomy by showcasing successful bioeconomy stories.	Forestry Biorefinery Agro Bioenergy	SMEs Universities Technological centres Clusters	Project	European (Greece, Portugal, Italy, United Kingdom, Slovakia, Spain and Estonia.)	Bioways

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BIOWASTE	This project focuses on the sustainable management of biowaste, exploring methods for its conversion into value-added products such as bioplastics and bioenergy.	Bioplastic Bioenergy	SMEs Universities Technological centres Clusters	Project	European (UK, Finland, Germany, Italy, The Nether-lands)	BIOWASTE
BIOREFINA	A project that aims to develop a sustainable biorefinery model for valorization of forestry residues and agricultural waste.	Agro-food	SMEs	Project	National (Spain)	Biorefina
BLUEMED	Promote research in marine ecosystems Develop new technologies related to the sea Biodiversity conservation	Marine	Research centres Public institutions Clusters	Initiative	International (related with Mediterranean see): Cyprus, Croatia, France, Greece, Italy, Malta, Portugal, Slovenia, and Spain	Bluemed
BIOTECFOR	A project that aims to develop sustainable biotechnological solutions to produce high-value compounds from forestry and agricultural biomass.	Forestry - Biomaterial	Clusters Technological centres	Project	EU (Spain and Portugal)	Biotecfor

Source: Own compilation.

3.5 Financing

3.5.1 Policy Instruments for Financing in selected MR countries

Many of the financing instruments with direct access to SMEs seem to come from funds or co-financing from private investors.

In Italy and Spain, the Next Generation Plan is certainly one of the main instruments.

In Italy it is known as the National Recovery and Resilience Plan, while in Spain it is the Spanish Strategic Projects for Recovery and Economic Transformation, known as PERTEs after the acronym for their name in Spanish. They are strategic projects that have considerable potential for kickstarting the Spanish economy and require the partnering up of several players, including public authorities, companies and research organizations. The Plan is mainly composed of 6 Missions or Policy Areas that correspond to the 6 pillars of the EU's Next Generation Plan: (i) the green and connected automotive industry, (ii) the green hydrogen industry, (iii) the aerospace industry, (iv) sustainable and efficient agriculture, (v) use of Spanish in artificial intelligence, (vi) or development of an advanced National Health System. They are subdivided into components that address specific challenges and are structured into investments and reforms. The plan targets individuals and citizens and is divided into several policy areas.

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Regarding funding for SMEs, next to European programs, a very significant role has been played by National Technological Clusters, which have been set up to create permanent dialogue platforms between public research networks and enterprises.
Direct funding is primarily observed in projects related to the digitalization of companies. As for other calls, the goal is to encourage participation between public and private entities, with a target that at least 20% of the aid budget goes to SMEs.
In Italy and Spain, the main funding resources are:

- European Structural and Investment Funds (ESIFs)
- European Territorial Cooperation programmes
- Fund for European Aid to the Most Deprived (FEAD)
- Complementary Programmes Action Plans for Cohesion

3.5.2 Company Financing

For South Macro-region, the volume and type of financing rounds is comparatively developed with more variety of the funding rounds in the more developed ecosystems in Italy and Spain which reflects the disparities across the ecosystems and the greater disparities between the countries with the most developed market, respectively amount and number of deals most prominent in Italy and Spain (Figure 20, Figure 22). The data for Greece and Cyprus suggests less developed financing markets in terms of number of financing rounds and financing amounts but on condition that all deals in these countries were proportionately reported. The grants are a notable part of the financing rounds in Cyprus, Greece and Portugal. This could indicate that companies in these countries are demonstrating heightened awareness of funding possibilities from public national or EU channels, along with a more advanced ability to navigate and oversee EU projects. This inclination might be attributed to limited number of local private investors and, respectively, limited investment prospects available at the local level, compelling these companies to explore grant opportunities elsewhere. Additionally, the involvement of privately or publicly funded intermediaries such as industry clusters, SME agencies, and accelerators may play a significant role, particularly when they offer services like guidance and support in applying for EU grants, facilitating networking, attracting foreign investments, and expanding into international markets.

The companies in the South macro-region receive funding from private investors located predominantly outside their countries with private investors from Spain and Italy being in the top 20 investors by number of deal participation (5.11% and 2.55% of all deals respectively). Otherwise, there are reported active private investors in all South macro-region countries with 601 investment rounds in total.
It is notable that there are similar proportions in the amounts per investment round (Figure 23) for early-stage companies (TRL 1-6) in all countries. It is obvious that the volume of the deals both in the number of round and the total investments are significantly bigger in Spain and Italy. This can be explained by differences in country and population size and the internal markets that early-stage companies initially rely on to commercialise and develop their product.

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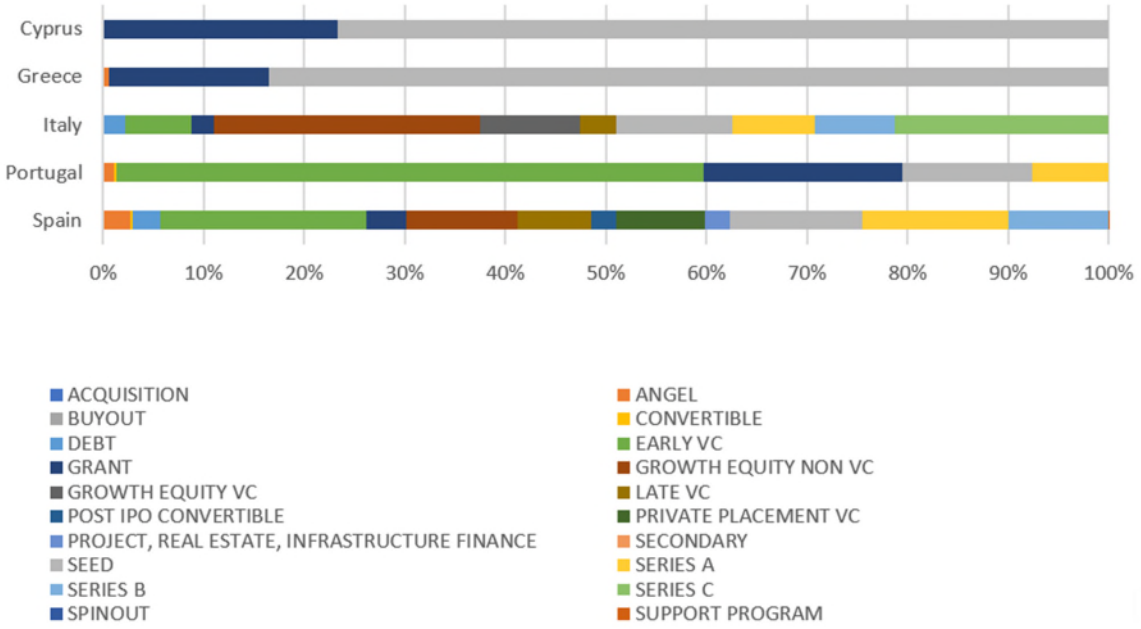

Figure 22. Type of financing rounds in Southern MR.
Source: Dealroom.co.

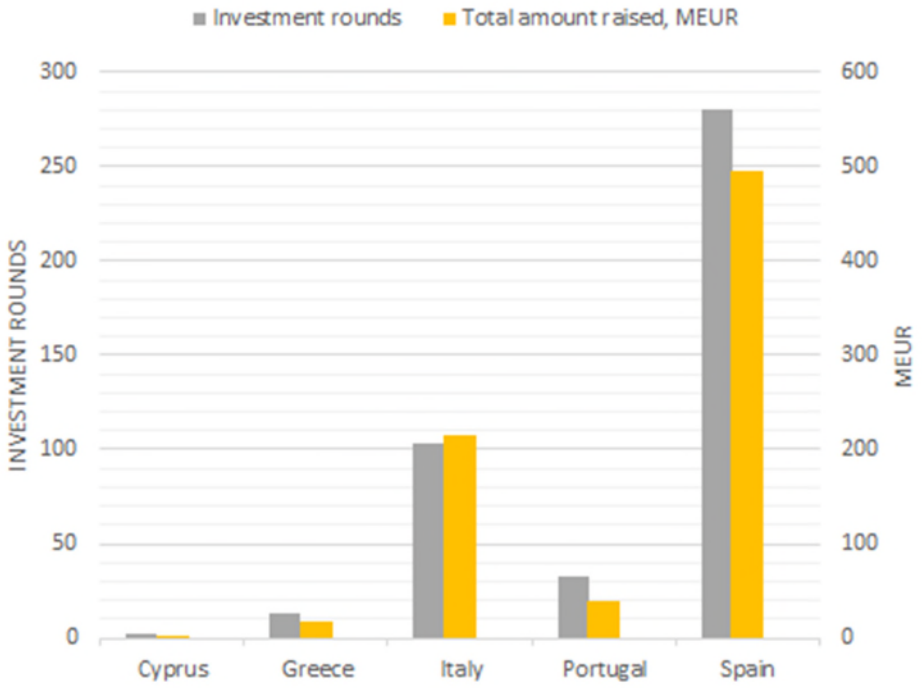

Figure 23. Early stage funding rounds and amounts in Southern MR.
Source: dealroom.co.

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The total amount raised per country for all investment deals is presented on Figure 24. The difference comes from the more mature investment deals that in later company development stages might be in significant amounts but take place less often. Example is the biggest deal in the South macro-region in Italy for the amount of approximately EUR 185 million in January 2022.

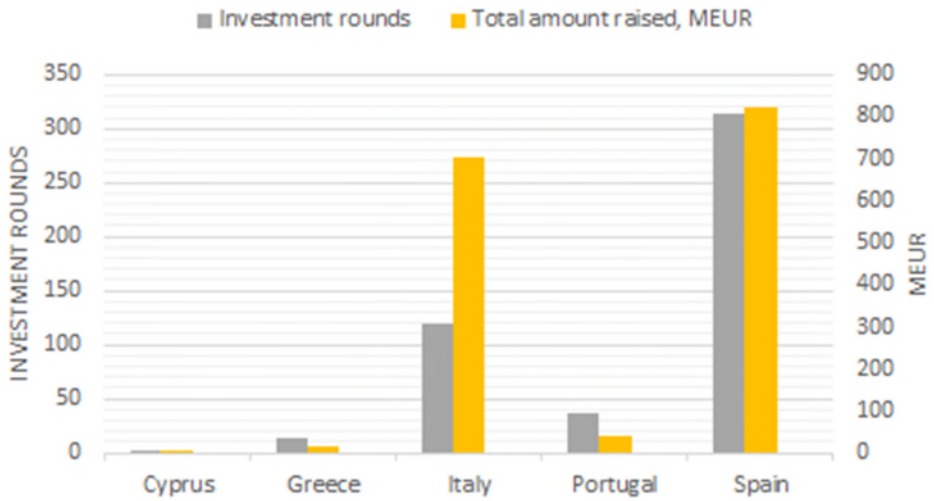

Figure 24. Total reported amount raised by country in Southern MR.
Source: dealroom.co.

3.5.3 Impact of Policies for Financing in selected MR countries

There are several opportunities and policies implemented in the bioeconomy at European level that can be match with the needs of Italy and Spain.
However, it is necessary to improve the integration of programming in a common strategic framework and strengthening the capability of financial mechanisms to ensure the long-term stability of bio investments – beyond the programming period of public administration budgets. This function should be performed by the Cohesion.
Policy Funds that make resources available along seven (plus three) year programming periods in thematic objectives and with investment priorities consistent with the bioeconomy development. Cohesion Policy Funds, according to their rules, are therefore allowed to support investments structured and amortized over the medium to long term by integrating and stabilizing resources from the ordinary national policy, to create a funding matrix in which programming and financial needs are blended.
Another barrier that needs to be addressed at this point is the lack of experts and professionals with a cross-sectoral and cross-industry background who are able to seize funding opportunities on an activity-by-activity basis.
In this direction, as the framework is so complex and heterogeneous as are the procedures, it is increasingly necessary to bring SMEs and the private sector closer to intermediaries that perform this function.
Finally, a critical issue is related to the results and outcomes of the financed activities and initiatives in the SMEs and private sector. There is not an update database in the selected countries, an overall open-source report available to track the implementation of plans or programmes (especially for the PNNR in Italy). This create a fragment framework and it is difficult to track the investments and as far the state of the art of the bioeconomy.

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3.6 SWOT-Analysis of the Southern Macro-Region

Table 8 SWOT Analysis of the Southern Region (Spain, Portugal, Malta, Italy, Greece, and Cyprus)

Strengths	**Weaknesses**
- Good example of defined policy in Italy and Spain that could drive the development of the overall macro-region - Universities studies programme and universities and research centres that help to develop technologies and knowledge that can subsequently be transferred to industry and other sectors - High expertise and level of technology at pilot scale for valorisation of feedstock - Accelerator programmes and start-up incubator promoting technology transfer - Significant participation in EU programs such as Horizon 2020 and Horizon Europe, CBE-JU and Interreg - Several clusters and technological platforms that facilitate collaboration and knowledge exchange to promote innovation	- Lack of dedicated actors and dedicated bioeconomy policies In Greece, Portugal, Malta, and Cyprus - Lack of infrastructure for development and scale-up of technologies in the bio-based industrial sector (pilot plants, open pilot facilities, etc.) - Limited implementation of bioeconomy strategies - Lack of structured policy coordination at national level - Low capabilities and resources for technology transfer - Lack of experts and professionals with a cross-sectoral and cross-industry background who can seize funding opportunities on an activity-by-activity basis - Lack of Horizontal coordination among Ministries and political departments' results in the blurring of responsibilities and tasks of each one in the development of the bioeconomy strategy.
Opportunities	**Threats**
- Take advantage of the importance of the agro sector and marine in the Southern MR to promote the bioeconomy. - Take as a model for Greece, Portugal, Cyprus and Malta the policies of Italy and Spain. - National recovery plans as opportunity for bioeconomy support - Bioeconomy as vehicle to rejuvenate traditional incumbent industries - Mutual learning and knowledge exchange between Mediterranean area and Baltic Sea	- Climate change threatens agricultural sector - Pollution of the Mediterranean Sea - Immigrants flow may lead to setting other political priorities, with a potential negative impact on the bioeconomy - A culture in academia that rewards discovery and publication over applied or translational research. - Lack of awareness and environmental interest among entrepreneurs who, while considering sustainability criteria, do not prioritize them - Foreign direct investments of the southern actors over national ones.

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3.7 Conclusions for the Southern Macro-Region

1. The most important sector in the economy of the countries that make up the southern macro-region is the primary sector (agriculture, fishing and forestry). Agriculture stands out but the arable land has significantly decreased in recent years.
2. Related to biorefineries, most of the biomass supply comes from the agriculture, forestry and fisheries sectors and is turned into products related to food and feed, bioenergy and biomaterials.
3. In the southern macro-region, different situations can be identified between countries that have already defined a bio-economy strategy and are implementing it in an exemplary manner like Italy and those that have not yet so especially for what concern Malta, Cyprus and Greece. Moreover, both Spain and Portugal have bioeconomy strategies, but its application in Spain is stagnant and the Portugal one is focused on marine sector.
4. The Italian bioeconomy strategy and its implementation plan are the best practice of the macro-region but also a good example in the European context. The strategy focuses on the valorization on secondary raw materials on a local basis, also in Spain the bioeconomy strategy is based on valorization of by-products such as those from agricultural sector. Moreover, these two strategies are focused on the sustainable and efficient production and use of biological resources.
5. The southern macro-region countries, especially in Italy, Spain and Greece, collaboration and coordination are crucial for effective bioeconomy development due to the absence of a single responsible organization. The formation of working groups, involvement of various ministries, and integration of expert opinions guide the creation of National Bioeconomy Strategies. However, challenges in horizontal coordination both in Italy and in Spain led to unfulfilled objectives and hindered progress in realizing the potential of the bioeconomy.
6. Over the years, regions have been increasingly recognized - including in EU policy - as key players that are in a unique position to promote the development of the bioeconomy. Regional bioeconomy strategies are especially relevant in Italy, Spain and Portugal.
7. Bioeconomy actors are also strongly linked to industry through clusters and networks that are active in the dissemination of the bioeconomy topic (through conferences, events, etc.), but also play a key role in the implementation of the bioeconomy.
8. However, research and academia are rarely involved in this type of activity and are mainly integrated through European projects and programmes. There are resources and best practices, for example there exist several academic and studies programmes that include applied R&D knowledge on bioeconomy, but they are not still applied at industrial level. The involvement of research is struggling to become a solid and structured reality in the industrial sector. Most of the technology transfer is taking place in technological poles and depends on accelerator or incubator programmes. Innovation is mainly driven by private SMEs.
9. Applied R&D and technology transfer in this sector are still to be implemented in the macro-region even if innovation is identified as a key to economic growth and plays an important role in tackling bioeconomy development.
10. Cross-sectoral collaboration in bioeconomy aims to leverage diverse expertise and resources for sustainable development and innovation. The southern macro-region employs policies, financing, R&D programs, public-private platforms, tax incentives, and European programs to promote intersectoral collaboration in bioeconomy projects.
11. Many of the financing instruments with direct access to SMEs seem to come from funds or co-financing from private investors.
12. An important role is recognized to national recovery plans that support the financing of national specific needs. On this point it needs to improve the integration of programming in a common strategic framework that can fund long term investments.

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4 Macro-Region Baltic Sea

Authors and Affiliations: Karolina Granja (Submariner Network) and Kersti Haugan (Food Bio Cluster Denmark)

4.1 State of Play of the Bioeconomy in the Baltic Sea Region

The Baltic Sea Region (BSR), lying in the north-eastern region of Europe, consists of 9 countries (Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Poland, Russia, Sweden), of which only Russia is not an EU Member State and is therefore not considered. In this report, however, also Germany and Poland – normally considered as part of the BSR – have been taken out of the analysis as they are covered separately by the reports analysing the Western and the Eastern European countries, respectively. Hence this report deals only with Denmark, Sweden, Finland, Estonia, Latvia, and Lithuania (Figure 25). These countries are considerably varied in terms of the size and population. Table 9 shows the size and population of the BSR countries. The largest of the BSR countries, covering 447,430 sq. km, is Sweden, while Denmark is the smallest, having around 42,944 sq. km. The largest population (10.5 million people) lives in Sweden. The second most populous country is Denmark, with ca 5.9 million inhabitants, and Finland comes in the third place, having a population of 5.5 million. The population in the remaining three countries each does not exceed 3 million and Estonia has the smallest population, of just 1.4 million. While the total area of the Baltic Sea region (around 1 million sq. km) represents 23.7% of the total EU-27 area, its total population (28 million) is only 6.2% of the total EU-27 population (Eurostat, 2023). Hence, the BSR has a large land area available for a relatively low number of inhabitants.

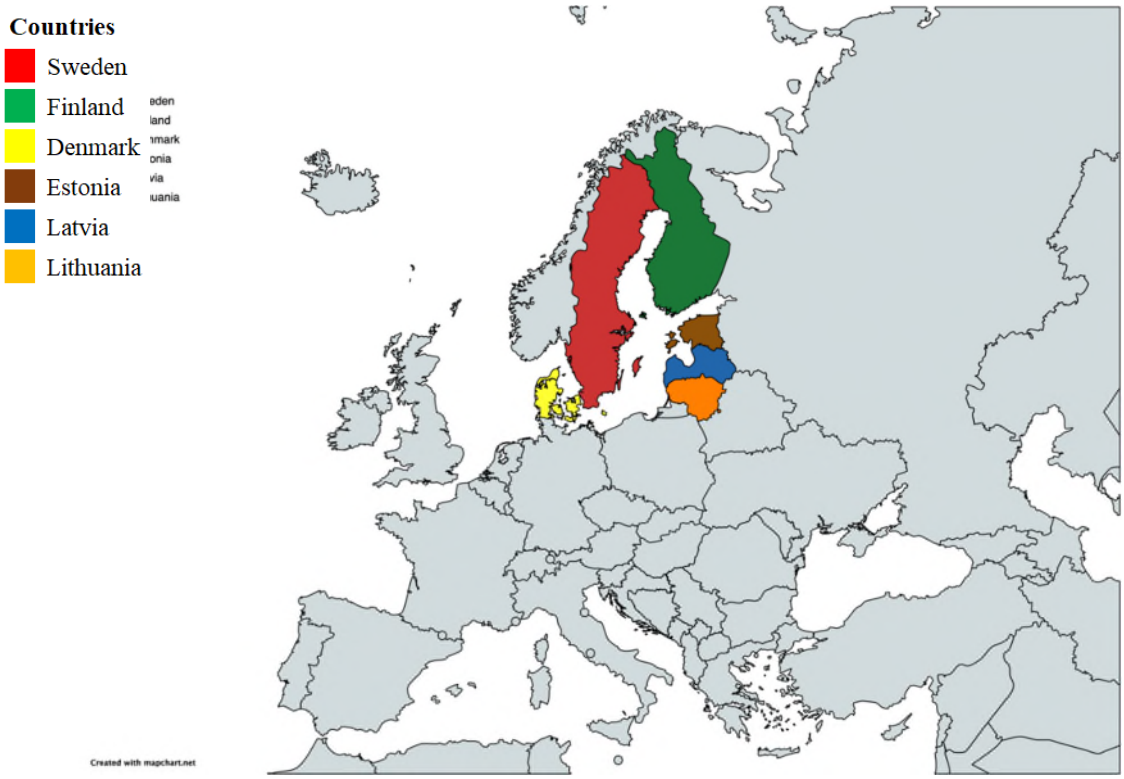

Figure 25. Countries of the Baltic Sea Region.
Source: mapchart.net (2023).

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Table 9 Area and inhabitants of the Baltic Sea Region

Country	Area (sq. km)	Area as a share of EU-27 (%)	Inhabitants (million)	Inhabitants as a share of EU-27 (%)
Denmark	42,944	1	5.9	1.3
Estonia	45,339	1	1.4	0.3
Finland	337,030	8	5.5	1.2
Latvia	64,589	1.5	1.9	0.4
Lithuania	65,300	1.5	2.8	0.6
Sweden	447,430	10.5	10.5	2.3
Total	1,002,632	23.7	28	6.2

Source: Eurostat (2023)

4.1.1 Production and industrial use of biomass

From the EU perspective, the BSR region stands out for having the highest availability of land for wood biomass supply. In the BSR, the countries that have major forest-based economic activities are Estonia, Latvia, Finland, and Sweden (in Lithuania and Denmark the sector has much smaller significance). Sweden has the largest area covered with forests, namely 279,800 sq. km in 2021 followed by Finland (224,090 sq. km) in 2021, representing over 2/3 of land area in both countries. In Estonia and Latvia, the forest area also represents more than ½ of the land area. The forest and wood production of these four countries account for about 1/3 of respective values for the entire EU-27 and is therefore of major importance for the EU forest sector (Table 10). In comparison to the much smaller Baltic States Estonia and Latvia, Finland and Sweden have, however, much bigger forest resources, volume of forest products production and have companies that are major players at the global level. The two countries are also major producers of both pulp and paper and wood products, whereas the Baltic countries have very small or no pulp and paper production, and instead focus very much on wood products only (sawn wood and wood panels).

With respect to agricultural land, Sweden hast the largest agricultural area (30,029), followed by Lithuania (29,378 sq. km) and Denmark (26,180) (Table 10). Whereas in Sweden agricultural land amounts to only 7.4% of total national land area and thus plays a comparatively less significant role, in Denmark and Lithuania the share of agricultural land, account to 65.5% and 47% of total national land area in 2021, respectively. In all other BSR countries the agricultural land was less than 1/3 of the total land area in 2021. The total agricultural area in the BSR countries corresponded to 8.4% of the total land area in BSR in 2021.

All six BSR countries have access to the sea. Sweden has the largest territorial sea area (70,000 sq. km), followed by Finland (54,130 sq. km) and Denmark (40,000 sq. km) (Table 10). These three countries also have the largest exclusive economic zones: Denmark (61,500 sq. km), Sweden (60,000 sq. km), and Finland (29,080 sq. km).

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Table 10 Forest, agricultural, territorial sea area, and exclusive economic zone of the Baltic Sea Region

Country	Forest Area (sq. km)	Agricultural Area (sq. km) *	Territorial Sea Area (sq. km)[8]	Exclusive Economic Zone (EEZ) (sq. km)	Inland waters area (sq. km)
Denmark	6,294	26,180	40,000	61,500	na
Estonia	24,384	9,870	11,811	11,300	13,389
Finland	224,090	22,680	54,130	29,080	34,515[9]
Latvia	34,147	19,700	10,178	17,656	668
Lithuania	22,027	29,378	1,810	4,560	35
Sweden	279,800	30,029	70,000	60,000	122,000[10]
Total	590,742	137,837	187,929	184,096	170,607

Source: Worldbank (2021), European MSP Platform.
**Agricultural land refers to the share of land area that is arable, under permanent crops, and under permanent pastures.*

Primary Production

In the primary sector (agriculture, forestry, fishing), forestry is the most important sector in the bioeconomy in the BSR (DK, EE, FI, LV, LT, SE). Forestry amounts to 59%, agriculture almost 41%, and fishery is below 1% of the total biomass production measured in tonnes of dry matter (Figure 26). In Finland and Sweden forestry amounts to more than 74% of the production (Figure 27). Denmark leads when it comes to production from agriculture (91.5%), followed by Lithuania. With regards to fishery, Denmark features as the lead country in the region, followed by Estonia, Finland, Lithuania, and Latvia.
However, it is worth noting that the only available macro data on biomass production are from 2016 and not up to date. Currently, the countries in the Baltic Sea macro-region are also focusing on the blue bioeconomy. Therefore, it must be considered that the percentage of biomass production from fishery as well as aquaculture must have also increased in the last few years.

[8] www.maritime-spatial-planning.ec.europa.eu
[9] https://www2.stat.fi/tup/suoluk/suoluk_alue_en.html
[10] https://www.arl-international.com/knowledge/country-profiles/sweden#:~:text=date%20of%20access).-,Overview,km2%20is%20inland%20waters

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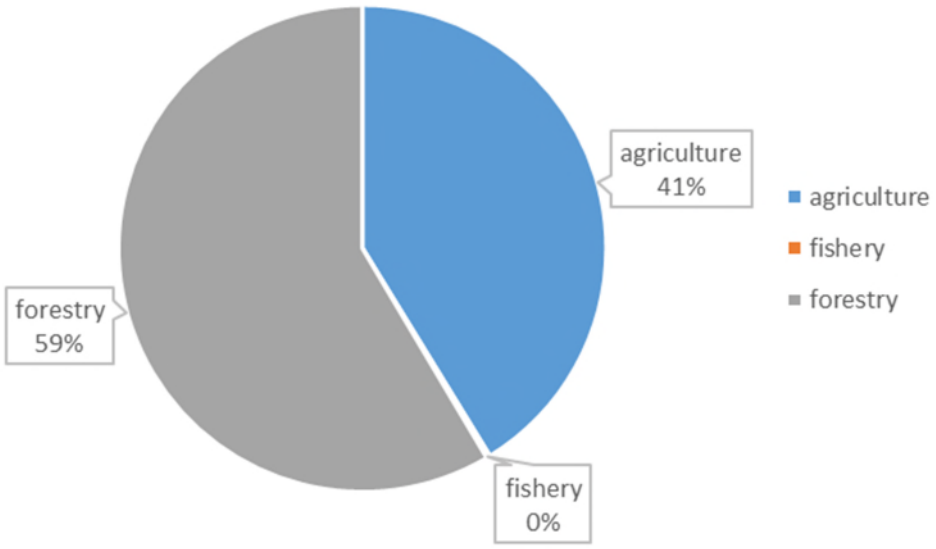
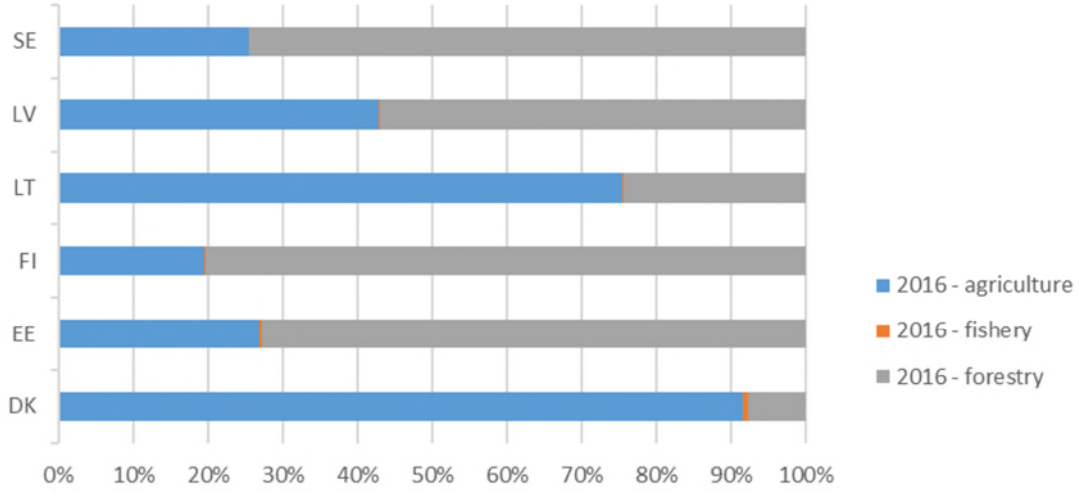


Figure 26. Biomass Production from Primary Production Systems.
Measure: tonnes of dry matter, agriculture: includes crop and animal production.
Source: Datam JRC, European Commission.



	DK	EE	FI	LT	LV	SE
2016 - agriculture	91,51%	26,91%	19,54%	75,35%	42,73%	25,41%
2016 - fishery	0,69%	0,26%	0,13%	0,19%	0,24%	0,11%
2016 - forestry	7,81%	72,83%	80,33%	24,46%	57,03%	74,48%

Figure 27. Biomass Production from Primary Production Systems in BSR (DK, EE, FI, LV, LT, SE).
Measure: tonnes of dry matter, agriculture: includes crop and animal production.
Source: Datam JRC, European Commission.

Use of Biomass

In the BSR (DK, EE, FI, LV, LT, SE) about 108 million tonnes of biomass (dry matter) from agricultural, woody, and marine sources were consumed to produce energy, materials, and food in 2017 (Figure 28 and Figure 29). This data represents 13.4% of the total biomass consumption in the EU-27. Clearly, the highest

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demand among the countries in the BSR (DK, EE, FI, LV, LT, SE) coincides with those that have a larger area and a higher population. In these countries, over half of the biomass is used for energy production, about a quarter for food and feed production, and the rest for biomaterials.

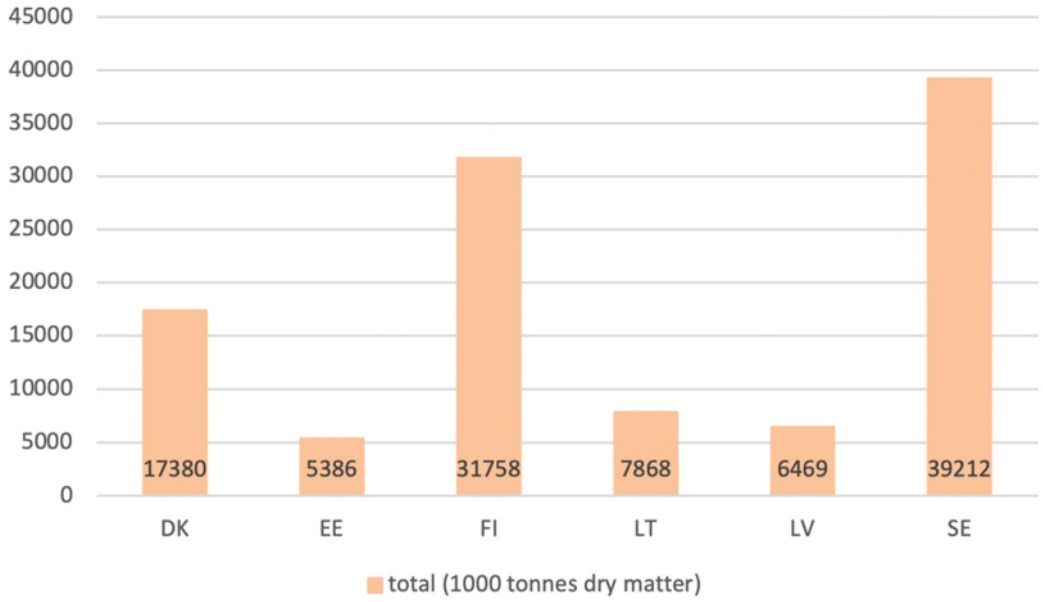

Figure 28. Total biomass consumption in the Baltic Sea region.
Measure: tonnes of dry matter, agriculture: includes crop and animal production.
Source: Datam JRC, European Commission.

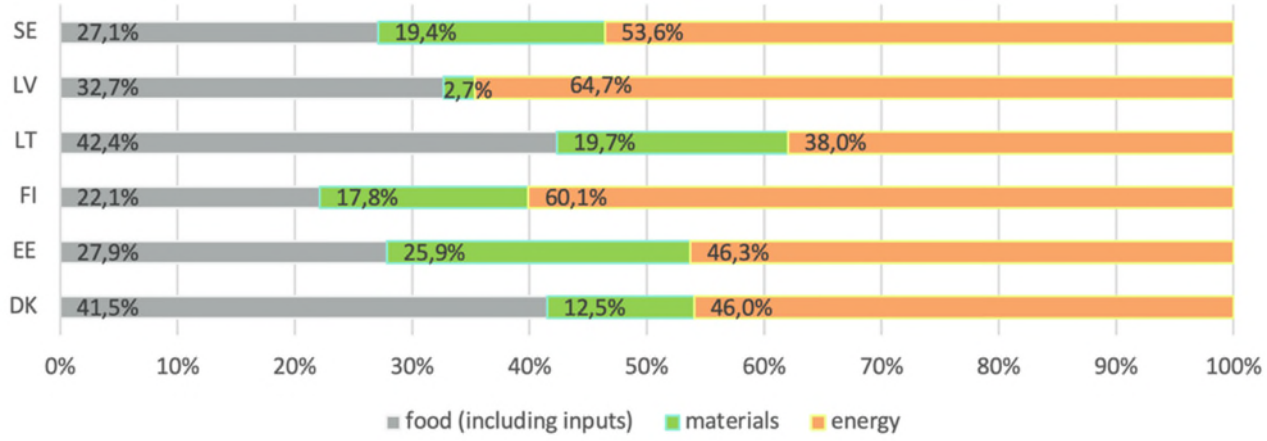

Figure 29. Total biomass consumption in the Baltic Sea region.
Measure: tonnes of dry matter, agriculture includes crop and animal production.
Source: Datam JRC, European Commission.

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Biomass Flows

Figure 30 shows a summary of the biomass flow data in 2023 for the BSR (DK, EE, FI, LV, LT, SE).[11] Most of the biomass is produced locally and only a small fraction is net-imported from outside of EU-27. The largest amount of biomass imported comes from agriculture. When it comes to its use, most of wood biomass is consumed within the EU-27 countries and only a small fraction of wood biomass is net-exported to outside of the EU-27 countries. By contrary, only 60% of the amount of fishery biomass is consumed within the EU-27 countries, 40% is exported to outside of the EU-27, and about 3% is wasted. As for food biomass, over a half is either lost or unknown how it was used. From the known part, more than 80% is consumed and the rest exported.

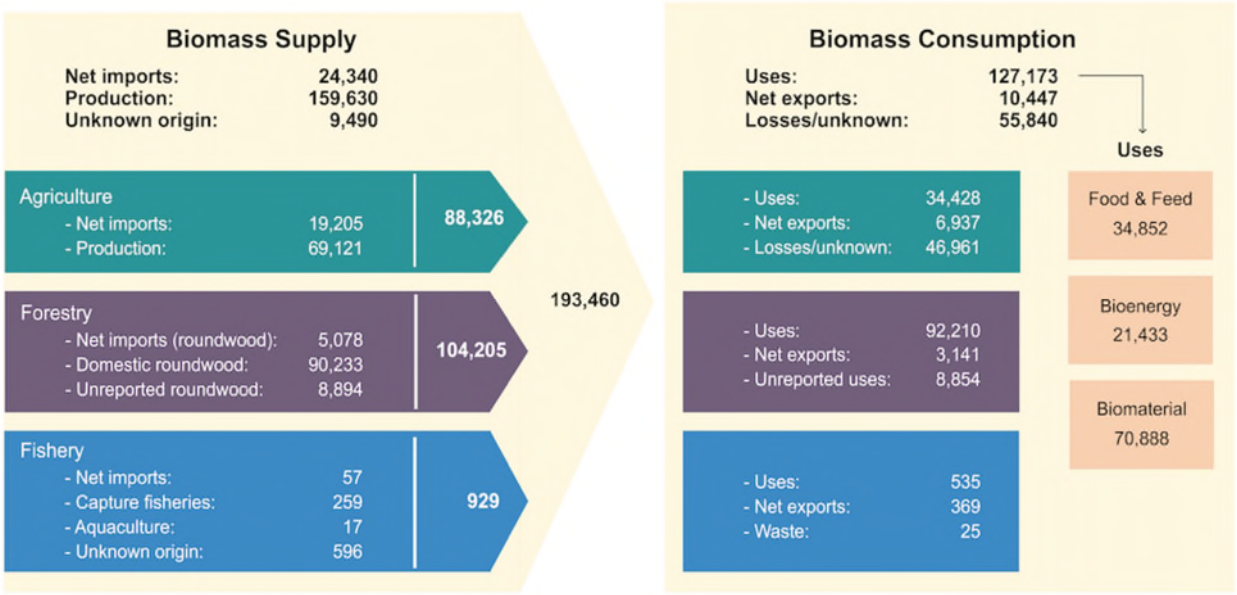

Figure 30. Biomass flows by sector for the Baltic Sea region
Measure: tonnes of dry matter, in net trade (exports/imports from outside of EU-27 countries).
Source: Datam JRC, European Commission.

Agriculture and food, forest-based and chemical industries are among the strong drivers of BSR's economy. Forestry, wood products and furniture and paper play a vital role (45.8% of total GDP of BSR countries[12]). The wood value chains in BSR are diverse, with ranging uses from energy and construction.

Forestry

In recent decades, some important structural changes have taken place for which purposes the wood produced in the Baltic Sea Region has been used. Especially two developments stand out, and they are the mirror images of each other:

1. From 2006 to 2018, fuelwood (used for energy) production has increased by 7.4 million m^3 or by 56%.

[11] Slight deviations to the figures above are possible, due to partly different reference years and additional attribution steps of data
[12] https://datam.jrc.ec.europa.eu/datam/mashup/BIOECONOMICS/index.html

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2. On the other hand, the graphics paper production (in Finland and Sweden) declined from 2006 to 2018 by 6.7 million tonnes or by 43%.

Fuelwood increase is a result of the EU and national policies that have encouraged the phasing-out of fossil energy by bioenergy. Furthermore, graphics paper decline is a result of digital media replacing print media (Borkowski et al, 2020).
Finland is one of the most heavily forested countries of the European Union covering over 70% of its land, with its forestry sector accounting for over 20% of the country's export revenue. Sweden ranks the second in the forest area with 68% of its land area.

Agriculture

All studied countries in the BSR are experiencing a structural transformation in agriculture – the number of farms is decreasing while farm size is increasing. Overall, the acreage of agricultural land remains fairly stable. In Denmark and Sweden, the structural transformation from many small farms to fewer, larger farms has come the furthest, but rate of transformation has accelerated in the Baltic States (Estonia, Latvia, Lithuania) during more recent years. The driving forces behind the structural transformation towards larger farms include technological advances, changes in the market, and agricultural policy. Larger farms are generally more profitable. Parallel to this, agricultural is becoming increasingly specialised, which means that some regions in each country are dominated by crop production and others by livestock production (Stockholm University, 2016).
Denmark has the largest agricultural system (including permanent crops and pastures) – covering over 60% of its land area and accounting for nearly one-quarter of its export value. Lithuania ranks the second with more than 45% of its land area provided for agriculture. In the rest of the countries in the BSR agricultural land is below 1/3 of the total land area.

Blue Bioeconomy

The studied Baltic Sea Region countries differ in the structure and composition of their maritime economies. Fishery is a much more developed – as highly traditional - sector than the relatively new aquaculture sector, which has only started some 50 years ago. However, aquaculture activities have been increasing in the recent years mainly due to EU support. Lithuania and Estonia almost only practise fishing. Estonia and Finland also perform aquaculture but mainly in freshwaters. Denmark and Sweden practise fishing as well as both inland and marine aquaculture. The leader among the BSR countries in fish catches and production from aquaculture is Denmark. The total fish catch and harvest from aquaculture in this country was over 500 thousand tonnes in 2021. In the other countries this value ranges from about 60 in Latvia to 170 thousand tonnes in Sweden.
Overall, both fishery and marine fish aquaculture are problematic within the Baltic Sea Region due to the severe environmental problems, which persist in the Baltic Sea mainly caused by eutrophication and oxygen depletion. Hence cod and herring fishery are currently highly restricted and hardly any new licenses have been handed out for new fish aquaculture sites in the past years. However, numerous initiatives exist, which promote sustainable fishery of invasive species as well as uptake of so-called low trophic / regenerative aquaculture, which does not breed fish, but grow mussels or algae, which do not need to be fed – but live of the surplus nutrients in the Baltic Sea waters.
European aquaculture accounts for around 20% of seafood production, and is mainly concentrated in Spain, France, Italy, the United Kingdom, and Greece. The BSR accounts for around 5% of total EU production and 3.7% of total EU value (FAO, 2018). With environmental regulation limiting offshore aquaculture in the Baltic Proper, Baltic production predominantly refer to extensive freshwater aquaculture. Table 11 shows the state of play of aquaculture in studied countries.

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Table 11 State of play of aquaculture in BSR

Country	Size of Sector	Main species
Denmark	Freshwater aquaculture has increased 7 times since 2008 despite the strong environmental legislation concerning aquaculture in DK.	Rainbow Trout, 90% European eel, Blue Mussels
Sweden	Rapid growth of inland aquaculture between 1995-2015	Rainbow Trout, Arctic char, Blue Mussels
Finland	Leaders in aquaculture: Baltic Sea Offshore Cage	Rainbow Trout, European Whitefish, Sturgeon, Pike perch, Nelma
Estonia	Environmental conditions limit Estonian aquaculture to 700 tonnes annually.	Rainbow trout (90%), Common Carp, Sturgeon, European eel
Latvia	Small aquaculture sector	Common Carp, some sturgeon, trout, pike, crayfish
Lithuania	Increase of 45% between 1995 and 2015	Common Carp, some rainbow trout, sturgeon, African catfish, and European eel

Source: Schultz-Zehden et al. (2021).

Mussel farming in the Baltic Sea Proper is still in infancy, with hardly any large commercial farm being operational yet in the region. However, there is an increasing number of pilot sites (e.g. in the Stockholm archipelago, Estonia), a growing community of mussel farmers (including some from the Western Baltic) and an increasing willingness among environmental decision makers to accept mussel farming as a possible sea-based nutrient removal measure. Apart from some farms in Sweden and Denmark, there is also already one operational mussel farm in Estonia (Schultz-Zehden et al, 2021).
Production of macroalgae (seaweeds) is at a nascent phase in the Baltic and almost 100% macroalgae raw material supply come from import from EU countries and third countries, like in Norway, Russia, China, and Japan. Commercial macroalgae production activities in the Baltic are mostly limited to wild harvesting at local radius, with Denmark being the largest seaweed producer (100 tonnes in 2018). Only a handful of marine seaweed farms exist so far in the Baltic Sea Region: three farms at the Western coast of Sweden and 4 farms in Denmark (Table 12). There are also a few experimental farms in Western Baltic and one in Estonia. However, seaweed cultivation activities are expected to grow exponentially in Denmark and Sweden in the next few years (Schultz-Zehden et al, 2021).

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Table 12 Seaweed farms at the Baltic Sea Region

Name	Stage	Type	Country
Nordic Seafarm	Commercial	Marine	Sweden
Bohus Seaculture	Commercial	Marine	Sweden
Kristineberg Research Centre	Research	Marine	Sweden
Hjarnø Havbrug	Commercial	Marine	Denmark
Dansk Tang	Commercial	Marine	Denmark
Sømad	Commercial	Marine	Denmark
Pure Algae	Commercial	On land	Denmark
Algae Centre	Research	Marine	Denmark
Estonia	Research	On land	Estonia

Source: Schultz-Zehden et al. (2021).

4.1.2 Industrial deployment of bioeconomy and economic relevance

4.1.2.1 Industrial deployment

Open-Access Pilot Plants
Regarding open-access pilot and demo facilities, the Pilots4U network database shows a mixed picture. While Finland and Sweden possess a high one-digit number of facilities, Denmark and Estonia rather lack such infrastructure.

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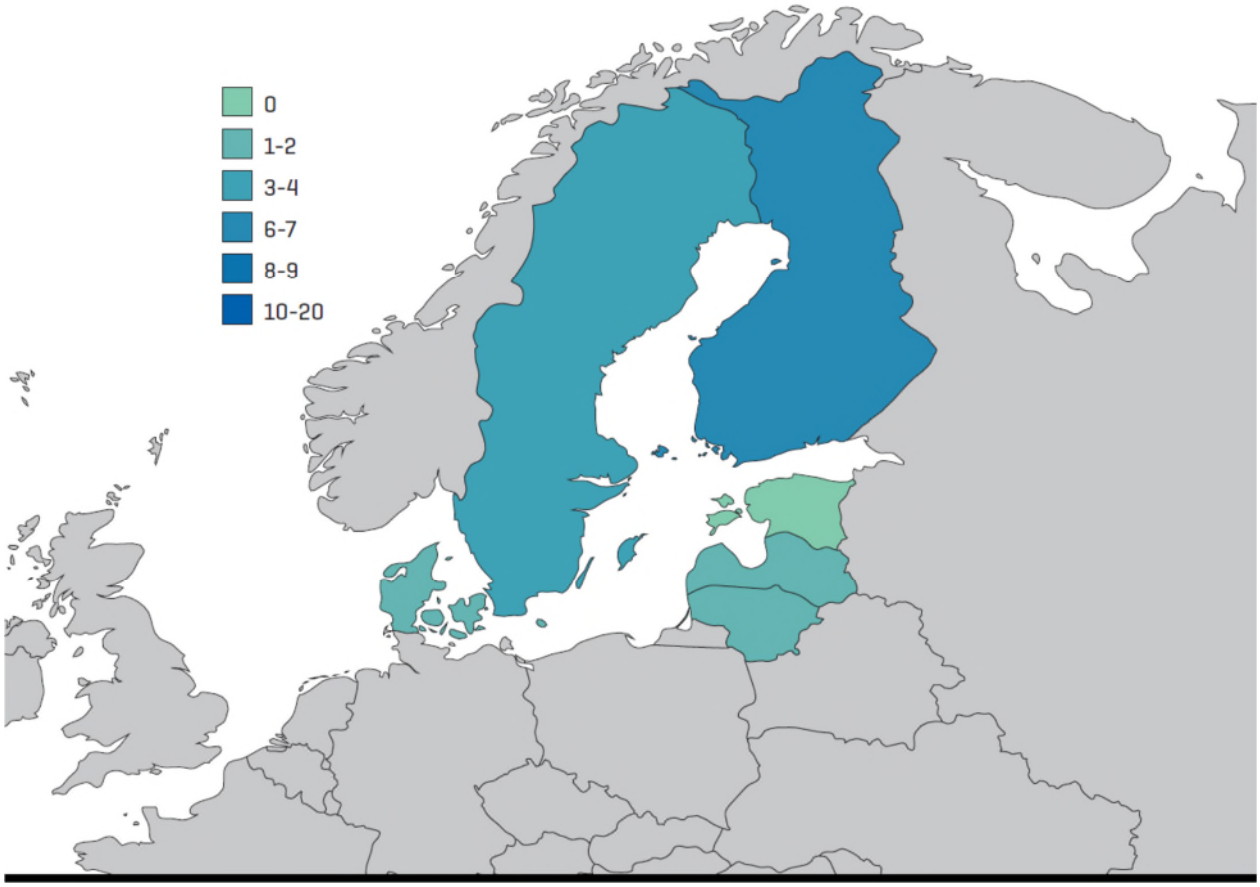

Figure 31. Distribution of number of open access pilotplants in the BSR (2023).
Source: Pilots4U network.

Biorefineries

An important element of the bioeconomy mapping exercise is information on biorefineries. The mapping of biorefineries distribution and an overview of their main feedstock sources and products in the Baltic Sea Region helps to understand the potential of bioeconomy in the region.

A biorefinery is a facility that enables 'a sustainable processing of biomass into a spectrum of marketable products (food, feed, materials, chemicals) and energy (fuels, power, heat), using a wide variety of conversion technologies in an integrated manner'. Biorefineries combine the necessary technologies of the bio-based raw materials with those of chemical intermediates and final products.

The European Commission's Joint Research Centre (JRC) has consolidated a wide range of sources on biorefineries in Europe and established an interactive mapping dashboard[13], which is available for public use. The ShapingBio team used this database to draw out key graphs that can characterise the bioeconomy in the Baltic Sea Region. The extracts cover the 6 countries in the Baltic Sea region per type of biorefineries and their main feedstock sources. As noted by the JRC, the mapping information 'includes a wide range of plants, from innovative, recently built biorefineries in which the newest principles of circular economy are applied, to very traditional, decades-old plants obtaining products from biomass (e.g. some timber, paper, or starch plants).

[13] https://datam.jrc.ec.europa.eu/datam/mashup/BIOBASED_INDUSTRY/index.html

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The bio-based industry in the Baltic Sea Region is quickly evolving. In the whole region, there are 572 facilities, which account for 24,2% of the total 2,362 biorefineries in the EU-27 (Table 13). Sweden features as the leader in the number of bio-based industry facilities (284), followed by Finland (161) and Denmark (67). In Estonia, Latvia, and Lithuania the number of biorefineries is less concentrated.
Figure 32 shows the share of bio-based industry plants by feedstock origin in the Baltic Sea Region. The industry plants using raw materials from the primary sector, specifically from forestry and agriculture, clearly dominate. By contrary, the percentage of feedstock originating from waste, grasses and short-rotation coppice industries is much lower.
Table 13 shows the share of bio-based industry facilities in BSR based on the product class they generate. There is a wide variety of products obtained from biomass, but the strongest industry is the timber sector followed by the biomethane, pulp and paper, and bio-based chemicals sectors (Table 13). In all countries at least half of the facilities are based on timber. In fact, currently, there are 6 industry plants generating biomethane in bio-based composites and fibres in Estonia, 2 in Latvia and 1 in Lithuania (data are from 2020 thus some not up to date).

Table 13 Number of bio-based facilities by product category in the BSR region in year 2020

Product category	**LT**	**LV**	**EE**	**DK**	**SE**	**FI**	**Total**
Starch & sugar	3	1		7	8	6	25
Bio-based composites and fibres				1	7	10	18
Timber	11	14	15	17	144	78	279
Pulp & paper	2		1	1	42	37	83
Bio-based chemicals	2	4	2	9	27	23	67
Liquid biofuels		7	2	15	16	22	62
Biomethane				22	63	12	97
Total	17	24	19	67	284	161	572
Number of bio-based facilities in commercial plants	16	23	18	55	277	151	
Number of bio-based facilities in pilot, demo, and R&D plants	1	1	1	12	7	10	

Source: Datam JRC, European Commission[14].

[14] https://datam.jrc.ec.europa.eu/datam/mashup/BIOBASED_INDUSTRY/s

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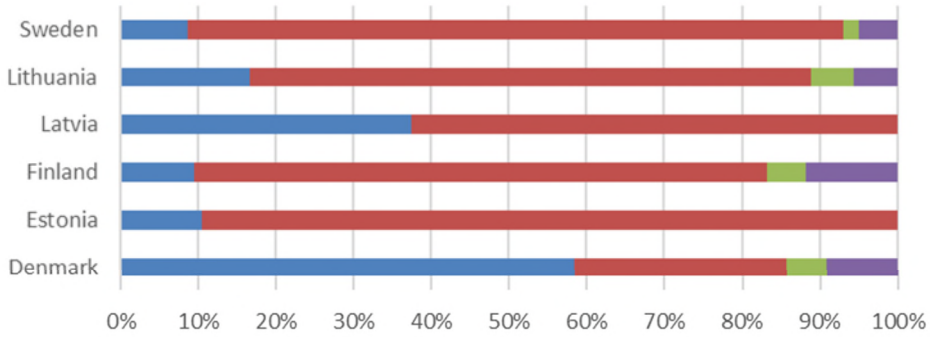

	Denmark	Estonia	Finland	Latvia	Lithuania	Sweden
Agriculture	58,44%	10,53%	9,50%	37,50%	16,67%	8,61%
Forestry	27,27%	89,47%	73,74%	62,50%	72,22%	84,43%
Grasses and Short-rotation Coppice	5,19%	0,00%	5,03%	0,00%	5,56%	2,05%
Waste	9,09%	0,00%	11,73%	0,00%	5,56%	4,92%

Figure 32. Share of bio-based industry plants[15] *by feedstock origin in the BSR.*
Source: Datam JRC, European Commission.

Table 14 shows the distributions of chemical and material biorefineries by pathways in the studied BSR. Probably the most interesting aspect is to look at geographies where there is conversion capacity of waste. Figure 33 shows that such biorefineries are mainly focusing on production of bio-based chemicals. These are mainly operating in Denmark, Sweden, and Finland, with only one such facility being based in Estonia (and none in the other Baltic States). Bio-based composites and fibres from waste are produced only in Finland, Denmark, and Sweden.
The capacities to produce bio-based chemicals from agricultural biomass are notable in Denmark, Sweden, as well as Finland and Latvia (Figure 34). Looking at the same capacities to produce bio-based chemicals, but from wood-based biomass, Sweden and Finland appear to lead heavily in this area, while Denmark, Estonia, and Latvia show only some sparse capacities (Figure 35).
While the absolute majority of biorefineries included in this database are commercial facilities, it is also interesting to explore where most R&D and pilot biorefineries are located across the Baltic Sea Region. Figure 36 shows that the majority of R&D and pilot facilities in BSR focus on liquid biofuels. Finland appears as the main research hub on bio-based composite and fibre biorefining. Research on bio-based chemical refining is visible in Sweden, Finland, as well as across all three Baltic States.

[15] As plants can produce multiple products of different categories, the number of plants may exceed the total number of plants per country.

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Table 14 Distributions of chemical and material biorefineries by pathways in BSR in 2020

Pathway	Number	Share in %	Location country and number
A – One platform (C6 sugars) biorefinery using sugar crops	2	5	- Finland - 1 - Denmark – 1
B – One platform (starch) biorefinery using starch crops	3	7.5	- Finland - 1 - Sweden – 2
C – One platform (oil) biorefinery using oil crops, wastes, and residues	1	2.5	- Sweden – 1
D - Two-platform (pulp and spent liquor) biorefinery using woody biomass	25	62.5	- Finland - 17 - Sweden – 8
E – Three-platform (C5 sugars, C6 sugars, and lignin) biorefinery using lignocellulosic biomass	6	15	- Estonia – 1 - Sweden - 4 - Denmark – 1
F – Two-platform (organic fibres and organic juice) biorefinery using green biomass	-	-	
G – Two-platform (oil and biogas) biorefinery using aquatic biomass	-	-	
H – Two-platform (organic fibres and oil) biorefinery using natural fibres	1	2.5	- Finland – 1
I – One platform (syngas) biorefinery using lignocellulosic biomass and municipal solid waste	2	5	- Finland – 1 - Sweden - 1
J – Two-platform (pyrolytic liquid and biochar) biorefinery using lignocellulosic biomass	-	-	-
Total	40	100	-

Source: Datam JRC, European Commission.

Classes from A-D represent the pathways that are available commercially, Pathways E-J have not yet reached a commercial scale (Datam, 2023)

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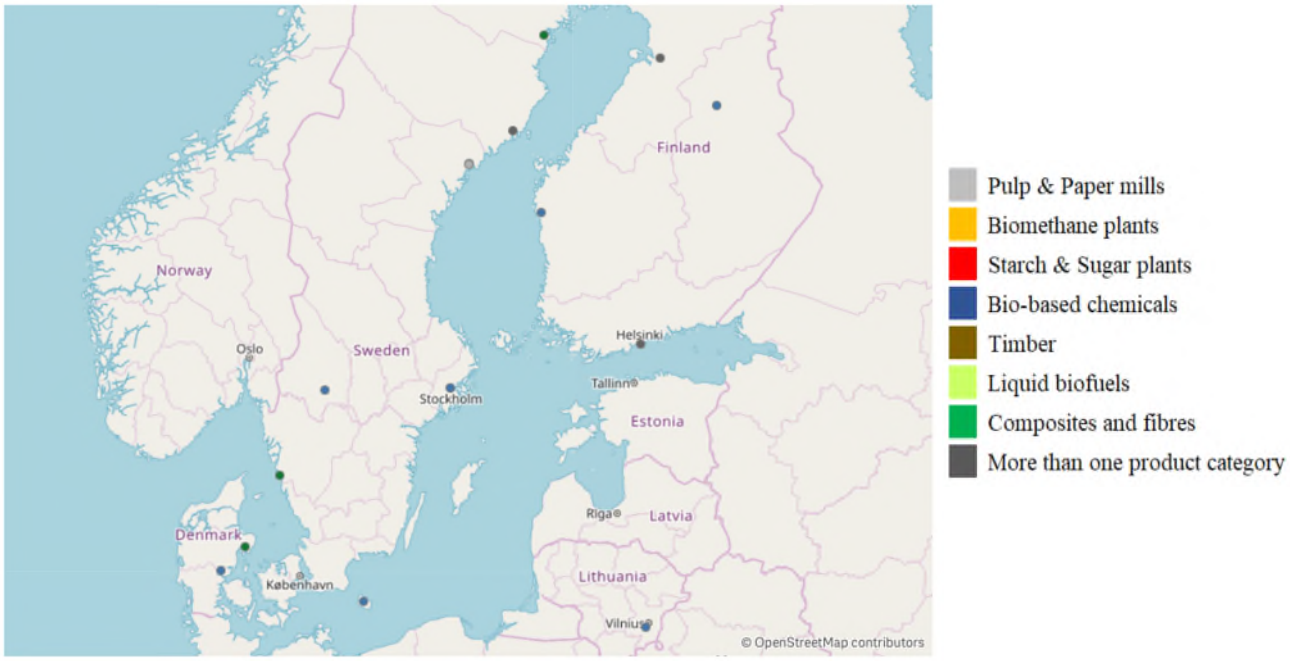

Figure 33. Mapping of BSR biorefineries focusing on waste conversion.
Source: Datam JRC, European Commission.

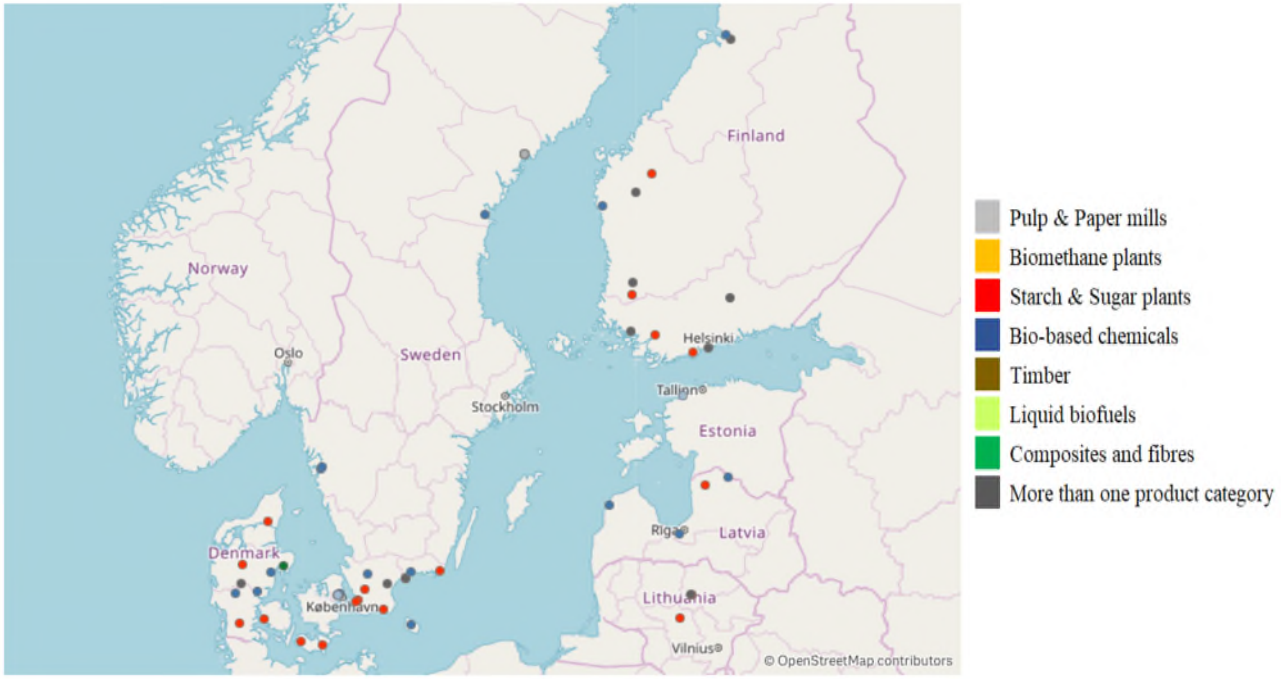

Figure 34. Mapping of BSR biorefineries focusing on agriculture conversion (Datam JRC).
Source: Datam JRC, European Commission.

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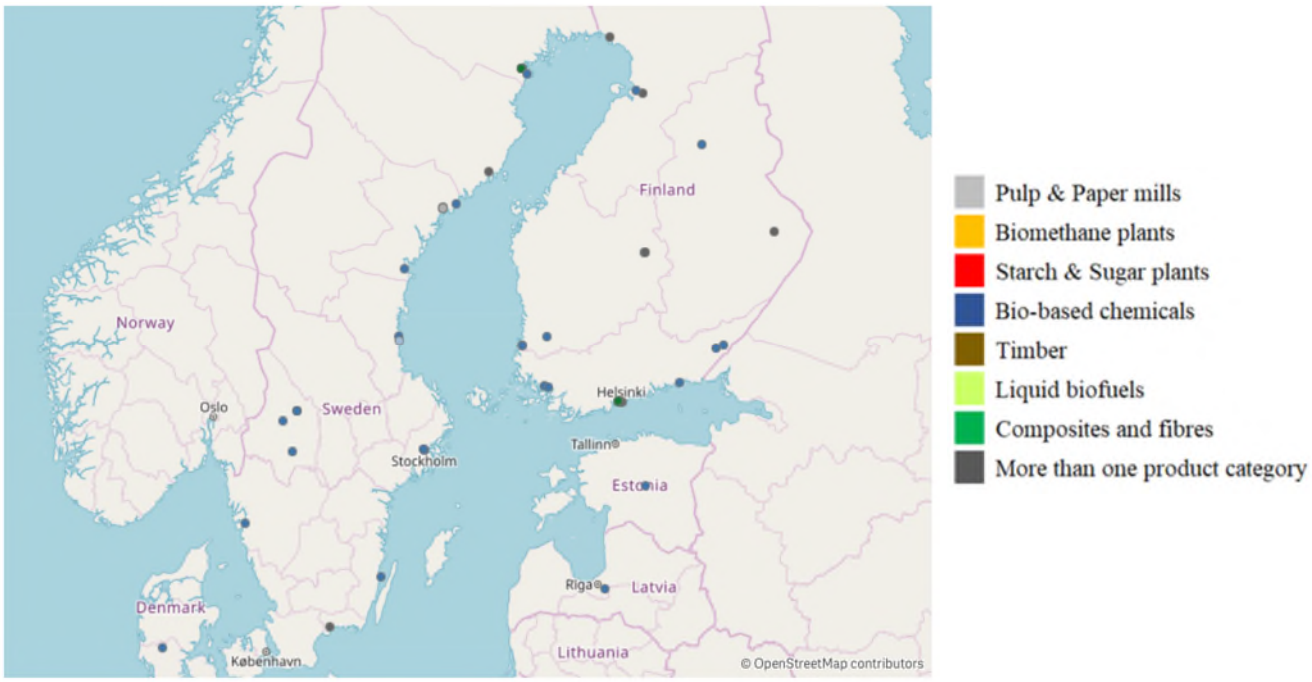

Figure 35. Mapping of BSR biorefineries focusing on wood biomass conversion (Datam JRC). Source: Datam JRC, European Commission.

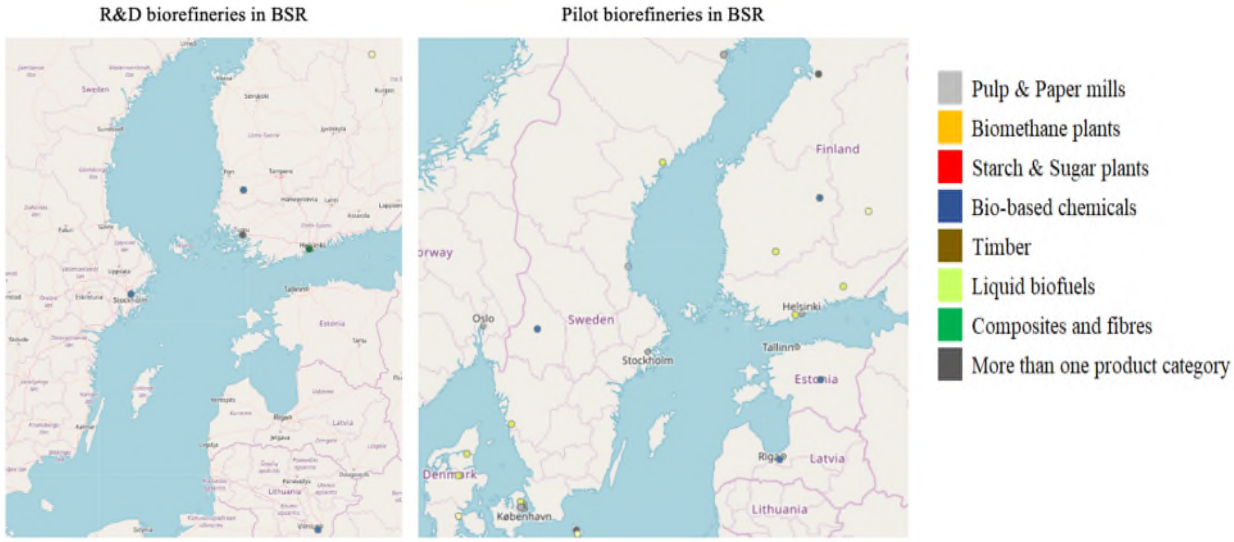

Figure 36. Mapping of R&D and pilot biorefineries in BSR (Datam JRC). Source: Datam JRC, European Commission.

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4.1.2.2 Economic relevance

Figure 37 shows the number of people employed in bioeconomy sectors in total in the Baltic Sea Region from 2008 until 2020. The total employment in the bioeconomy in the Baltic Sea Region decreased slightly in the last few years, mainly due to a reduction in the agricultural labour force. It reached 0.97 million total employments in the bioeconomy sectors in 2020 (7.3% of total employment in BSR). The primary production, comprising agriculture, forestry, and fishery, still employed most people in the bioeconomy. As for primary production, fishery and aquaculture were the smallest on the scale, comprising only 0.8% of the total employment in the bioeconomy. Although agriculture employed the largest number of people, it decreased gradually between 2008 and 2020.

By contrary, bio-based electricity, and liquid biofuels sectors as well as bio-based chemicals, pharmaceuticals and plastics sector have the smallest number of people employed, since these sectors are still not that developed in the Baltic Sea Region. However, they are the fastest growing sectors as it can be seen in the Figure 39, which shows the employment growth between 2008 and 2020 in the Baltic Sea Region. Between 2008 and 2020, bio-based electricity and liquid biofuels sectors increased the number of people employed by more than 65%, whereas the more traditional sectors, such as fishing and aquaculture, paper, agriculture, wood products and furniture decreased it.

This may be partly explained by the increasing use of technology and automation and partly by the decline in the number of farms in the agricultural sector (Schuh et al., 2019). The largest negative growth was observed in the bio-based textiles sector, which experienced a 43% reduction in employment.

In addition, the distribution per country in Figure 38 shows that the Scandinavian countries highly differ in their structure compared to the Baltic ones, with the former having relatevly more employed person in forestry and biomass conversion sectors.

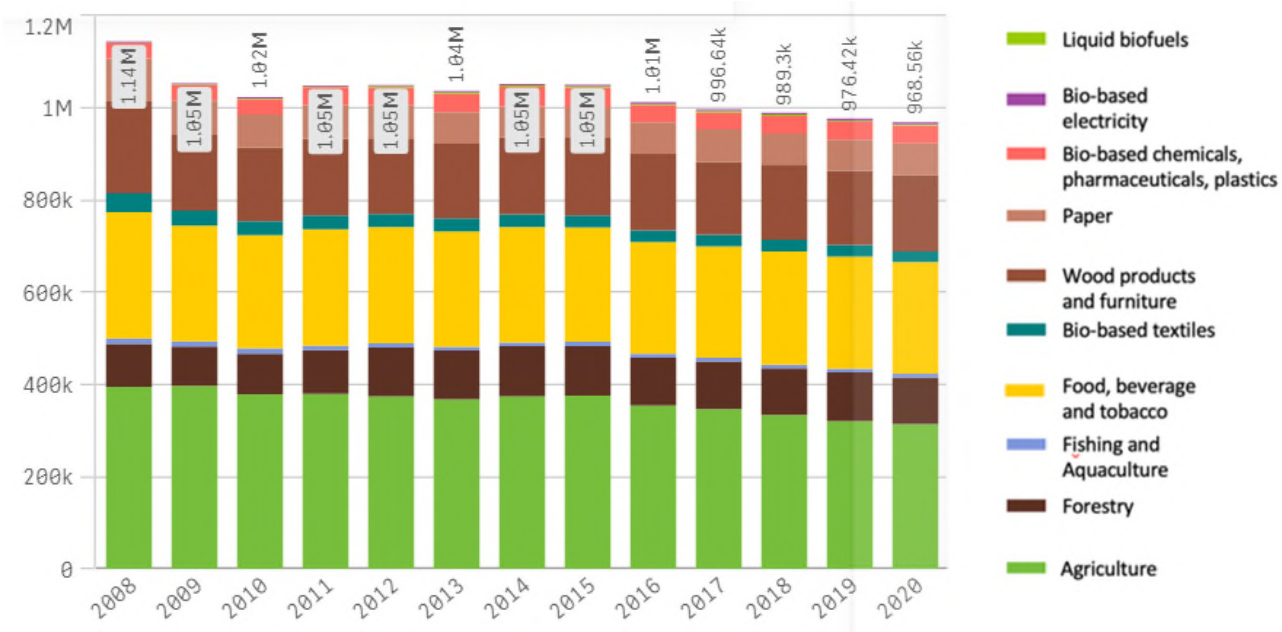

Figure 37. Number of people employed in bioeconomy sectors in BSR between 2008 and 2020
Source: Datam JRC, European Commission.

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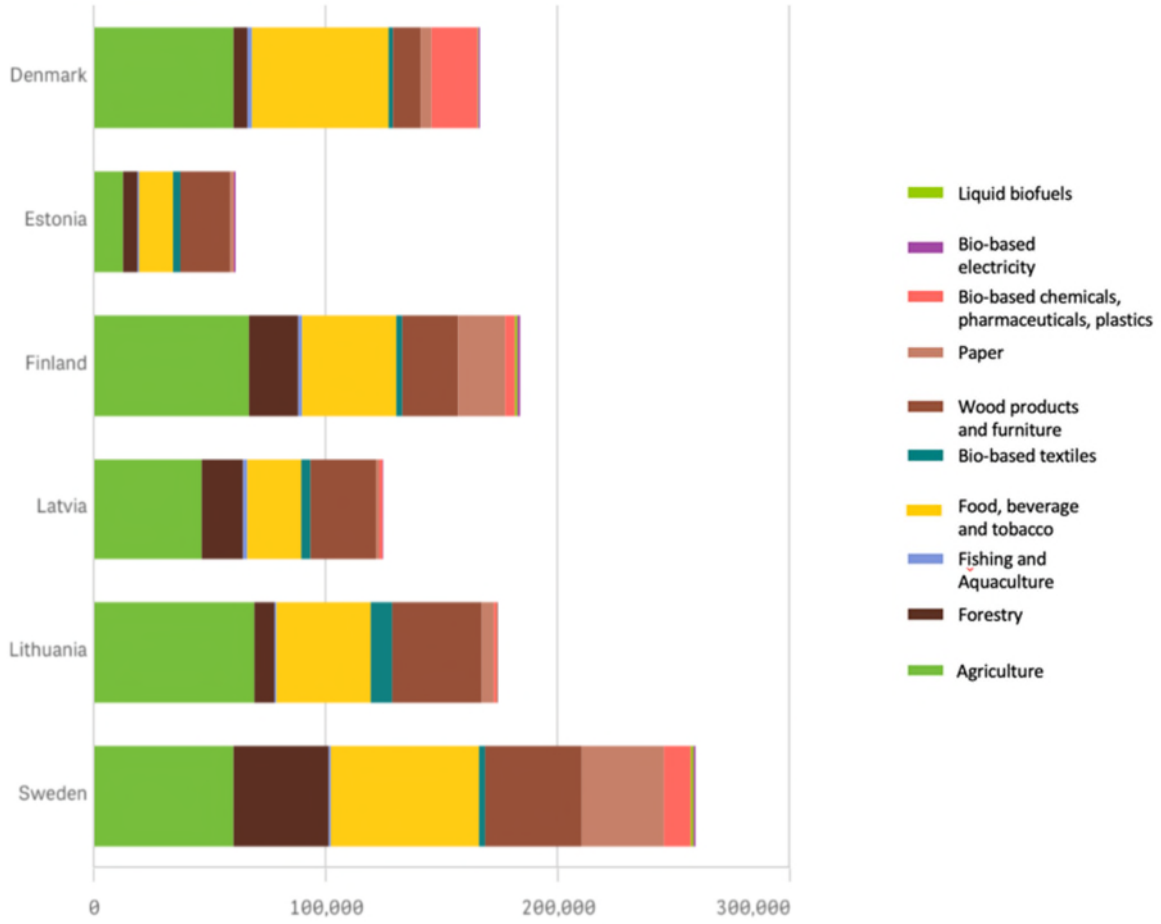

Figure 38. Number of people employed in bioeconomy sectors per country in 2020
Source: Datam JRC, European Commission.

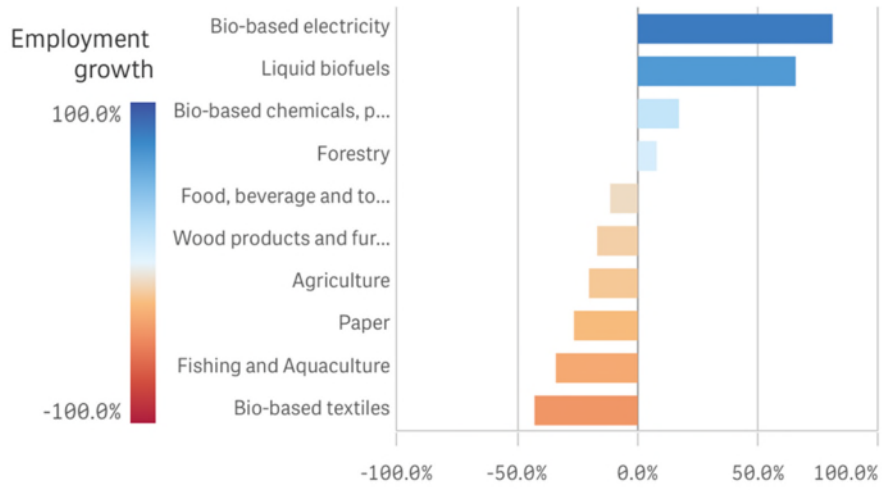

Figure 39. Employment growth between 2008 and 2020 in BSR
Source: Datam JRC, European Commission.

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Figure 40 shows the value added in bioeconomy sectors in the Baltic Sea Region between 2008 and 2020. The total value added in bioeconomy in BSR increased significantly in the last years mainly due to a rise in the value added in the bio-based chemicals, pharmaceuticals and plastics and food, beverage, and tobacco sectors. It reached EUR 62.47 billion total value added in the bioeconomy sectors in 2020. The primary production, comprising of agriculture, forestry, and fishery, creates the largest value added (one third) of the total added value, where fishery and aquaculture sector generates the lowest value of EUR 613.1 million. All sectors except for the bio-based textiles sector increased their value added between 2008 and 2020. The largest growth was experienced by the liquid biofuels sector, which more than doubled its value added, followed the bio-based chemicals, pharmaceuticals and plastics sector that increased its value added by 86.3%. This is visualised in the Figure 41 showing the growth of value added in the bioeconomy sectors in the Baltic Sea Region between 2008 and 2020. Interestingly, most of the bioeconomy sectors that decreased their employment between 2008 and 2020 increased their value added, most notably the agriculture and fishing and aquaculture sectors. Although bio-based textiles sector almost halved its employment, its value added decreased only by about 7%, meaning that also this sector increased its value added per person employed.
Figure 42 shows the value added created by bioeconomy sectors in BSR per country in 2020. It is apparent that bioeconomy sectors in Denmark, Finland and Sweden created relatively more value added than the bioeconomy sectors in Estonia, Latvia, and Lithuania. In the latter, the added value was generated mainly by the traditional sectors. In the former the novel bioeconomy sectors generate a significant part of the total added value.

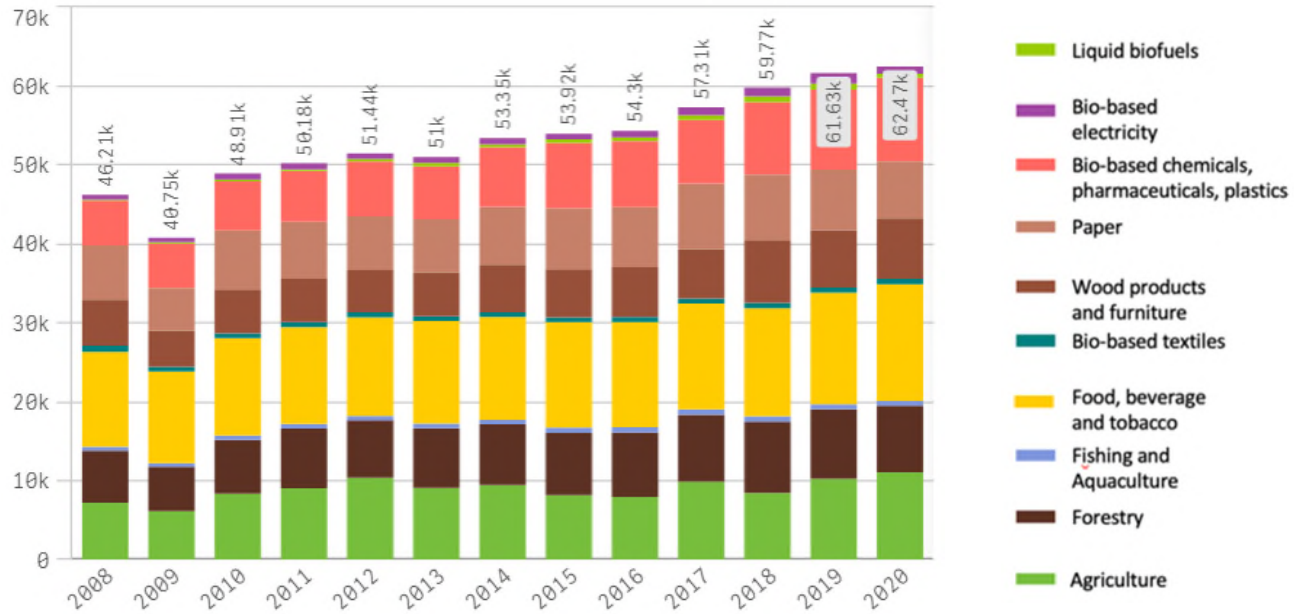

Figure 40. Value added created by bioeconomy sectors in BSR between 2008 and 2020
Source: Datam JRC, European Commission.

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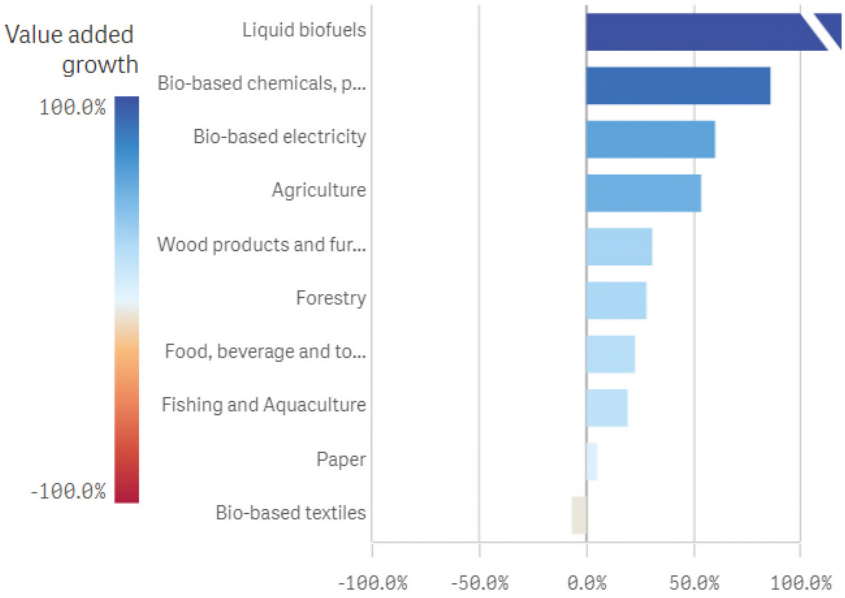

Figure 41. Value added growth in bioeconomy sectors in BSR between 2008 and 2020
Source: Datam JRC, European Commission.

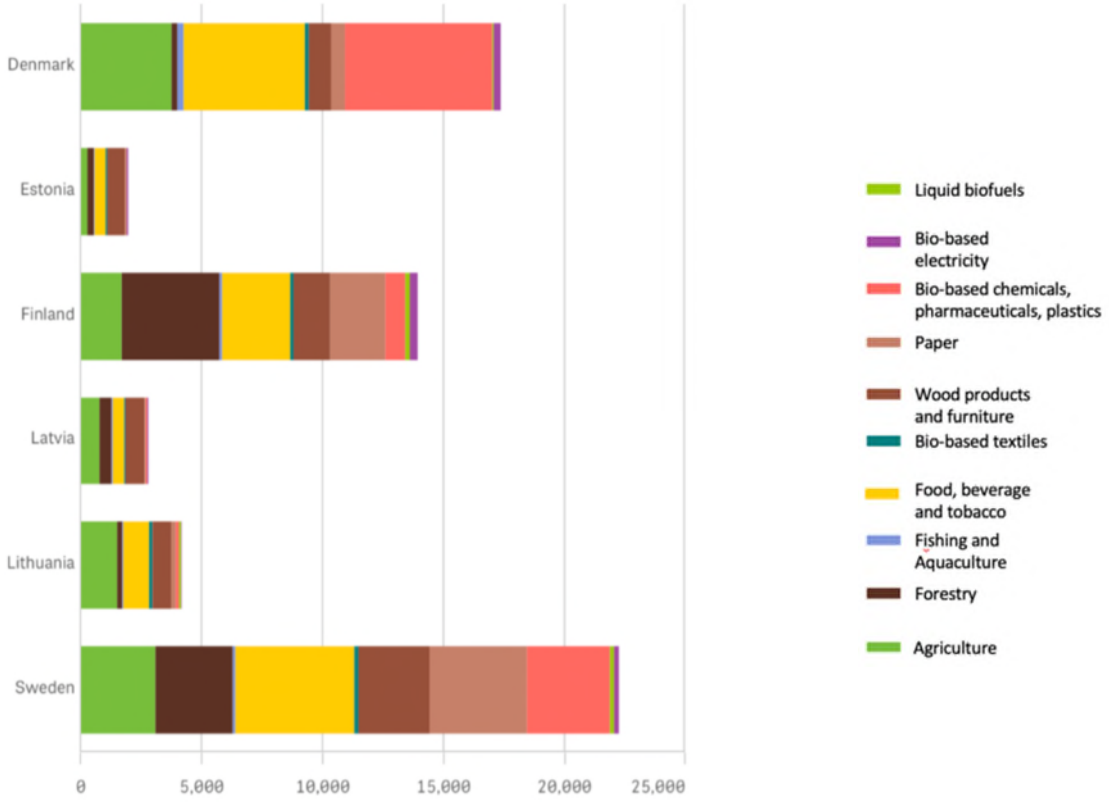

Figure 42. Value added created by bioeconomy sectors in BSR per country in 2020 (in million €).
Source: Datam JRC, European Commission.

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Finally, Table 15 shows the total value added and employment generated in the bioeconomy sectors in the Baltic Sea Region compared to the EU average in 2020. The Baltic Sea Region's share of people employed in all bioeconomy sectors in EU amounts to 6%, while the region's share of value added of all bioeconomy sectors adds to 9%. Put differently, the value added per person employed in the bioeconomy sectors is 64,000 EUR, which is almost double the value of the EU average of 38,000 EUR.
Yet, it should be noted that despite a very good supply of bio-raw materials, the ability of the Estonian, Latvian, and Lithuanian bioeconomy to create added value per employee has been below the EU-28 average Figure 42). The labour productivity of bringing wood and wood products and producing food and beverages in the three countries is two to three times behind the corresponding indicator of Finland, Sweden, and Denmark. The much lower competitiveness of the Baltic States' bioeconomy can be largely explained by the lower complexity of their export products compared to the Nordic countries.

Table 15 Total value added, and employment generated in BSR compared to the EU average in 2020

Number of people employed in biomass producing and converting sectors (thousand)	**BSR's share of people employed in biomass producing and converting sectors (% of EU)**	**Value added of biomass producing and converting sectors (billion €)**	**BSR's share of value added of biomass producing and converting sectors (% of EU)**
968.6	6	62	9
Value added per person employed in biomass producing and converting sectors (thousand €)			
Baltic Sea macro-region		EU	
64		38	

Source: Datam JRC, European Commission[16].

4.1.3 Actors

4.1.3.1 Academia, Research and Development

The Baltic Sea Region has an infrastructure of universities, research centres and industries, and active associations for bioeconomy research. There is a strong support towards high-tech university spinoffs. The R&D in the BSR covers the entire bioeconomy. However, each of the Baltic Sea countries specialises in different areas of bioeconomy:

- Denmark has strong competences when it comes to the health sector and production and development of feed, food, and other products based on proteins.
- Lithuania is strengthening its position as a regional hub for biotech. Finland is a pioneer in circular economy and cleantech.

[16] https://datam.jrc.ec.europa.eu/datam/mashup/BIOECONOMICS/

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- Sweden has strong bioenergy and innovative bio-based sectors predominantly based on wood[17].

The range of studies related to the bioeconomy offered by higher education institutions has expanded. Universities and universities of applied sciences have dozens of degree programmes related to the bioeconomy from basic education to opportunities to specialise in bioeconomy. For instance, Finnish higher education institutions offer a study module "Bioeconomy Expert's Competence Portfolio", which includes courses in bioeconomy offered as part of open higher education at many different higher education institutions (Finnish Government, 2022).
A study from 2019 done by Lovric et al. mapped research activities in the field of forest-based bioeconomy, based on projects from the EU framework programmes and the European Research Area. Projects listed in the CODRIS database (FP7, H2020 and Work Programme on European Research Area) were used as a primary data source between 2008 and 2018. During that period, Swedish and Finnish organizations received the third and fourth highest amount of funding, respectively. Sweden received EUR 126 million and Finland EUR 125 million, after Germany and France. Finland had the highest number of project coordination's (62) followed by Germany (59). Also, when looking at the share of funding allocated to private companies Sweden and Finland stand out. Among the most funded private organizations in Europe were Swedish Biofuels AB and the Technical Research Centre of Finland (VTT). When looking at the number of cooperation done between countries, Finland after Germany has the second highest number of bilateral project cooperation ties out of all European countries. These ties were mostly with Germany and Sweden. At the company level, VTT is the organization with the highest overall number of project participations (68), followed by Fraunhofer Society (41) and Swedish Research Institute (34).
Also, Denmark has strong bioeconomic research environments that over time have had great success in the EU framework programmes for research and development. Several EU-funded research projects using biomass feedstock and biotechnologies have also been running in Lithuania and Latvia in the last few years. This demonstrates the interest and commitment for bio-based activities by the scientific and industrial communities in these countries.
Recently, there have been some important investments made into the bioeconomy development. For instance, in 2020, Fortum and Metsä Group in Finland launched a joint EUR 50 million R&D programme in circular bioeconomy. The joint work between Fortum and Metsä Group is focused especially on the textile and bio composites themes. The companies work in close co-operation with academia, technology developers and R&D service providers to drive R&D that supports the future commercialization of new bioproducts. Fortum and Metsä Group joined forces with Business Finland to create a world-class R&D programme with pulp fibre from renewable and sustainable sources as its node. The 4-year joint R&D programme, called ExpandFibre, aims to develop ground-breaking technologies and smart business concepts that are required to convert straw and wood pulp fibre into novel bioproducts, such as textile fibres. The R&D programme has been granted EUR 20 million from Business Finland[18].

[17] https://www.ri.se/en/our-stories/bioeconomy-arena-will-make-sweden-a-world-leader-in-bioeconomy#:~:text=leader%20in%20bioeconomy-,Bioeconomy%20Arena%20will%20make%20Sweden%20a%20world%20leader%20in%20bioeconomy,by%20the%20end%20of%202023.
[18] https://www.fortum.com/media/2020/06/fortum-and-metsa-group-launch-joint-eur-50-million-rd-programme-circular-bioeconomy

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4.1.3.2 Industry

The BSR bioeconomy is dominated by the forest industry and the products that are created by the forest as raw materials. Other important sectors are agriculture and food, biotechnology, and bioenergy (mainly from forestry) industries. It also features a solid chemical industry (fed by forestry).
The presence of many international actors in the biotechnology sectors and a well-organised innovation support infrastructure provide an ideal environment for a sustainable bio-based sector. The Baltic Sea Region offers many high-tech hubs including biotech (with specialisations in medicine and industrial biotechnology, pharmaceuticals, chemicals) and has active national biotechnology associations. The BSR has a network of technology parks and incubators. It also has a strong start-up community with a high potential to support and foster bioeconomy.
There are many hubs in BSR, especially in the forestry industry. For instance, Örnsköldsvik in central Sweden is a world leader HUB in the forestry, wood, and paper industry and the centre for the development of new sustainable products from forest raw materials.
BSR also offers many science and business parks associated with bioeconomy. Examples are:

- **Tehnopol Science and Business Park (EE)** is the largest science park in the Baltics providing enterprises with everything they need to develop and scale up, including real-life test environments, office space, business counselling and innovation testing.
- **Sunrise Valley Science and Technology Park (LT)** surrounded by 2 major universities, 5 open access research centres and business community supports the development of entrepreneurship, promotes business and science collaboration, provides infrastructure and innovation support services to young, innovative enterprises as well as to other knowledge-intensive business.
- **Medeon Science Park (SE)** surrounded by 3 major universities supports the development of life science and health-based companies, runs an active Life Science Network, and has an incubator for newly started companies in life science.
- **Medicon Valley (DK)** is the strongest life science cluster in the Nordic countries. There are 350+ biotech, medtech and pharma companies with local R&D, 9 life science universities, and 7 science parks with a major focus on life science, (with a total of 1500 companies) as well as 10 incubators.

Considering the ”blue” industries, production of macroalgae and seaweed is at a nascent phase in the BSR and almost 100% macroalgae raw material supply come from import from third countries, like Norway, Russia, and China. Commercial macroalgae production activities in the BSR are mostly limited to wild harvesting at local radius, with Denmark being the largest seaweed producer (100 tonnes in 2018). Only 6 marine seaweed farms exist: all being in the Western Baltic Sea Region. In addition to these primary producers, however, already around 60 commercial companies are active in processing and producing seaweed products marketed in the BSR. There are 15 macroalgae and 6 microalgae enterprises in the BSR, where most of them are in Denmark (13), followed by Sweden (5), and Estonia (3). Algae cultivation is not yet fully established in the Baltic countries, however, there are some starters (Submariner roadmap beyond 2021, 2021).
Around 60 commercial companies are active in producing seaweed products marketed in the Baltics; of which some samples are shown in Table 16 (Schultz-Zehden et al, 2021).

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Table 16 Examples of companies active in producing seaweed products in BSR

Food products	Nordisk Tang, Dansk Tang, Seaman, and Gourmet Tang from Denmark Numami in Estonia
Cosmetics	Melissa and Organic Seaweed in Denmark Furcella and Vetik in Estonia
Seaweed enriched feed	Fermentation Experts in Denmark Volta Greentech in Sweden
Technology providers	Metal production/Rocket Cluster is a Lithuanian-Norwegian company offering non-standard design of hardware installations for aquaculture SFTec in Finland is a SME that developed a modular drying solution for macroalgae; Origin by Ocean is a Finnish start-up producing biorefining technologies for macroalgae as well beach-wrack (eelgrass) bioresources EHP Environment in Finland is developing sensors for collecting marine and oceanographic data. Pure Algae DK produces technologies for growing green seaweed in tanks on land AquaGreen is a Danish company that has developed an integrated steam drying and pyrolysis solutions, suitable for wet biomass.

Source: Schultz-Zehden et al (2021).

Many initiatives take place in BSR that boost the bioeconomy development through the start-up community. For instance, Hackathon is a solution-based start-up competition that brings together teams with the common goal of quickly solving problems based on local industry and private sector needs. Following the competition, selected companies/initiatives receive support for developing ideas and turning them into prototypes, including full-scale mentoring by national and international experts supported by local entrepreneurs. Some of the most prominent hackathons include:

- **Hacking Wood (EE)** "Garage48 Future of Wood" is a makeathon series where people with varying expertise and backgrounds develop wood-based solutions.
- **ValioHackathon (FI)** is an innovation competition aiming at finding concrete and effective ways to balance seasonality on farm level.
- **Foodhack (SE)** is an innovation competition that connects food entrepreneurs and innovators.

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Investments

Some important investments have been made into the bioeconomy development. For instance, the Swedish cooperative Lantmannen is currently designing a new large-scale production plant in Lidkøping for EUR 85 million (SEK 1 billion). The factory aims to process peas into a highly concentrated pea protein isolate, and the residual stream will be connected to existing biorefineries. The protein will have many uses such as protein drinks and bars, milk replacers, bread, and meat substitutes. The production facility is expected to be completed in early 2026[19].

Further, in Sweden, SCA and St1 have entered a joint venture to produce and develop liquid biofuels. A new plant is expected to be operational still be this year (2023) and will produce renewable diesel (HVO) and sustainable aviation fuel (SAF). The project is worth around EUR 215 million (SEK 2.5 billion) with a capacity to produce 200,000 tonnes. The raw material is pine oil, which is a residual product from the production of sulphate pulp at several SCAs factories[20].

Taaleri's EUR 20 million investment Joensuu Biocoal Oy will build a bioindustry plant producing torrefied biomass in Joensuu in Finland. The plant is expected to start production end of 2024. The planned total production of the plant is about 60,000 tonnes of torrefied biomass per year. The product can replace the use of coal in, for example, the cement and steel industries. It can also be used in soil improvement and water treatment[21].

NCC and Research Institutes of Sweden about EUR 13 million (SEK 150 million) investment (with over EUR 30 million (SEK 350 million) contribution from the Swedish state) will build the Bioeconomy Arena, a pilot hall with test bed facilities for the development of new biochemical products. The new pilot hall will facilitate the scaling up and commercialization of new biological products and solutions. Occupancy is planned for the winter of 2023/2024[22].

Another new investment area is biosolutionss in Denmark, a business area based on understanding and utilizing biological systems and producing enzymes, proteins, bacteria, biomaterials, etc. on an industrial scale. Biosolutions are particularly widespread within advanced foods, where they have strong positions within bio-based ingredients and fermentation technologies that, among other things, are used to produce beer and cheese[23].

Industrial clusters

Cluster mapping helps to understand better the industrial strengths in bioeconomy related areas across the BSR. The European Observatory for Clusters and Industrial Change offers an extensive cluster mapping dashboard that allows visualisation of cluster locations by sectoral industries[24]. The ShapingBio team extracted a series of cluster mapping visualisations in the main bioeconomy related thematic fields (based on the on NACE 2-Level sectors system) covering the BSR.

The mapping shows that within the studied BSR, a lot of attention is paid to bioeconomy-related cluster development. Clusters first appeared in the BSR several decades ago, but the pace of clusterisation increased dramatically during the period of 2010– 2015, with the implementation of EU financial instruments supporting their development. Today, BSR has a well-developed cluster structure: most industrial sectors have their own cluster representation. The majority relate to biotechnology, energy, food, paper and pulp, and waste. Finland also has many water expertise clusters, ecosystems, and networks.

[19] https://www.lantmannen.com/about-lantmannen/newsroom/press-releases/2022/billion-sized-investment-makes-lantmannen-unique-in-northern-europe/
[20] https://www.st1.com/sca-and-st1-enter-joint-venture-to-produce-and-develop-liquid-biofuels
[21] https://yle.fi/a/74-20031476
[22] https://www.ri.se/en/our-stories/bioeconomy-arena-will-make-sweden-a-world-leader-in-bioeconomy
[23] https://www.dti.dk/testing/biosolution-technology-centre-btc/44422
[24] www.clustercollaboration.eu/cluster-mapping

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Figure 43 shows all clusters of the main bioeconomy related thematic fields including agriculture, forestry, blue economy, bio-based sectors, and food systems. The cluster mapping data shows 38 clusters across the entire region, except for Estonia. Figure 43 shows that forestry clusters are concentrated in the regions of the Scandinavian countries, especially in Finland. Agriculture and food clusters are apparent in all BSR countries (except for Estonia). Whereas the agriculture and forest clusters are situated in the countryside, the food clusters are also frequently situated around urban areas such as Malmö, Riga, Kaunas, and Vilnius. There are only a few clusters in the blue economy, and these are in Denmark, Finland, Latvia, and Lithuania. The cluster mapping data shows that there are strong industrial capacities in bio-based sectors in BSR. There are 26 bio-based industry clusters in total, where Finland features as the leader. The Table 17 summarises the number of clusters per bioeconomy field in EU-27 and BSR. Most clusters represent between 16 and 20% of all EU-27 clusters per field. Yet, 31.3% of all forestry clusters in EU-27 take place in BSR.

Table 17 The number of clusters per bioeconomy field in EU-27 and BSR

Sector	**EU-27**	**BSR (DK, EE, FI, LV, LT, SE)**	**Bioeconomy sectors in BSR as a share of EU-27**
Agriculture	44	7	15.9%
Forestry	16	5	31.3%
Blue Bioeconomy	23	4	17.4%
Bio-based sectors	162	26	16%
Food Systems	54	11	20.4%
Total	237	38	16%

Source: European Observatory for Clusters and Industrial Change.

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Figure 43. Mapping of clusters in BSR (DK, EE, FI, LV, LT, SE).
Source: European Observatory for Clusters and Industrial Change.

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4.1.3.3 Civil society

In the BSR, there are many different environmental organisations. Yet, those more active are found especially in the context of forestry. This comes from the fact that the environmental organisations and the forestry industry have often very opposing views on how forest bioeconomy should develop. These organisations are mainly active on a national level. Some of the most active environmental organisations in BSR are listed in the Table 18.

Table 18 Examples of environmental organisations in BSR

Country	**Name of environmental organisation**
Denmark	Greenpeace Noah VELUX Foundation
Estonia	Estonian Forest Aid
Finland	Finnish Association for Nature Conservation WWF Finland
Latvia	Latvian Ornithological Society
Lithuania	Circula economy lt
Sweden	The Swedish Society for Natural Conservation WWF Sweden

Source: Own compilation.

The environmental organisations in BSR have objections mainly to the forest policies, insufficient protection measures and practises by the forest industry:
In Finland, for instance, environmental organisations are opposing the updated Finland's bioeconomy strategy saying that it does not sufficiently address the role of the bioeconomy as an accelerator of habitat loss and climate change, nor does it propose measures to ensure the sustainability of the bioeconomy in the future (Wolfgang, 2022).
In Denmark, the climate policy is challenged for being based on burning (imported) wood biomass for energy and leading to cutting down of trees abroad.
In Sweden the intensive forestry industry based on monoculture and clear-cutting is objected by environmental organisations as loggings conducted by forest companies do not adequately comply with its rules, at the same time as sanctions are lacking and basic requirements are too low. The industry is also being criticised for allowing fertilization, soil scarification, cleaning of ditches, exotic tree species and pesticides. Moreover, the system is based on voluntary protection; only 3.6% of the productive forest area is formally protected and further 4.8% voluntary protected in Sweden (Fisher et al, 2020).
Similarly, only 14.1% of forests in Estonia and 7% in Latvia are strictly protected. Forest management regulations for those forests have become more laxed in Estonia in recent years, and there is heavy pressure from the forestry industry in Latvia to follow the same path (Kuresoo et al, 2020).
Recently, there have been many initiatives aiming to involve youth into bioeconomy activities. One example is the successful Estonian entrepreneurship education programme "Edu ja Tegu". The aim and task are to

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develop young people's entrepreneurial competencies in line with the labour market needs. The programme gathers various stakeholders, such as the Education and Youth Board, different ministries, universities, and county development centres. Another well-working initiative is the Junior Achievement Programmes in secondary schools in Estonia, in which students are encouraged to create student enterprises and propose ideas for the valorisation of local resources (Nordregio EE, 2022).

4.1.4 Bioeconomy Policies in the Baltic Sea Macro-Region

Among the BSR countries, Finland and Latvia have developed dedicated bioeconomy strategies with cross-sectoral approaches, while Sweden is in the process of setting up national bioeconomy strategy (expected to be completed at the end of October 2023). Estonia published a roadmap on circular bioeconomy, which serves as the main policy document for the national bioeconomy development. Denmark and Lithuania have several single-sector strategic documents that support their respective national bioeconomies.

Most of the national bioeconomy documents listed in Table 19 focus on the production and use of biological resources. Generally, agriculture and forestry are seen as the most significant bioeconomy industries. A few countries emphasise additional specific strengths; for example, industrial enzyme production is a particular focus in Lithuania, while Finland and Denmark concentrate on the industrial use of biotechnological processes. Also, chemical industry is important in several countries. Lithuania has set priorities in the bio-based chemistry and biorefining areas and the bioeconomy development is also strongly related to the health sector and bio-based pharmaceuticals (Bio-based Industries Consortium, 2020). Finland focuses on wood processing, specifically the pulp and paper industry.

Latvia and Finland increasingly emphasize the blue bioeconomy in their strategies. The Latvian bioeconomy strategy lists exploring untapped marine bioresources such as sea grass, mussels, and algae as a priority (German Bioeconomy Council, 2018) The Finnish government is pursuing a pro-active policy for promoting sustainable fish aquaculture (Schultz-Zehden et al, 2021).

Some countries have developed specific research and innovation strategies with a priority on bioeconomy-related areas, such as bio-based industries, bioenergy, biosciences, or agriculture/forestry/marine innovations. In these strategies, interdisciplinary cooperation between university, research institutes and business play an important role. Key research topics include new technologies on water treatment (Finland), new bioeconomy value chains (Denmark), environmental (Lithuania) & marine biotechnology (Denmark) (German Bioeconomy Council, 2015).

Even though bioeconomy strategies significantly differ among the countries of BSR, the following aspects are common: the increase of competitiveness, value-added, export, employment rate and sustainable production of biomass.

Table 19 National bioeconomy policies in the Baltic Sea Region

Country	Perspective	Bioeconomy Strategies (year of publication)	Strategy Goals	Priority Areas of the Strategy	
				Target Sectors	Policy Interventions
Denmark	Green Economy	Growth Plan for Water, Bio and Environmental Solutions (2013), Growth Plan for Food (2013)	Economic growth, Job creation, Competitiveness, Ressource efficiency, Grand societal changes	Agriculture, Fishery, Testing of high-value products	Promoting innovation, Commercial-isation

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Estonia	Holistic Bioeconomy Development	Ministry of Regional Affairs and Agriculture of Estonia (2023)	Wealth creation, Sustainable production, Exploit untapped resources, Reduce dependency on non-renewable resources, Promote R&D in biotechnology	Forestry (wood), Agriculture, Food, Fisheries, Biochemicals and plastics, Enzymes, Biofuels	Promoting innovation Infrastructure
Finland	Holistic Bioeconomy Development	Finnish Bioeconomy Strategy (2022)	Economic growth, Job creation, Competitiveness, Wealth creation	Forestry (wood), Agriculture, Food production, Chemical, energy industries, Bioenergy	Promoting innovation, Infrastructure, Commercial-isation, Policy framework conditions
Latvia	Holistic Bioeconomy Development	Latvian Bioeconomy Strategy 2030 (2017)	Economic growth, Socially responsible and sustainable development	Agriculture (food), Forestry (wood), Fisheries (aquaculture), Chemicals	Promoting innovation, Demand-side instruments, Infrastructure, Commercial-isation
Lithuania	High-Tech	National Industrial Biotechnology Development Programme 2007-2010 (2006)	Economic growth, Competitiveness, Grand societal challenges	Industrial enzyme production, Biotechnology, Agriculture (food production)	Promoting innovation, Infrastructure, Commercial-isation
Sweden	Research & Innovation	Swedish Research and Innovation Strategy for a Bio-based Economy (2012), Swedish strategy for circular economy (2020)	Economic growth, Grand societal challenges, Sustainable society	Bio-based industries, Forestry (wood), Agriculture, Biofuels for transportation	Promoting innovation, Infrastructure, Commercial-isation, Demand-side instruments

Source: Various national strategies.

4.1.4.1 National bioeconomy strategies

The Latvian bioeconomy strategy and the Estonian circular bioeconomy roadmap set vision for the national bioeconomy but do not provide an action plan. In 2022, Latvia published its first action plan on research and innovation within S3 that goes along with the bioeconomy strategy. A key aim guiding the update of Finland's Bioeconomy Strategy has been the preparation of a systematic, comprehensive, and exhaustive action plan for developing the bioeconomy's value added. The upcoming Swedish bioeconomy strategy will include an action plan. One of the known key actions will be the continued research and innovation.
The national bioeconomy strategies have been shaped by the EU bioeconomy policy. Finland, Latvia, and Estonia have included the five EU Bioeconomy Strategy objectives in their national bioeconomy strategies (European Commission, 2018).

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EU bioeconomy strategy objectives

- Ensuring food and nutrition security
- Managing natural resources sustainably
- Reducing dependence on non-renewable, unsustainable resources
- Mitigating and adapting to climate change
- Strengthening European competitiveness and creating jobs

In fact, the Finnish strategy is even more ambitious and goes beyond the goals of the EU Bieconomy Strategy (expert interview). Reference to Green Deal particularly circularity can be seen in the national documents (FI, EE, LV), as a key aspect in the sense of them stating not to waste natural resources but to use and recycle them efficiently. In addition, the Finnish and Latvian Bioeconomy Strategies strive to make their country into a low-carbon and resource-efficient society, which aligns with the Paris Agreement as well as with the SDGs. (The idea is there, but with less debt and regulating.) Moreover, the development of LIBRA is based on insights from the guidelines of the EU Strategy for the Baltic Sea Region policy area "Bioeconomy - agriculture, forestry and fisheries", (LIBRA, 2017; Ministry of Regional Affairs and Agriculture of Estonia, 2023; Finnish Government, 2022).
The Finnish, Latvian and Estonian national documents aim to develop and promote horizontal and vertical cooperation at different stages and levels of the value chain. They encourage cooperation between research and business life as well as participation of actors in international networks and promote cross-sector cooperation. Finnish and Estonian national documents also encourage companies in different sectors to engage in regional cooperation to develop a business ecosystem based on side and waste streams. Additionally, the Finnish strategy promotes cooperation between nature tourism and other nature entrepreneurs as well as between educational institutions and business life.
The Finnish, Latvian and Estonian national documents support investments in piloting, piloting and demonstration infrastructures and bio-processing facilities, and investments in the development of already existing facilities. Further, they aim to educate bioeconomy sector experts, producing new knowledge and knowledge transfer to prepare enough specialists with the necessary skills. Further, an effort is made in vocational education and training and its planning to anticipate the increasing competence needs of different sectors. Furthermore, Estonian circular bioeconomy roadmap aims to create and use of 'hands-on' circular bioeconomy teaching materials in kindergartens and general education schools (LIBRA, 2017; Ministry of Regional Affairs and Agriculture of Estonia, 2023; Finnish Government, 2022).
They aim to strengthen research and development and innovation competences, the development, deployment, and acceptance of new technologies in society. Beyond that, the national strategies use different instruments to further promote bioeconomy. For instance, Finland offers business advisory services for SMEs and provide better communication on available funding opportunities. Latvia promotes forest owners' certification, offers tax incentives for bio-based companies, increases the real estate tax on agricultural land not used for production and using the revenues for the development of the industry. Estonia applies IT solutions, including artificial intelligence, to use circular bioeconomy data and develop products and services, create digital collaboration platforms, optimise processes, and increase efficiency.

Policy governance responsibility

Whereas in Estonia, Latvia, Lithuania, and Denmark the Ministries of Agriculture are responsible for the bioeconomy policy development, in Finland and Sweden the Ministry of Economic Affairs and Employment and Ministry of Enterprise and Innovation, respectively, are responsible for it. This differences in responsible ministries may influence the bioeconomy policy of a country as such. According to an expert interviewed, a national bioeconomy strategy developed by a ministry of agriculture may focus too much on

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primary production and too little on higher levels of the value chain and not foster intersectoral collaboration adequately. By contrary, a strategy developed by a ministry of economy and innovation is in expert's opinion more appropriate, because the ministry aims to foster and innovate bioeconomy across the whole value chain.
All BSR countries horizontally coordinate their bioeconomy strategy development. Usually, they have an advisory board composed of representatives of the ministries involved. For instance, the Latvian advisory board consists of representatives of the Ministry of Agriculture, Ministry of Economics, and Ministry of Science and Education. Additionally, some have advisory boards at universities that consult ministries, provide necessary information, and make analyses, and conduct applied research. Moreover, Finland, Denmark and Sweden have national bioeconomy panels (in Sweden it is an expert group) that consist of representatives of different sectors, administration, research, industries, non-governmental organisations, and other stakeholders. The panel's aim is to facilitate a continuous dialogue between public authorities, research institutions, business and civil society and actively participate in the bioeconomy policy process. Estonia is considering establishing a comparable bioeconomy advisory entity.

Policy instruments

As described above, the Baltic Sea Region, encompassing the countries of Denmark, Sweden, Finland, Estonia, Latvia and Lithuania is characterized by a high wood biomass supply with forest-based economies in Estonia, Latvia, Finland, and Sweden on the one hand, and blue bioeconomic activities as all of the countries have access to the sea. These economic landscape is also reflected in several policy instruments of the region. The most significant ones are listed in the Table 20. For instance, in the Scandinavian Sweden and Finland, several forest-based policy instruments can be identified. As has been observed in the other Macro-regions, also in the Baltic Sea Region, supply side policy instruments persist with support for public research and grants for industrial R&D as the most implemented instruments. Several funding activities shape the bioeconomy landscape in the countries. These policy instruments are not directly dedicated to the bioeconomy though, but deal with aspects, which are important for bioeconomy development in the region. The Innovation Fund Denmark, for instance aims to provide new climate mitigating solutions, healthier food or a cleaner environment. Also in the biotechnology domain, several countries of the Baltic sea region support public research with different funding schemes. The Finnish Flagship Program, offered by the Finnish Research Council, provides long-term funding and fosters collaboration between different actors and stakeholders. An interesting project that is funded under the Finnish Research Council is FORBIO - Sustainable, Climate-Neutral and Ressource-Efficient Forest-based Bioeconomy that aims at providing solutions for enhancing climate-neutrality and resource-efficiency of the forest biomass production or the production and use of forest biomass-based products . Moreover Finnland launched an 'Accelerator for low- carbon and circular economy public procurements' was launched in 2018 and is managed by the Finnish Environment Institute in cooperation with the Competence Centre for Sustainable and Innovative Public Procurements (KEINO).
In conclusion, while significant support for the bioeconomy exists especially for the Scandinavian countries and to some extent in the Baltic ones almost all of the identified measures relate to support for public research or grants for industrial R&D. This is inline with findings from Scordato et al. (2022) for Scandinavian countries, who only identify Finland as an exception with increasing activities in public procurement for bio-based products.

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Table 20 Policy instruments targeting bioeconomy development in BSR

Country	Policy Instrument
Denmark	GUDP – Green Development and Demonstration Program EUDP – Energy Technology Development and Demonstration Program MUDP – the Environmental Technology Development and Demonstration Program Innovation Fund Denmark Independent Research Fund Denmark Green Tax Reform (2030)
Estonia	ResTA Baltic Innovation Fund 2 (BIF 2) RITA NUTIKAS Circular economy program Forestry program Fisheries program
Finland	Food from Finland BioFuture2025 Finnish Flagship Programme FinnCERES – Competence Centre for the Materials Bioeconomy ForestValue2 Co-Creation funding Co-Innovation funding
Latvia	Baltic Innovation Fund 2 (BIF 2) Fundamental and Applied Research Program
Lithuania	Baltic Innovation Fund 2 Tax incentives for investment and innovations Large-Scale Projects
Sweden	FORMAS VINNOVA BioInnovation Bioeconomy Arena SamInvest AlmiInvest

Source: Own compilation.

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4.1.4.2 Regional bioeconomy strategies

At the regional level, bioeconomy has been integrated into a wide range of different regional strategies in the Baltic Sea region in recent years Table 21. There are 87 strategies (published and under development) at regional level that are fully or partially dedicated to bioeconomy and contribute to its deployment across BSR regions (situation as of November 2021). Of these, 7 are fully dedicated to the bioeconomy, i.e. directly focus on the deployment of the bioeconomy (Figure 44). Of those remaining, bioeconomy is addressed in sectoral strategies in 22 cases of the published regional strategies. In most cases, it is addressed in forestry plans/strategies (18), followed by strategies on energy (4).

In 65 cases, bioeconomy is embedded into wider strategic frameworks. This is mostly the case within regional/territorial or rural development plans (24), within Smart Specialisation Strategies (15), and within climate/low-carbon plans (8). In several cases, bioeconomy is part of circular economy strategies (3), sustainable development strategies/plans (3), green transition/green growth (3), economics/industrial development at regional level (1).

Sweden is the country with the largest number of strategies, adopted or under development, related to the bioeconomy in BSR (39), followed by Finland (38). These two countries display intense regional strategic action to deploy the bioeconomy. Except for Estonia, which has no bioeconomy-relevant regional strategy, in the rest of the BSR countries the bioeconomy is deployed to some extent at regional level (Denmark (7), Latvia (2), Lithuania (1)).

The regional strategic frameworks link directly to the five objectives of the EU Bioeconomy Strategy. The objective most frequently addressed, is the ‘Sustainable management of natural resources’. ‘Reducing the dependence on non-renewable resources’ and ‘Strengthening the competitiveness of the regions and creating jobs’ are also prominent objectives addressed by the regional strategies.

Certain patterns per country could be observed, e.g. how and in which wider frameworks bioeconomy is embedded. For example, in Sweden, the bioeconomy is often included in forestry and regional/territorial/rural development strategies, while in Denmark it is typically addressed within green transition and energy strategies. In Finland, bioeconomy is covered in almost every Regional Development Plan and in many Smart Specialisation strategies, but also often in climate plans.

Only few bioeconomy strategies aim at enhancing the value added of the bioeconomy sector, while some strategies, mostly the fully dedicated strategies, address all steps of the bioeconomy value chain.

Table 21 Overview of regional bioeconomy strategies in BSR – Strategies per country (published and under development)

Country		**DK**	**EE**	**FI**	**LT**	**LV**	**SE**	**Total**
Fully dedicated bioeconomy strategies		1		3		1	2	7
Sectoral	Forestry			3			15	18
	Energy	3		1				4

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Embedded into	Smart Specialisation			12	1		2	15
	Regional/Territorial/ Rural Development			8			16	24
	Circular Economy			2			1	3
	Sustainable Development	1		1		1		3
	Climate/ Low-Carbon			6			2	8
	Economics/ Industrial Development						1	1
	Green Transition/Green Growth	2		1				3
	Other			1				1
Total		7		38	1	2	39	87

Source: Haarich et al. (2022).

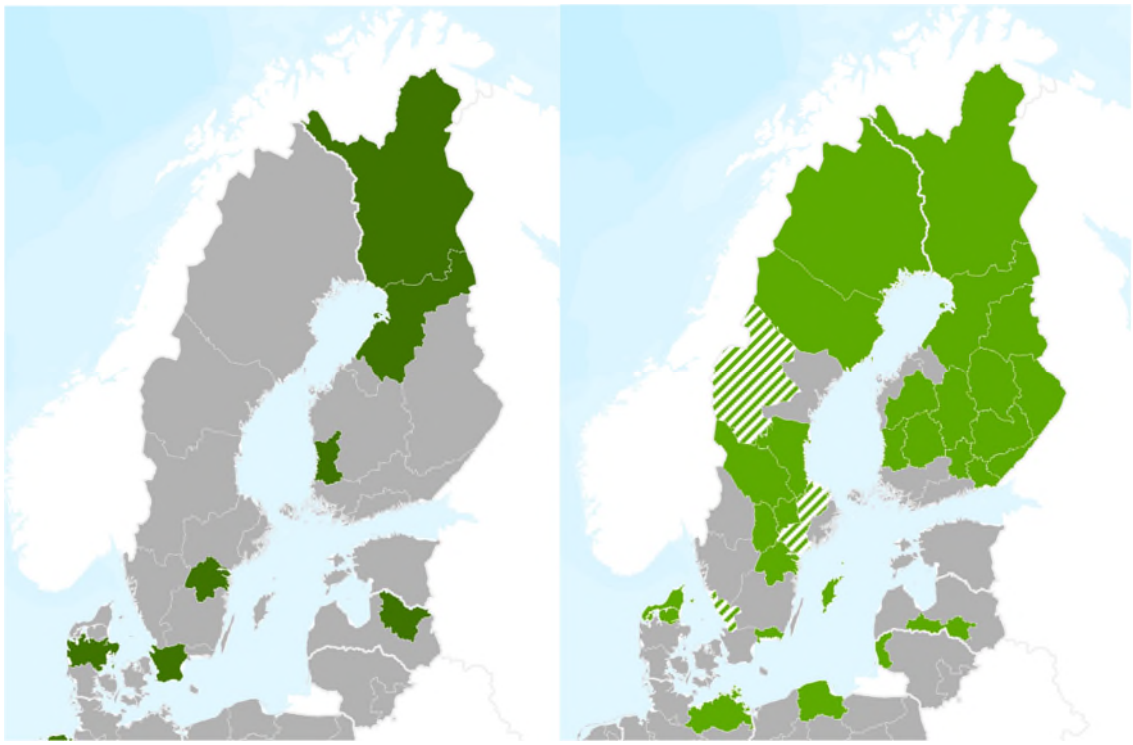

Figure 44. BSR regions with fully dedicated bioeconomy strategies (left), with strategies where the bioeconomy is one of the key elements (striped are under development) (right).
Source: EC Bioeconomy strategy development in EU regions (2022).

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4.1.4.3 Macro-regional bioeconomy strategies

EU strategy for Baltic Sea region

The Baltic Sea region has a long tradition of cooperation. There are more than 40 transnational organisations and networks in BSR. Some examples are:

- The Nordic Council of Ministers
- Council of the Baltic Sea States
- The Union of the Baltic Cities
- Helsinki Commission
- Baltic Sea States Sub-Regional Cooperation
- Baltic Sea Commission of the CPMR
- SUBMARINER Network for Blue Growth

Based on that tradition, in 2009 the EU Member States in the region decided to start a new type of transnational cooperation. The EU strategy for Baltic Sea region (EUSBSR) - the first macro-regional strategy in Europe - provides a unique platform for cooperation and coordination between eight EU Member States (Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Poland, and Sweden (EUSBSR, 2021).
The EUSBSR is accompanied by an action plan, a document to be regularly revised as necessary. The updated strategy from 2018, recognises the need for increased involvement of EU's Member States, actions to develop a circular economy, and better monitoring of progress of the bioeconomy. Prioritized policy areas include security of energy supply, promotion of the bio-economy, and improved nutrient recycling. The Policy Area Bioeconomy coordinates national bioeconomy policies, promotes the usage of bio-based business solutions, fosters the development of biological resources and new technologies and reaches out to new stakeholders. The Policy Area Bioeconomy covers sustainable use of biomass, agriculture, forestry, fisheries, aquaculture and rural development and it takes the entire value chain into account. The Policy Area Bioeconomy is aligned with EU regional - and international strategic frameworks such as the EU Bioeconomy strategy for sustainable Europe (EUSBSR, 2021). It also swiftly mentions the climate objectives of the Paris Agreement.
EUSBSR does not have specifically allocated financial resources. Thus, funding for operations under the Strategy is intended to come from existing financial instruments. In the period 2021-2027, the Interreg Baltic Sea region transnational programme continues to support the implementation of the strategy, especially with regards to its governance. However, the limited programme budget cannot cover all the needs of the EUSBSR. Therefore, it must mobilise and use EU 'mainstream' national and regional programmes, cooperation programmes and other EU funding sources (EUSBSR, 2021).
According to an expert from the Nordic Council of Ministers, cooperation works better between regional actors as regions are closer to local industries (e.g. through local clusters), they have specific tools to work with, and have key resources to work with industries. Also, knowledge can be transferred more easily on a regional than national level.
One of the biggest gaps of the EUSBSR strategy is that food is not as prominent as it should be. The reason for this is that food policy has a lot of overlap with other areas like health, environment, tourism, and security. At the same time, focusing too much on food would have excluded forestry, which is more relevant in the BSR. Further, some areas of the policy framework are still underdeveloped or restricted. For instance, industries find it difficult to get approvals for producing certain products made from algae or for mixing insects into other food products (expert interview).
Moreover, there are also challenges related to the governance structure. Whereas bioeconomy covers all areas where biological resources are used, the strategic and guiding body "steering group" consists of representatives from ministries who cover only one area. It turned out it would be more efficient to divide

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administration into three areas based on production: (1) protein produced by agriculture and maritime sectors (2) fibre and material made by utilization of bioproducts (3) energy produced by forestry (expert interview).

BSR bioeconomy programme

Besides the EUSBSR there is also the BSR bioeconomy programme, which was initiated by the Nordic Council of Ministers and presented in the same year as the revision of the EU bioeconomy strategy in 2018. The compatibility between economy and environment is the main aspect of the BSR bioeconomy strategy which is based on four main pillars: 1. competitive bio-based industries, 2. inclusive economic development, 3. sustainable resource management, and 4. resilient and diverse ecosystems. BSR bioeconomy programme is not binding and has no action plan. The document is more a vision than a holistic program. Considering individual BSR countries, the strategy has been adopted in national bioeconomy strategies (Germany, Finland, Latvia) or integrated into other policy documents (Sweden, Poland, and Denmark). Only Lithuania and Estonia have not adopted this strategy yet (Nordic Council of Ministers, 2015).

The BSR-Bioeconomy strategy is not pursued under one joint budget. Activities related to providing oversight, management and facilitation of BSR-Bioeconomy cooperation are funded by the Nordic Council of Ministers, with contributions from the European Union. Implementation of more specific and specialised project activities need support from other partners (e.g. Nordic institutions; the EU Horizon 2020 programme; the EU Baltic Sea Region programmes) (Nordic Council of Ministers, 2015).

4.2 Policy process and policy coordination in Denmark

The Baltic Sea Region bioeconomy is developing rapidly, and it is vital that the BSR's national and regional policies follow and support this development.

A detailed analysis of the policy process and policy coordination for the bioeconomy in Denmark is shown below.

4.2.1 Characterization of horizontal coordination between different ministries/departments

The policy process for bioeconomy has origins in various ministries in Denmark. Bioeconomy seems to be considered as a system in Denmark, and expands across agriculture, forestry, and fishery sectors with many aspects of climate, environment, and nature conservation as well as research and innovation support at administrative and policy levels and is rather difficult to extract as such from various ministries and bodies. Furthermore, the public handling of organic waste fractions (food waste, sewage treatment, and Garden/Park waste should be considered part of the bioeconomy. Finally, the 'fermentation industry' using microorganisms to produce medicine and ingredients could also be viewed as part of the bioeconomy (interview with Food & Bio Cluster Denmark).

The central ministries involved in the policy process of bioeconomy solutions are:

- Ministry of Food, Agriculture and Fisheries of Denmark which is responsible for administrative and research tasks in farming, fisheries, and food production.
- Ministry of Environmental of Denmark which is responsible for administrative and research in environmental protection.
- The Ministry of Industry, Business, and Financial Affairs seeks to improve the conditions for business in Denmark. The Ministry conducts thorough economic analyses and suggests policy initiatives in areas imperative to economic growth.
- The Ministry of Higher Education and Science has responsibility for research policy, innovation, and higher education. Universities, colleges of applied sciences, business academies, research

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parks, sector research institutes, research centres, and Danish institutes abroad belong, among others, to the ministry.
- The Ministry of Climate, Energy and Utilities is responsible for national climate policy and international cooperation on climate change, as well as energy issues, meteorology and national geological surveys in Denmark and Greenland.

The Ministry of Food, Agriculture, and Fisheries of Denmark has been most active in the policy process of bioeconomy and is the initiator of the National Bioeconomy Panel (NBP). The NBP works within the framework of political objectives at the national, European, and international levels. Examples include Agreement on the green transition in agriculture, Green Deal, Fit for 55, Strategy for PtX, and carbon capture and storage.
It is the Minister for Food, Agriculture, and Fisheries who decides on which theme the NBP must prepare recommendations to the government. The minister makes the decision after dialogue and reconciliation of expectations with the chairman of the panel and the inter-ministerial steering group.
The NBP sets up a thematic business group that corresponds to the theme being addressed. The company group can consist of 5-10 companies. The business group is appointed by the panel's chairman. The business group's role is to inspire and challenge the panel during the work on a theme.
The cross-ministerial steering group consists of a representative from the Ministry of Food, Agriculture and Fisheries, The Ministry of the Environment, The Ministry of Industry, Business, and Financial Affairs, the Ministry of Higher Education and Science and Ministry of Climate, Energy and Utilities. The Ministry of Food, Agriculture and Fisheries is chairman of the group. The steering group meets as at least once a year and is responsible for the government's feedback on the panel's recommendations.
The NBP is served by a cross-ministerial secretariat under the leadership of the Ministry of Food, Agriculture and Fisheries with the participation of employees from the Ministry of Food, Agriculture and Fisheries, the Ministry of the Environment, The Ministry of Industry, Business, and Financial Affairs, the Ministry of Higher Education and Science and the Ministry of Climate, Energy and Utilities
The NBP recommendation as the number 1 priority is to draw up a national bioeconomy strategy for Denmark, which sets clear political goals and creates a framework for cooperation with other countries that must ensure Denmark plays a central role in the global circular bioeconomy (NBP, 2022).
The Danish Chamber of Commerce has long called for a bioeconomy strategy that will be able to create a long-term and good framework for public and private investments.
The policy-making process in Denmark has until now focused on green transition in the agriculture and fishery sector and there is a need for a broader approach for example biosolutions, and sustainable materials for textiles and packaging.
It is expected that the Ministry of Industry, Business, and Financial Affairs will take the lead in developing the bioeconomy area in the future. They work to strengthen the Danish position within green technologies, and this is done by
- Strengthen the framework to produce green technologies in Denmark.
- Investment in bioeconomy via regional funds. Focus areas include lighthouse projects (e.g., Biosolutions Zealand) and thematic calls (e.g., circular economy 2023 – approximately EUR 27 million (DKK 200 million))
- Strengthen the conditions for Danish SMEs and the ability of companies and entrepreneurs to develop, adapt, and innovate.

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4.2.2 Role of stakeholder involvement in bioeconomy policy making

Denmark is a democratic country with long traditions of inviting stakeholders around the table to listen to good arguments, learn from, and negotiate needs and wishes in policy making.
In 2019, the government set up 13 climate partnerships, which were to come up with proposals for initiatives that can contribute to the government's climate objective of a 70% reduction in the emission of greenhouse gases in 2030 compared 2019.
In the partnership for the food and agriculture sector, Jais Valeur, Group CEO at Danish Crown, was the chairman with the Danish Agriculture & Food Council (an interest organization representing farmers, food firms and the agroindustry) as secretariat for the partnership.
The partnership, which represented agriculture, aquaculture, forestry, process industry and consumption, discussed and selected several concrete initiatives divided into the categories of agriculture, aquaculture, forestry, food processing and consumers.
The recommendations from the partnership for the food- and agriculture sector formed the background for the agreement 'Green transformation of the Danish agriculture' (2021). In this agreement has the government, together with a broad majority of the parties in the Danish Parliament agreed on that the Danish agriculture must reduce the emission of greenhouse gases by 55-65% by 2030, the emission of nitrogen must be reduced by 10,800 tonnes in 2027 and that massive investments must be made in green technologies, which shall contribute to the green transformation of agriculture.
As part of the agreement on the green transformation of Danish Agriculture of 4 October 2021 (the agricultural agreement), the NBP was relaunched by the Ministry of Food, Agriculture, and Fisheries of Denmark.
The members of the NBP (around 20) were appointed by the Ministry of Food, Agriculture, and Fisheries of Denmark and come from:

- Knowledge institutions (Roskilde University, Aalborg University, Aarhus University, University of Copenhagen, Technical University of Denmark, Danish Technological Institute),
- Trade organizations (Confederation of Danish Industry, Danish Chamber of Commerce, Danish Forest Association, National Ecological Association, Green Power Denmark, 3F-United Federation of Workers in Denmark),
- Industry representatives (Arla Food Ingredients, Topsoe),
- Consulting companies (LLa-Bio-Economy),
- National cluster organisations (Food & Bio Cluster Denmark),
- NGOs (3F, Denmark's Nature Conservation Association).

The mandate was to assess whether Denmark could achieve a 7.4 million CO2 reduction in 2030 by

- Increasing the national protein production.
- Developing new biomaterials.
- Implementing recommendations described in the Agricultural Agreement.

The recommendations that were submitted to the Minister of Food, Agriculture, and Fisheries in September 2022 were a proposal for a concrete development of the seven principles on which the Agricultural Agreement is based:

- Agriculture must be developed and not dismantled.
- Agriculture must be adjusted to be more climate and environmentally friendly while economically sustainable.

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- Agriculture's development of greenhouse gases must be reduced as much as possible, considering the continued sustainable development of the industry, the competitiveness of Danish agriculture, healthy public finances, employment, cohesion, and social balance.
- Discharge of nutrients must be reduced to improve the aquatic environment.
- Agricultural production must take place with consideration for nature and biodiversity.
- Agriculture must ensure sustainable framework conditions and retention of jobs in all parts of the country.
- Agriculture must continue to create jobs and contribute to producing good, healthy, climate- and environmentally friendly and safe food and thereby maintain its decisive position in Danish exports.

To support the work in NBP, scenarios have been drawn up for bioresources for a green transition, to which Aarhus University, the University of Southern Denmark, and Copenhagen University have contributed. The scenarios form the basis for the recommendations on prioritizing bioresources for the green transition.
The feedback from the members of the NBP is that the Ministry of Food, Agriculture, and Fisheries listens to recommendations. As an example, based on recommendations from NBP, GUDP has invested over EUR 3 million (DKK 25 million) in demo and test facilities.
In 2023, NBP was given a new task by the Minister of Food, Agriculture, and Fisheries to assess how to make better use of biorefining and cascade utilization including the need for new supply chains.

4.2.3 Dealing with goal conflicts

Denmark is only a small part of the global bioeconomy, but in the lead when it comes to the intensity of agricultural land use and production. Of the total Danish land area of 4.3 million hectares (ha), there are currently 2.6 million ha. agricultural land (60.5%). Of these, some 80% are used to produce fodder for livestock. At the same time, Denmark has formed comparatively ambitious policies for a translation to renewable energy, including bioenergy, which are all policies that can increase pressure on land use and crop production systems.
Several conflicts exist and new conflicts may arise with the increased focus on the bioeconomy transition in Denmark as

- Release of agricultural land for both climate measures and pure nature and biodiversity purposes
- Lack of carbon from biomass to ensure the transition from fossil fuels to bioenergy.

To address the conflicts of interest inherent in the release of agricultural land, the government has taken the initiative to establish a partnership with agriculture, the food sector, nature organizations, consumer organizations, and municipalities. They aim to come up with a proposal for an overall vision plan for agriculture and address the goals for land use for agriculture, nature, renewable energy, etc.
Recommendations are expected to be available at the end of 2024. The government also plans to establish an inter-ministerial collaboration to ensure better spatial planning (committee on spatial planning). In the first instance, the government awaits the recommendations from the partnership on a vision plan for agriculture and then takes a position on the committee for holistic planning for land use in the open country.
Another approach being debated is the reduction of the need to produce as much fodder in Danish agriculture – which is a political issue. Around 80% of the agricultural land is used for fodder production (pigs and cattle). An implication is that animal production will decrease and more focus could be dedicated to plant food. This transition could be a policy instrument to reach climatic goals but will dramatically change the jobs and the food processing industry.
In addition to the biogenic carbon capture and utilization, direct capon capture and storage are needed to balance the Danish Carbon utilization by 2050.

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Competition is not only concerning land use. It is expected competition concerning the utilization of biogenic carbon resources /biomasses for construction/building materials, plastic, packaging, energy, etc. This leads to the need that biorefining/cascading of the biomass is a key issue towards optimal bioresource utilization. High-value products should be extracted first, materials, food, and fodder next and the bulk low-value side-streams end up being used for energy and fertilizer use for the next production cycle.

4.3 Applied R&D and Technology Transfer in Denmark

Higher R&D funding throughout the value chain in the Baltic Sea Region will speed up progress toward the BSR's bioeconomy. This can be done within the Nordic/Baltic Sea Region where the NordForsk and Nordic Innovation play a particular role.

4.3.1 Policy Instruments for Applied R&D and Tech transfer

According to expert interviews, Denmark benefits from one of the world's best systems for funding opportunities.

There are public options for TRL 4 – 7 activities within the bioeconomy, but there is currently no special scheme. Table 22 shows an overview of relevant public subsidy schemes for TRL 4-7 level in applied R&D.

Table 22 Overview of relevant public subsidy schemes for TRL 4-7 level in applied R&D

Actor/Ministry	**Name of policy instrument**	**Relation to bioeconomy**	**Focus area/technology**	**Instrument**
Ministry of Food, Agriculture and Fisheries	GUDP – Green Development and Demonstration Program	High	Danish food sector. Invests in sustainability and growth between industry and research	i) Grants for applied R&D ii) Grants for networking activities
Ministry of Food, Agriculture and Fisheries	EHFAF – the European Maritime, Fisheries and Aquaculture Fund	Medium	Green transition in the fishery and aquaculture sector	Grants for applied R&D
Ministry of Environment - Danish Environmental Protection Agency	MUDP – the Environmental Technology Development and Demonstration Program	Medium	Development and application of new environmental and resource-efficient solutions. Boost and strengthen cooperation between companies, knowledge-based institutions, and partners in EU.	i) Subsidy scheme. Funding for the development, testing, and demonstration of new technologies. ii) Innovation partnership. iii) International environmental cooperation

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Ministry of Environment/Danish Energy Agency	EUDP – Energy Technology Development and Demonstration Program	Medium	Demonstration of new energy technologies	i) Funds work by enterprises and universities on the demonstration of energy technologies ii) GreenLabs DK iii) international cooperation
Ministry of Higher Education and Science	IFD – Innovation Fund Denmark	Medium		
Danish Board of Business Development, FBCD A/S	Innovation cooperation projects	Medium	The projects must contribute with solutions within FBCD's 4 strategic benchmarks.	Grants for applied R&D based on partnerships.
Danish Board of Business Development	Biosolutions Zealand Innovation fund	High	Scale-up solutions for biosolutions	Grants for vouchers and innovation cooperation projects

Source: Own compilation.

The business lighthouse project ' Biosolution Zealand' supported by the Ministry of Industry, Business, and Financial Affairs will in autumn 2023 offer scale-up vouchers (total budget about 67,000 EUR (500,000 DKK, 50% subsidy) with a deadline of 15th of November. The voucher scheme aims to make it financially possible for SMEs with a solution within the biosolutions area to scale up the solution as an established facility and thus demonstrate its potential for investors and customers without having to make large investments in their own facilities.

4.3.2 Structures and Challenges for Applied R&D and Tech Transfer

Structures and challenges for three major applied R&D and tech transfer activities in Denmark will be reviewed.

4.3.2.1 Green biorefining

Gras protein production can cut the top of Danish soy import of approximately 1.7 million tonnes per year. This will help agriculture on its way to a reduction of CO2 by 70%.

The existing set-up for applied R&D is suitable for green biorefining innovation. The development work with grass protein has come so far that a protein concentrate with a high protein content and high quality can be made, so it is a good feed. At the same time, the side stream of fibre cake is suitable for both cattle feed and biogas. A technical challenge that has not yet been sufficiently resolved is that the yield of protein concentrate is often far too low, and that the business model for green biorefining is therefore still challenged. Downstream projects as 'Value creation of gras protein' with partners from the whole value chain have therefore been established to increase the protein content in the gras and to test equipment that can break down whole grass prior to juicing and protein extraction. By processing the gras into smaller

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particles prior to juicing, you can get more protein out of the juice and thus increase the yield of protein concentrate.
Major challenges in tech transfer include a need for new knowledge about green biorefining/the production of green proteins, and the establishment of processing facilities. There is currently one demo plant (Aarhus University, Foulum), one scale-up facility (Ausamgaard, a farm) and a commercial plant (BioRefine Denmark A/S) producing gras protein in Denmark that regularly organize open house events.
To spread green biorefining in Denmark, the Danish Agricultural Agency has two open calls for green biorefining in 2023/2024:

- A funding program for project maturation of a plant for green biorefining which provides a subsidy to investigate and assess the potential for establishing a plant for green biorefining. Applicants can therefore receive grants to find business partners, consolidate and develop a business and financing plan.
- A funding program for the establishment of a plant for green biorefining, which provides a subsidy for the establishment of a plant that at least refines grass, clover, alfalfa, etc. with a view to the production of protein concentrate for animal feed.

The Danish Agricultural Agency also facilitates network meetings where actors in ongoing projects (>12) can share experience with each other.
It is estimated that green biorefining will become an attractive business area that simultaneously provides great technical CO2 reduction potential in Danish agriculture.

4.3.2.2 Plant-based foods

Plant-based foods are a future growth area and conversion to more plant production is a central element in the green transition in Denmark. An action plan for plant-based foods has been prepared, which contains objectives for how to strengthen the plant-based value chain as:

- The Danish raw material base must be strengthened through subsidies and development efforts.
- The overall Danish plant-based value chain must be strengthened, and the cohesion in the individual value chain links must be increased.
- Research and innovation must be strengthened through public-private cooperation. The government will work to establish research collaborations between the state and stakeholders in the agricultural field, possibly including one or more external actors (e.g., companies, private foundations, or other countries).

Furthermore, the fund for plant-based food (https://plantefonden.lbst.dk/) has been established to support promotion, education, and knowledge dissemination about plant-based foods.
When it comes to strengthen the research and innovation through public-private cooperation, the Novo Nordisk Foundation has taken the initiative to establish Plant2Food with up to EUR 26 million (DKK 200 million) over a five-year period. Plant2Food is a new open innovation in Science platform and will be a hub for researchers and companies who want to collaborate to solve some of the complex issues of developing plant-based foods – without taking out patents based on the results. Plant2Food will focus on developing basis knowledge about the properties of crops and how they can be used in food products. This knowledge can subsequently be used further up the value chain to develop nutritious products that are attractive to consumers.

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4.3.2.3 Lighthouse biosolutions Zealand

A partnership agreement has been entered for the business lighthouse biosolutions in the Zealand region where biosolutions companies like Novozymes, Nordic Sugar, and CP Kelco are located, which will spearhead the long-term national development of the future position of strength in this area.
The partnership includes the consortium for Business Lighthouse Biosolutions Zealand, the Danish Board of Business Development, the Board of Directors from Business Hub Zealand, the Ministry of Industry, Business, and Financial Affairs, the Ministry of Food, Agriculture and Fisheries, the Ministry of Environmental and the Ministry of Higher Education and Science.
The Zealand region is a natural starting point for the development of the business lighthouse biosolutions, as the region has a high concentration of world-leading biotechnology companies, innovative entrepreneurs, high-quality research, and education as well as well-functioning innovation collaborations between universities, GTS institutes, and companies.
The consortium behind has started the development of the Business Lighthouse Zealand by initiating a series of activities with funding from the Danish Board of Business Development. The consortium aims to create an optimal framework and infrastructure for developing, testing, and upscaling biotechnological products and solutions. Danmark unlike other European countries, there are no facilities in Denmark that smaller companies can access during the scale-up phase, and towards 2025, the consortium will contribute to the establishment of

- A pilot plant for bio-fermentation at the Danish Technological Institute (TI), which is to be integrated with the existing pilot facilities for biorefining of TI's Development Center for Industrial Bioeconomy, which will open before the end of 2024.
- A prototype fermentation unit with data acquisition equipment at DTU Chemical Engineering
- A bio-fermentation demonstration facility at Fermhub Zealand, so the facility will include a full fermentation line at demonstration level opening by the end of 2023.
- A production and testing facility within biofermentation under the auspices of the private company 2st.BIO.
- A laboratory for SMEs within biorefining (Open-BioLab) at Roskilde University, which can support research-based knowledge development.

Major challenges in applied research and technology transfer in the bioeconomy / Biosolutions include:

- Relatively few new companies start up in Denmark based on our strong research base in Biosolutions. There is already an ecosystem, but it needs to be strengthened even more. FBCD A/S does incubation in this area, in addition, there is the Bio-Innovation Institute, DTU Skylab, and incubators at the University of Copenhagen and Aarhus University.
- Access to qualified labor. The companies generally find that the workforce from the universities is of high quality. An increasing need is expected for engineers who have both strong natural science skills and cutting-edge skills in data, machine learning, and artificial intelligence.
- No dedicated policy framework to support the growing industry.

4.4 Cross-sectoral Collaboration in BSR and Denmark

The cooperation levels of biomass producers in Lithuania, Latvia and Estonia are comparatively low despite interest for collaboration among producers. Instead, closed loop system solutions within a single company are more common, which means that companies improve their internal resource efficiency by giving residues new uses (Nordregio LT, 2022). By contrary, Denmark, Sweden, and Finland have a long tradition of cross-sectoral cooperation. Sweden and Finland have a long history of cross-sectoral collaboration in forest industry, whereas Denmark has it in agriculture and fishing industry. In Denmark, the close cross-

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sectoral cooperation is also reflected within new protein value chains: many research projects and innovation networks take place in cooperation between knowledge institutions, approved technological service providers, and companies.
Denmark has a strong tradition for dialogue, cooperation between public and private sectors and cross-sectoral partnerships creating refining and implementing innovative solutions for mutual benefit.

4.4.1 General overview of cross-sectoral collaboration

The classic examples of cross-sector cooperation in Denmark are the value creation of side streams from agriculture and the food industry. Among the collaborations that have had the greatest importance in terms of volume are

- Agriculture as the primary supplier of raw material (manure) to the Danish biogas industry
- The fishing industry is a supplier of raw materials (fish by-products) to the mink feed (closed industry due to Covid 19), pet food, and fish-meal industry.

Today there are around 190 large to very large plants in Denmark with a total production of 800 million cubic meters of biogas. The biogas plants ensure that nutrients in waste are recycled and reused as fertilizer in agriculture. At the same time, the energy content in the biomass is used to produce biogas, which substitutes for fossil fuels. Almost all biomethane is nowadays injected into the gas grid and biomethane constitutes around 35% of the gas in the grid today. Before injecting the biomethane into the gas grid, the biogenic CO2 is separated. The sector is actively developing the use of this CO2 to produce Power-to-X fuels and CO2 storage.
Denmark has a large fishing industry that refines and increases the value of the raw materials. When processing fish, up to 50% ends up as by-products such as heads, trimmings from fillet cutting, entrails, skin, and fish bones. In 2022, the total amount of fish by-products was 92,122 tonnes with an average sales price of 0.36 EUR (2.72 DKK) per kg (Nielsen, 2023). There is a great potential for more profitable utilization of the by-products.
Trends within cross-sectoral collaboration are towards the establishment of industrial symbioses with a circular approach to minimize resource consumption. Examples of successful industrial symbioses are:

- Kalundborg Symbiose - a partnership between sixteen public and private companies in Kalundborg. Together, they have developed the world's first industrial symbiosis with a circular approach to production. The main principle is that a residual flow in one company becomes a resource in another, benefiting both the environment and the economy. Every year, the symbiosis saves partners and the environment for about EUR 0.5 million (4 million) 3 million of groundwater using surface water, and 62,000 tonnes of residual materials are recycled, saving 586,000 tonnes of CO2.
- GreenLab in Skive- a green bioeconomy park. Here, incoming biomass from land and sea is converted in many forms into sustainable energy, proteins, biochar, and bio-oils. The energy is then transformed into heat, electrofuels, and other green products. In the energy park, everything will be connected by the co-called SymbiososNet an intelligent network of energy and data under development. The systems connect industries as they establish their operations to enable the exchange of surplus energy and resources. GreenLab is also a frontrunner in PtX and expects to launch the world's first full-scale 12MW PtX production facility in 2023.

In the new Biosolution Zealand project FBCD A/S is investigating the possibilities for more symbiosis collaborations on Zealand.
When launching new novel products, the cross-sectoral collaboration also includes the creation of new sustainable business models and value chains.

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Regarding the main barriers to cross-sectoral collaboration, the case “Grass Protein” is as an illustrative example. Grass protein has been developed as a green alternative to soy protein in animal feed and human consumption (foods, dietary supplements).
The biggest challenges in the collaboration of grass protein have been:

- The visibility of the value creation through the value chain. There seems to be a need to increase the incentive to use green solutions (e.g., via higher CO2 taxes).
- To ensure that all actors in the business models earn money. Economic asymmetries between the partners affect the power structure in the collaboration.
- A new to the market and the product approval phase is long and costly. By integrating regulatory clarification and requirements early in the development process, the time to market can be optimized.

There is great potential for cross-sectoral collaboration of improved utilization of bioresources within biorefining and cascade utilization (Figure 45).
This happens by first using the bioresources for high-value products, such as food and pharma.
Residual products from this are then used for e.g., feed, materials, and chemicals, after which residual products are used for energy purposes, nutrients are recycled back to production areas, and carbon is captured, used, or stored.

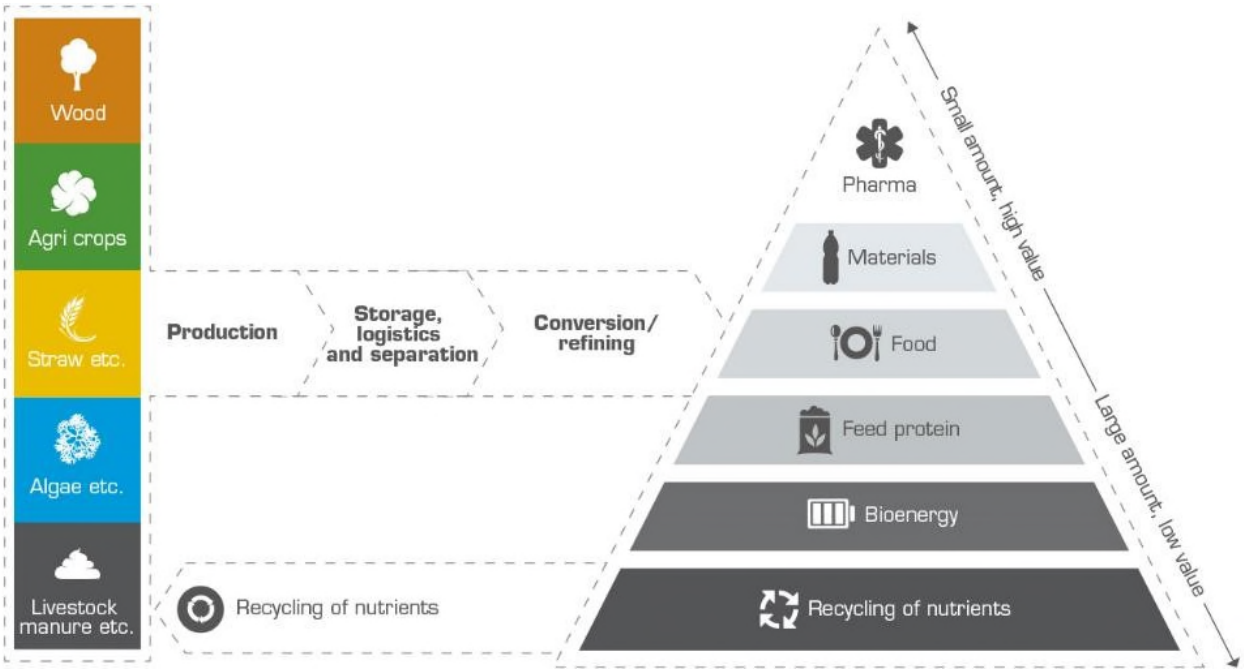

Figure 45. Illustration of the circular biorefining concept.
Source: Own graph by FBCD.

Examples of areas with high potential for development and collaboration within biorefining and cascade utilization in Denmark are (NBP, 2022):

- Upscaling of the biorefinery’s upper cascade link, including fermentation and enzymatic conversion of industrial residues and biorefining crops into products within food, pharma, health, industrial use, and feed.

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- Scale up refining technologies in the middle of the cascade, which can produce materials, textiles, and chemicals from straw, wood biomass, and fibre fractions from green refining, while at the same time producing a residual product that can be used in the lower layer of the cascade.
- Cascade utilization of lower links (pyrolysis and HT)

The Alliance for biosolutionss at the Danish Chamber of Commerce is an example of a bottom-up activity of cross-sectoral collaboration, where leading companies, SMEs, start-ups, knowledge and research institutions, and NGOs have organized themselves to accelerate the green transition with biosolutions.

4.4.2 Policy supporting cross-sectoral collaboration

There are many relevant policies (climate, agriculture, forestry, fisheries) for bioeconomy, but no dedicated a bioeconomy policy. No elected political parties have a speaker on Bioeconomy, so it is still mainly within the 'sector' we talk about bioeconomy and try to use existing frameworks meant for something else to be useful for the bioeconomy.
Based on the Danish Board of Business Development announcement of circular value chains for SMEs, the 4 Danish cluster organizations CLEAN, Lifestyle & Design Cluster, We Build Denmark, and Food & Bio Cluster Denmark have designed a program for a joint national effort, as they clearly see that Circular Economy is realized across industries and sectors.
The purpose of the effort is to support efforts to implement and scale existing circular measures, models, and methods. By assisting SMEs and companies to reduce, handle, and create value from the central resource flows. The focus will be on reducing the use of resources or the upcycling of resources with a large volume (tonnage), creating savings in CO2 pollution associated with extraction, production, or logistics as well as particularly problematic residual flows that create significant environmental problems or contain particularly scarce resources (not approved yet).

4.4.3 Mapping cross-sectoral collaboration structures

Table 23 shows examples of cross-sectoral collaborative structure in bioeconomy in Denmark.

Table 23 Examples of cross-sectoral collaborative structure in bioeconomy in Denmark*

Name	Objectives	Roles	Sectors	Type of actors involved
Food & Bio Cluster Denmark	Help companies accelerate innovation and sustainable development	Inspiration, networks, collaborations, and business development in partnerships	Food and bioresources	Companies, knowledge institutions, investors, and public authorities
Danish Biogas Association	An association for everyone with an interest in biogas	Works for the entire biogas value chain, which includes everything from the utilization of animal manure and organic residues from agriculture, households, and industry to the production and use of biogas, biogenic CO2, and green manure.	Biogas	Its 215 members include biogas plants, suppliers of residual products, technology, service, trade, consulting, and financial solutions as well as buyers of biogas and fertilizer from biogas plants.

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Danish Chamber of Commerce: Alliance for biosolutions	Turbocharge the great export and climate potential of biosolutionss.	i) better framework conditions for biosolutionss ii) Breaking down barriers that slow down the path of new green solutions to the market iii) increased knowledge of and larger market for biosolutionss.	Biosolutions	Large companies, SMEs, start-ups, Universities, and organizations.
The Confederation of Danish Industry: Network for Circular Economy:	To create a platform for companies that are interested in, working with or want to be updated on the circular economy	Knowledge Community	Circular action for climate neutrality, industrial symbiosis, industrial techniques	The network has around 150 members.
Climate Foundation Skive	To develop projects that contribute to solving climate, energy, and environmental challenges	i) Develop and demonstrate circular business models ii) Identify and resolve regulatory challenges iii) Set up living labs to test climate solutions	Primary production sector	Assist companies across sectors to co-create and share resources and residual flows
State of Green	Facilitate dialogue and spur international partnerships	Share Danish know-how via publications, digital showcases, international conferences, welcoming delegations, and through media engagements.	Energy transition, water management, green cities, circular economy, and trending	A not-for-profit, public-private partnership between the Danish government and the country's three leading business associations (Confederation of Danish Industry, Green Power Denmark, and the Danish Agriculture and Food Council).

Source: Own compilation.
**Kalundborg Symbiosis, GreenLab and BioSolutions Zealand see other sections.*

Despite the multiple benefits of being part of cross-sectoral collaborative structures, the establishment of an internal organization that supports the development of symbiotic exchanges as well as maintains and develops the network, is therefore key to long-term success.

4.5 Financing

4.5.1 Policy Instruments for Financing in Denmark

For start-ups, private capital is essential to get the biosolutions business off the ground. Although Danish companies are fortunate to have access to a significant number of European and domestic grant and soft funding programs that ensure overall financial de-risking and provide start-ups with time and money to work on realizing the idea, these programs are not sufficient to build a scalable business in the long run. Private capital from business angels, corporate venture capital funds, or venture capital is necessary for

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co-financing grants and covering costs related to back office and sales activities that soft funding typically cannot cover. In addition to the money, founders' benefit from valuable expertise and a relevant network by involving experienced investors with relevant connections in the ownership capital table.
The Danish biosolutions ecosystem is dominated by four investors making 25 investments in Danish biosolutions start-ups from June 2021 to June 2023:

- **Bioinnovation Institute** is the Novo Nordisk Foundation CVC accelerator supporting pre-revenue Planetary Health founders with early capital, network, and an industry-specific accelerator program.
- **Novo Holdings** is the direct investment fund of Novo Foundation investing in more mature scaleups.
- **Rockstart Agrifood** is a Danish-Dutch accelerator VC investing globally but with a specific focus on Danish agriculture and food start-ups incl. start-ups within the Biosolutions space.
- **The Export & Investment Fund of Denmark (EIFO)** also plays an important role in securing enough risk capital to the ecosystem. EIFO is backed by the Danish state and offers loans and direct investments into promising start-ups, while also making fund of funds investments into leading European Biosolution funds like Sofinnova Partners (Paris, London), Astanor, and Rockstart Agrifood.

Danish business angels invest around EUR 400 million in Danish start-ups per year. While the vast majority is invested in software-based, a minority of business angels' investments go into Biosolutions.
There are two predominant angel networks in Denmark:

- Danish Business Angel Network (DanBan)
- Keystones.

The 700 members in the two networks only represent a small share of the total number of business angels.

4.5.2 Impact of Policies for Financing

Figure 46 shows funding programs available for SMEs in Bioeconomy/Biosolutions in Denmark - but rarely directed towards the bioeconomy.

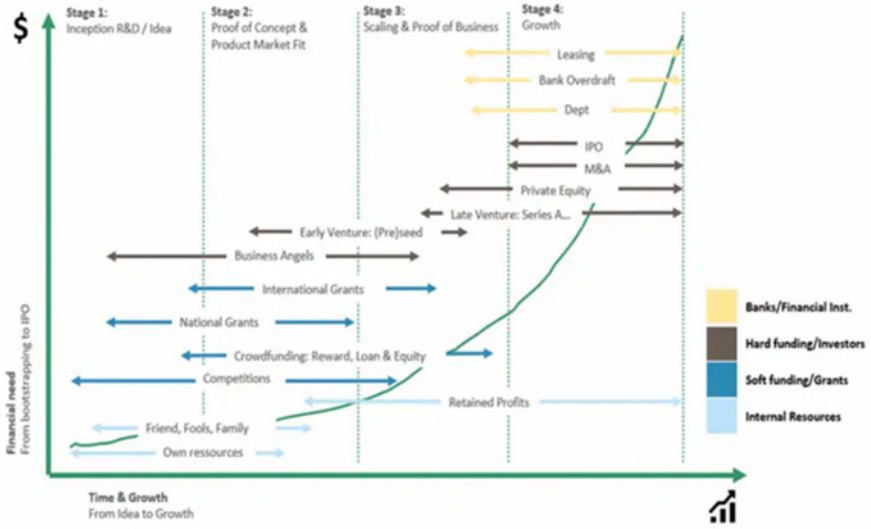

Figure 46. Funding programs available for SMEs in Bioeconomy/Biosolutions in Denmark.
Source: Own Graph by FBCD.

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4.5.3 Private financing in the Baltic Macro-Region

For Baltic Macro-region, the volume and type of financing rounds is well developed, with more various types of funding rounds in the more developed ecosystems of Denmark, Finland, Sweden and the non-EU Norway (Figure 47). The disparities across the countries with the most developed markets in terms of variety of funding rounds, amount and number of deals come from the differences in the bioeconomy industry volume dependent on country geographical size, population density, and probably free market development and access to international markets historically. These are probably the reasons behind the data for Latvia and Lithuania suggesting bioeconomy financing at national level with modest number of financing rounds and financing amounts, on condition that all deals in these countries were proportionately reported. The grants are a notable part of the financing rounds in both modest and developed innovation systems in Denmark, Finland, Lithuania and Sweden. This could indicate that there are more targeted policies in these countries, with higher awareness on national and EU-available funds, and with good absorption capacity from the local companies. The number of more mature stage deals is bigger and Series A deals (approximately TRL 5-7) are a notable part in the number of financing rounds in the region. This may be a result of more developed technology transfer and commercialisation mechanisms in research, development and investment.

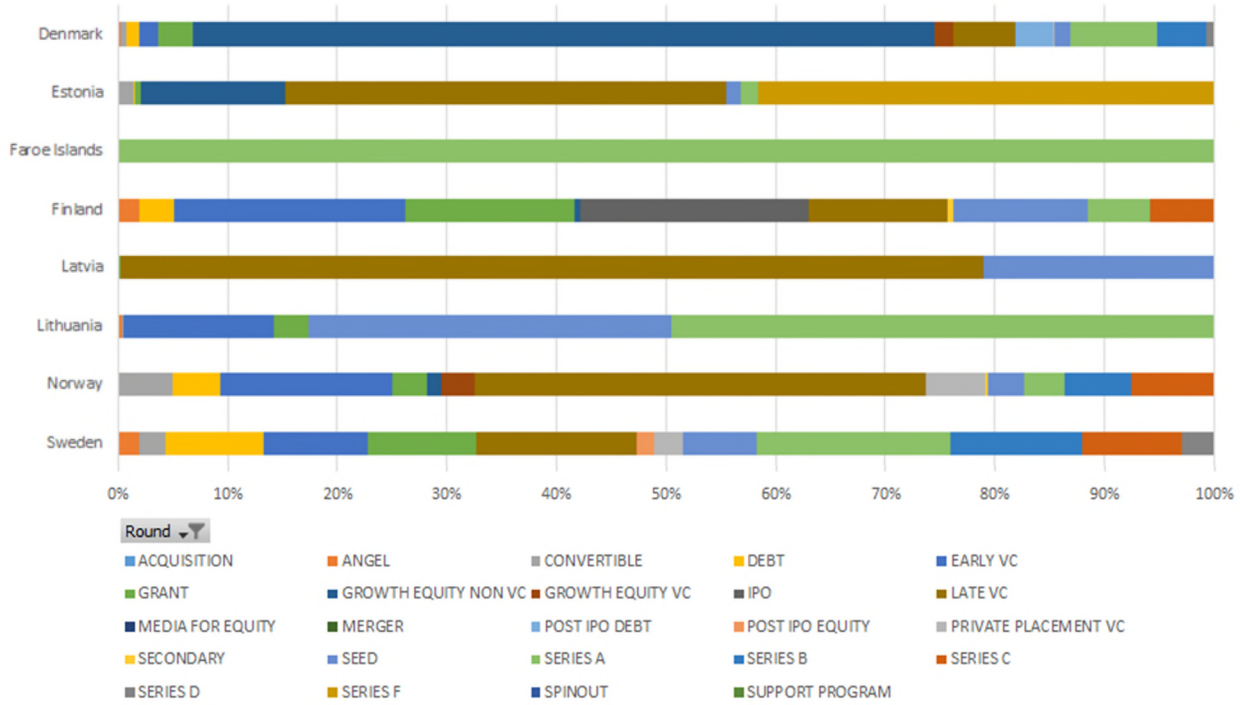

Figure 47. Type of financing rounds in Baltic MR.
Source: dealroom.co.

The companies in the Baltic macro-region receive funding from private investors located both inside and outside their countries with private investors from Denmark (1.34%), Finland (1.27%), Norway (2.93%) and Sweden with 4.02% of all deals by number of deal participation being in the top 20 investors in Europe. There are reported active private investors originating in all Macro-region countries with 774 investment rounds in total.

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It is notable that there are similar proportions in the investment amount related to the number of investment rounds (Figure 48) for early-stage companies (TRL 1-6) in all countries in the Baltic Macro-region, except Denmark where the amount per funding round is proportionately bigger.

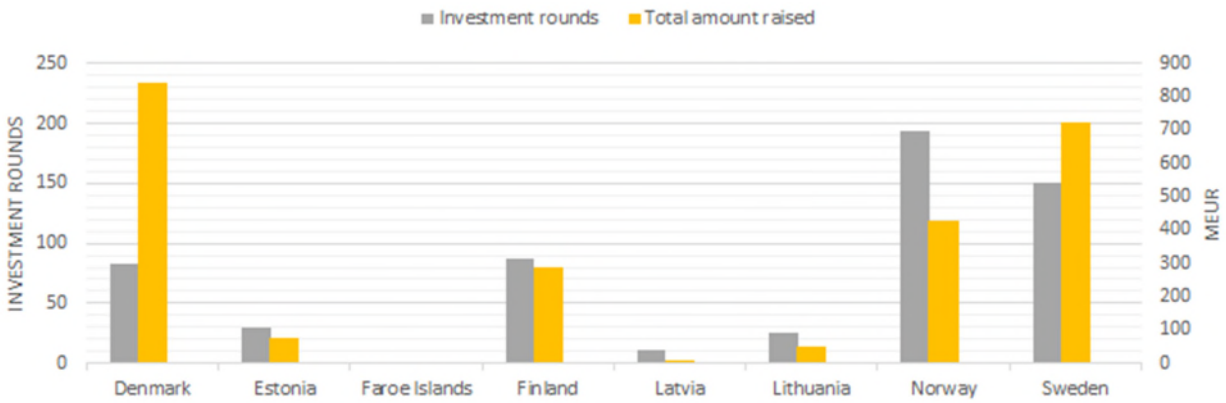

Figure 48. Early stage funding rounds and amounts in Baltic MR.
Source: dealroom.co.

The total amount raised per country for all investment deals is presented on Figure 49. The region is characterised by big number of investment rounds for all company development stages. The difference for Denmark comes from three (3) mature investment deals for the total amount exceeding EUR 3.85 billion with the biggest deal of 3.5 billion reported in December 2022 being the biggest in the entire researched area for the reporting period.

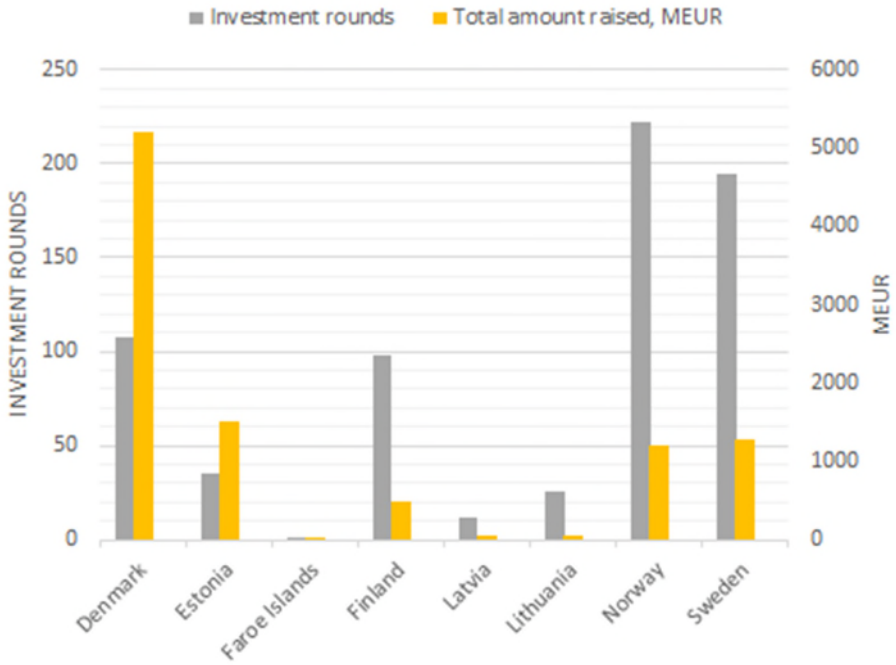

Figure 49. Total reported amount raised by country in Baltic MR.
Source: dealroom.co.

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4.6 SWOT Analysis of the Baltic Sea Macro-Region

The swot analysis Table 24) shows that the Baltic Sea Region is rich in natural resources (wood, agriculture, fisheries), which it can provide to bioeconomy. Existing high activity in bioeconomy (wood, agriculture, etc.), well-educated workforce, many capable institutions, expertise in innovation, and a strong tradition of intra-regional cooperation serve as a good base to start further development. The Scandinavian countries (DK, FI, SE) also show strong cross-sectoral collaboration especially related to wood, agriculture, food, and fisheries sectors.

While BSR is abundant with bio-resources (arable land, forest, and marine resources) in many cases (especially in EE, LV, LT) they are lacking smart, value-adding, and sustainable value-chains. In the Baltic States most of the raw materials is exported and higher-level processed products are imported. Moreover, while the cooperation levels of biomass producers are strong among the Scandinavian countries (DK, FI, SE), they are comparatively low in the Baltic States (EE, LV, LT) despite interest for collaboration among producers. Instead, closed loop system solutions within a single company are more common, which means that companies improve their internal resource efficiency by giving residues new uses. The low levels of cross-sectorial co-operation is another weak point in the Baltic countries. Also, the cooperation between research groups and entrepreneurs needs improvement. Moreover, the lack of a bioeconomy strategy (EE, DK, LT, SE) hinders further bioeconomy development. The lack of a holistic strategy is the main obstacle to providing funding as well as managing and steering the bioeconomy activities in a systematic way.

There is a large potential for adding more value to local biomass (especially wood). Another big opportunity for bioeconomy development lies in valorisation of waste and residual streams. The industrial sectors in BSR have substantial residual streams and waste, most of which find low-value applications. By feeding these streams into bio-based operations, they could be converted into higher-value applications than the state of the art in the countries. For instance, Lithuanian agriculture generates estimated 8 million tonnes of residues per year. These residual streams are either not being used or are being used to create little value. Instead, they could be used as feedstock for bio-based operations (BIC LT, 2020). Furthermore, biomass produced from macroalgae could be used as food and consumables, such as plastics and energy. Growing and harvesting macroalgae is still in its infancy in the Baltic Sea. There are gaps in legislation and regulations which hinder its potential. Algae can help improve water quality in the over-fertilised Baltic Sea as they filter nutrients. At the same time, they form a high-quality biomass as well as a source of valuable substances for the cosmetics industry. Great potential for bioeconomy development lies also in improved collaboration between research institutes and the business as well as along the value chain.

One of the biggest challenges to the bioeconomy development is the aging population. About 60% of the population in BSR will retire before 2035. This raises the question how to keep people with know-how in the sector and how to make bioeconomy more attractive to young people/talents. The situation in the Baltic States is even more exacerbated by a high emigration of young people. Moreover, rural areas are suffering from the loss of inhabitants due to urbanization. The biggest challenge of bioeconomy development in fishery is related to the pollution in the Baltic Sea. The Baltic Sea is surrounded by land and therefore is more endangered by pollution than other marine areas. The sources of marine pollution are municipal and industrial waste inputs directly into the sea or via rivers, and atmospheric inputs mainly from traffic and agriculture. This causes eutrophication and consequent oxygen depletion in coastal bottom waters as well as in the depths of the open sea destroying the bottom fauna. Further, bioeconomy development is threatened by the geopolitical situation in Ukraine, which causes a shift of financial resources to defence. The sustainable bioeconomy development in BSR is also challenged by the demand of wood from foreign bioenergy companies for energy purposes. In BSR a large share of forests is clear-cutted and exported to be used for bioenergy.

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Table 24 SWOT Analysis of the Baltic Sea Region (Estonia, Latvia, Lithuania, Denmark, Finland, Sweden)

Strengths	**Weaknesses**
- Availability and quality of biomass resources - Existing high activity in bioeconomy serves as a good base for further development - Strong biotechnology (enzymes) and chemical sectors - Good infrastructure of universities, research centres and industries - Strong cross-sectoral collaboration - Good funding opportunities - High-efficiency use of biomass and biogas for energy production - Strong bio-based sectors (e.g. construction)	- Lack of a national bioeconomy strategy (except FI, LV) - Lower value added, traditional mindset in development - Lower levels of cross-sectorial co-operation - Lower level of R&I transfer - Lower level of R&D caused by lack of funding and high R&D dependence on EU Funds - Limited access to test and demo facilities in scale up phase for smaller companies - No dedicated bioeconomy university degree in some BSR countries - Too much effort has been put on energy generation from forest biomass - Traditional technology-push instruments
Opportunities	**Threats**
- Higher value added products - Valorisation of residual streams and waste - Collaboration between research and business - Exploitation of invasive species in the Baltic Sea (e.g. round goby) - New materials from wood - Growing and harvesting macroalgae for food and consumables (e.g. plastics, energy) and algae for cosmetics while improving water quality - Strengthen competitiveness and contribute to growth and employment - Strengthen the ecosystem for start-ups - R&D to create innovative firms - Nature services - Circular economy in bioeconomy - Sea fish farming and aquaculture - Medical products made by biorefineries	- Pollution in the Baltic Sea from industry - Shift of financial resources to defence due to the geopolitical instabilities - Overexploitation of forests for energy purposes - Overfishing (e.g. cod, salmon, herring, and sprat) - Aging population causing a lack of qualified workforce - Emigration - Urbanisation - Climate change effects on the Baltic Sea (e.g. rising water temperature) - Climate change effects on forests (e.g. pest species) - Invasive species in the Baltic Sea (e.g. round goby) - USA, China, India threat to competitiveness

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4.7 Conclusions for the Baltic Sea Macro-Region

1. BSR is rich in availability and quality of biomass, especially when it comes to wood biomass.
2. The BSR bioeconomy is dominated by the forest industry and the products created by the forest as raw materials. Other important sectors are agriculture and food, biotechnology, and bioenergy (from forestry) industries. It also features a solid chemical industry (from forestry).
3. While BSR is abundant with bio-resources in many cases (especially in EE, LV, LT) they are lacking smart, value-adding, and sustainable value-chains. In the Baltic States most of the raw materials is exported and higher-level processed products are imported.
4. The value added per person employed in the bioeconomy sectors in BSR is almost double the value of the EU-28 average. However, it is below the EU-28 average in EE, LV, LT, which can be largely explained by the lower complexity of their export products.
5. BSR offers many high-tech hubs including biotech and has active national biotechnology associations. Also, there are many hubs in BSR, especially in the forestry industry.
6. Regarding biorefineries, most of the biomass supply comes from the forestry sector (woody and lignocellulosic biomass) and is turned into products mainly timber, biomethane, pulp and paper, bio-based chemicals and liquid biofuels.
7. In the BSR, different situations can be identified between countries that have already a dedicated national bioeconomy strategy and action plan and are implementing them like Finland, those that are developing it like Sweden and those that have no strategy at all like Lithuania and Denmark. The (updated) Finnish bioeconomy strategy and its implementation plan are the best practice in the BSR. The strategy focuses on the creation of value added, the increase of the degree of wood processing, new products, and entirely new product areas. A green transition and the circular economy are considered key drivers of change. The importance of industrial side streams and the increased efficiency of material cycles are emphasised.
8. The national bioeconomy strategies have been shaped by the EU bioeconomy policy, Green Deal (circularity) as well as the Paris Agreement.
9. Different ministries are responsible for the bioeconomy policy development in the BSR, which has implications on the bioeconomy development (e.g. value chain, intersectoral collaboration). Ministries of agriculture may focus too much on the primary sectors, whereas ministries of economy may more adequately promote bio-based sectors.
10. All BSR countries horizontally coordinate their bioeconomy strategy development. Usually, they have an advisory board composed of representatives of the ministries involved. Additionally, some have advisory boards at universities that consult ministries or national bioeconomy panels.
11. At the regional level, bioeconomy has been integrated into a wide range of different regional strategies in BSR in recent years. Sweden is the country with the largest number of strategies, followed by Finland. These two countries display intense regional strategic action to deploy the bioeconomy.
12. In Sweden, the bioeconomy is often included in forestry and regional/territorial/rural development strategies, while in Denmark it is typically addressed within green transition and energy strategies. In Finland, bioeconomy is covered in almost every Regional Development Plan and in many Smart Specialisation strategies.
13. At the macro-level, the EU strategy for Baltic Sea region provides a unique platform for cooperation and coordination between the member states in BSR. One of the biggest gaps of the strategy is that food is not as prominent as it should be. Also, there are challenges related to the governance structure: Whereas bioeconomy covers all areas where biological resources are used, the administration body consists of representatives from ministries who cover only one area, which leads to dysfunctions. It would be more efficient to divide administration into three areas based on

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production: (1) protein produced by agriculture and maritime sectors (2) fibre and material made by utilization of bioproducts (3) energy produced by forestry.

14. Cooperation works better between regional actors as regions are closer to local industries (e.g. through local clusters), they have specific tools to work with, and have key resources to work with industries.
15. The BSR has a solid infrastructure of universities, research centres and industries, and active associations for bioeconomy research. There is a strong support towards high-tech university spinoffs. The R&D in the BSR covers the entire bioeconomy. Yet, each of the BSR countries specialises in different areas of bioeconomy: health sector and food based on proteins (Denmark), biotech (Lithuania), circular economy and cleantech (Finland), bioenergy and innovative bio-based sectors predominantly based on wood (Sweden). However, often the knowledge does not get transferred from research to industry and vice versa.
16. While the cooperation levels of biomass producers are strong among the Scandinavian countries (DK, FI, SE), they are comparatively low in the Baltic States (EE, LV, LT) despite interest for collaboration among producers. Instead, closed loop system solutions within a single company are more common.
17. BSR has a well-developed cluster structure: most industrial sectors have their own cluster representation. The majority relate to biotechnology, energy, food, paper and pulp, and waste. Finland also has many water expertise clusters, ecosystems, and networks.
18. In the BSR, there are many different environmental organisations especially in the context of forestry, who often have objections to the forest policies, insufficient protection measures and practises by the forest industry.
19. Recently, there have been many initiatives aiming to involve youth into bioeconomy activities. One example is the successful Estonian entrepreneurship education programme “Edu ja Tegu”.

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5 Macro-Region Central and Eastern

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5.1 State of Play of the Bioeconomy in the Central and Eastern Macro-Region

The Central and Eastern Europe macro-region includes eight Central and Eastern European countries: Bulgaria, Croatia, Czech Republic, Hungary, Poland, Romania, Slovenia and Slovakia; all these countries belong to the BIOEAST macro-region that include also Estonia, Latvia, Lithuania. The BIOEAST macro-region is a grouping of 11 countries that have come together under the Central-Eastern European Initiative for Knowledge-Based Agriculture, Aquaculture and Forestry in the Bioeconomy - BIOEAST - offering a shared strategic research and innovation framework for sustainable bioeconomy efforts in Central and Eastern European countries. The BIOEAST initiative in the member states helps to perceive the concept of bioeconomy and supports the member states in setting up a strategic framework. For the ShapingBio project, which monitors the state of the bioeconomy in European countries (macro-regions), this initiative is a good example of how this approach helps to implement bioeconomy in individual states.

In the CEE macro-region (hereinafter referred to as the CEE macro-region) live more than 100 million inhabitants (i.e. 22% total EU-27 population based on the 2023 data). The CEE macro-region covers more than 887,000 sq. km (approximately 21% of the EU-27 area), the detailed information about each individual country is provided in Table 25.

Table 25 Area and inhabitants of Central and Eastern Europe macro-region

Country	Area sq. km	Share of EU-27	Inhabitants	Share of EU-27
Bulgaria (BG)	110,994	2.70%	6,673,444	1.49%
Croatia (HR)	56,594	1.38%	4,004,086	0.90%
Czech Republic (CZ)	78,871	1.92%	10,497,005	2.35%
Hungary (HU)	93,030	0.23%	10,123,732	2.27%
Poland (PL)	313,931	7.65%	41,026,067	9.18%
Romania (RO)	238,397	5.81%	19,836,159	4.44%
Slovakia (SK)	49,035	1.19%	5,776,322	1.29%
Slovenia (SI)	20,271	0.49%	2,119,531	0.47%
Total MR	877,396	21.38%	100,056,346	22.40%
Total EU-27	4,103,987	100%	446,735,291	100%

Source: Eurostat (2023).

Poland has the largest area in the region, followed by Romania and Bulgaria. Slovenia has the smallest area of 20,271 sq. km. Poland has the largest number of inhabitants, more than 41 million inhabitants, followed

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by Romania, which has almost half the population of Poland. The smallest country in the region, Slovenia, has also the smallest population.
The countries of CEE macro-region are marked in Figure 50.

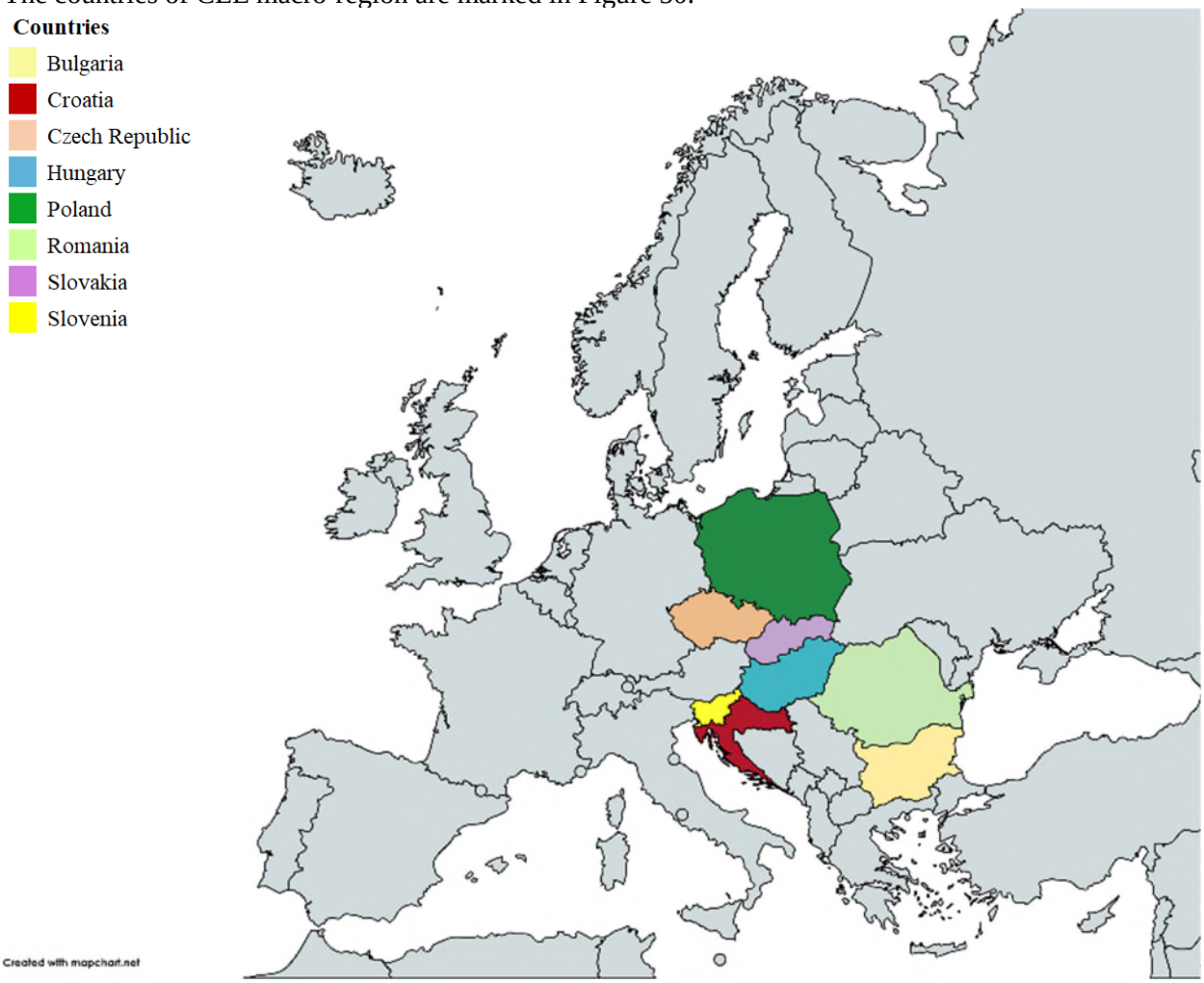

Figure 50. Countries of Central and Eastern Europe (CEE) macro-region.
Source: mapchart.net (2023).

5.1.1 Production and industrial use of biomass

Primary Production

In the primary sector (agriculture, fishing and forestry), agriculture is the most important sector in the economy of the countries that make up the CEE macro-region.
According to data from the Food and Agriculture Organization (FAO) of 2020, in the countries belonging to CEE macro-region, there is an area of 455,244 sq. km of arable land (27.77% of EU-27, and approximately 52% of the overall macro-region area Table 25) (FAO, 2020). However, as observed in Figure , there is a progressive decrease, more significant in recent years, in the cultivable land area. This situation is due to the increasing population and the demand from other sectors that put growing pressure on the available land resources.

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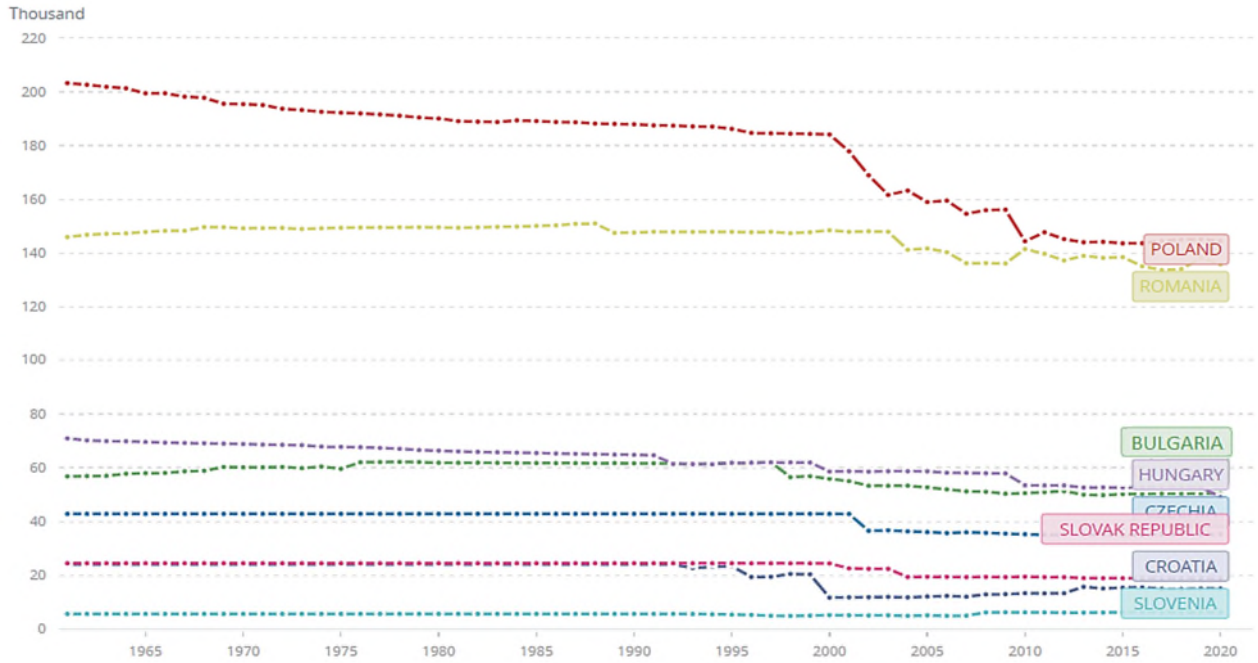

Figure 51. Arable land (sq. km) in Central Eastern Europe (2020).
Source: Food and Agriculture Organization (FAO).

The CEE countries differ by the type of biomass that can be produced on their arable land: Woodland covers more than half of the land available for biomass production in Slovenia (66%) and Croatia (56%), while Hungary is characterised by a relatively low share of woodland (27%), substituted by a relatively high share of cropland for cereal production (33%). Generally, cereals cover more than half of the cropland in all CEE countries (Figure 52).

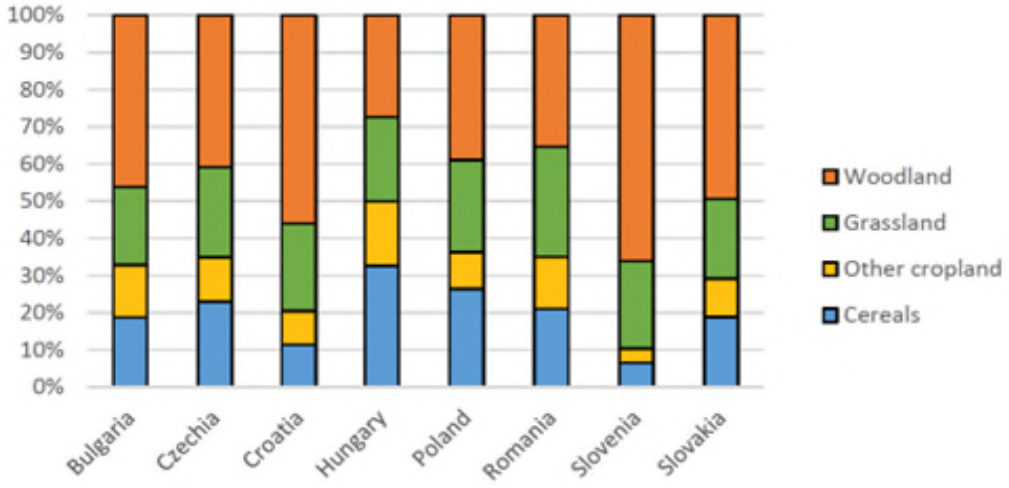

Figure 52. Share of key categories of land use in total land use available for biomass production in the CEE countries in 2015.
Source: EUROSTAT (2019).

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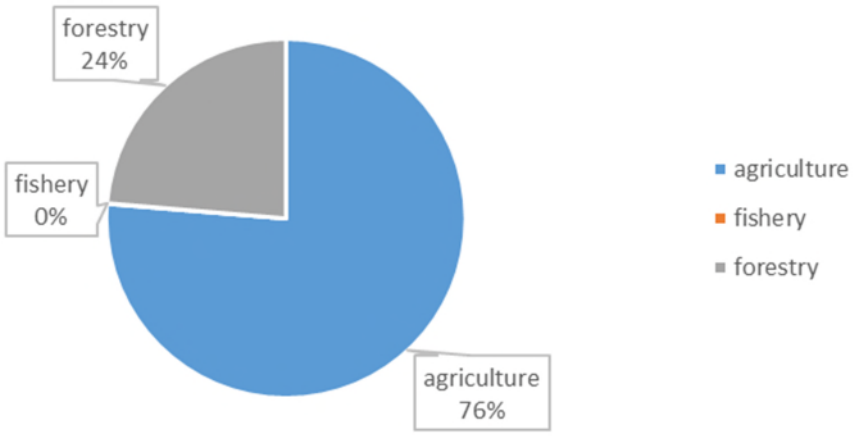
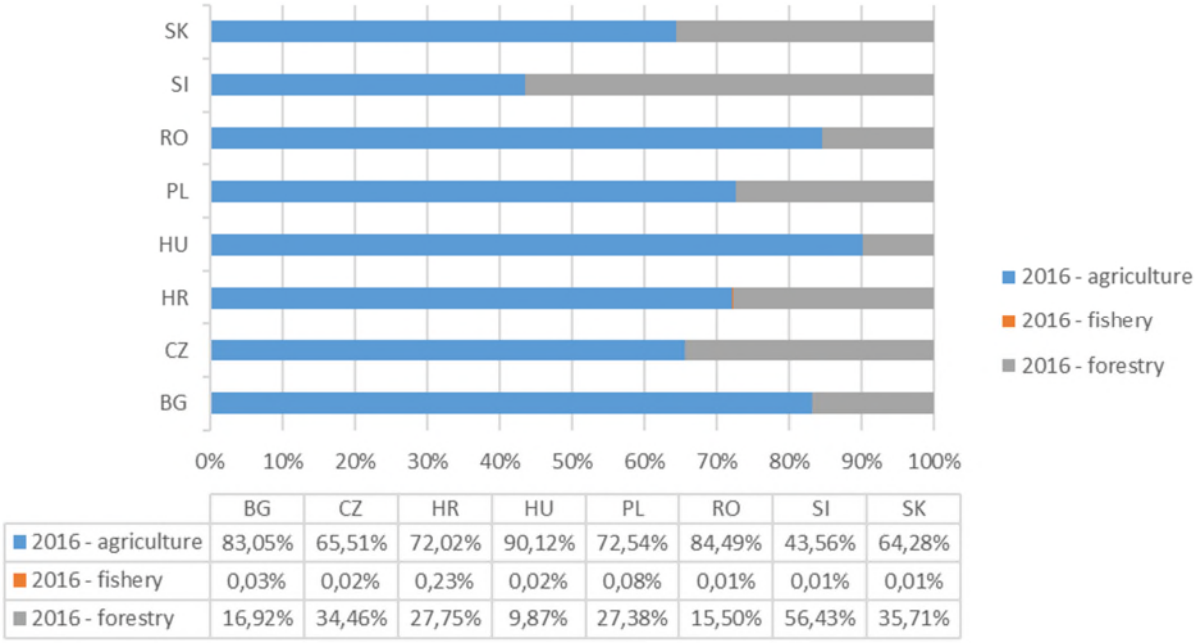


Figure 53. Biomass Production from Primary Production Systems in Central and Eastern Europe (2016). Source: Datam JRC, European Commission.



	BG	CZ	HR	HU	PL	RO	SI	SK
2016 - agriculture	83,05%	65,51%	72,02%	90,12%	72,54%	84,49%	43,56%	64,28%
2016 - fishery	0,03%	0,02%	0,23%	0,02%	0,08%	0,01%	0,01%	0,01%
2016 - forestry	16,92%	34,46%	27,75%	9,87%	27,38%	15,50%	56,43%	35,71%

Figure 54. Biomass Production from Primary Production Systems in Central and Eastern Europe and share of sectors (2016).
Source: Datam JRC, European Commission.

Figure 53 and Figure 54 refer to the biomass production from primary production systems (agriculture, fishery, forestry). In the Central Eastern Europe macro-region, almost all of the biomass comes from the agricultural sector.
The most important source of biomass in all countries of the CEE macro-region is the production of crops (this source is represented by 59%, corresponding to around 145 million tonnes dry mass). Less than 16% of biomass comes from residues, 14% from net import and 11% from pasture. The share distribution is

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nominally different in the individual states of the region, but the ratio corresponds to the character of the region as can be seen Figure 55.
Slovenia has a high share of biomass production from forestry which is in line with their high share of woodland (Figure 54). The forestry biomass in Croatia is remarkably, considering the 56% share of woodland in the arable land.
Biomass flows from fisheries are almost non-existent (values vary in hundredths of percent). This is mainly due to the fact that most of the region is inland and fishing is carried out primarily in the form of pond farming. Although pond farming and fish farming have a deep historical tradition in the Czech Republic, the entire industry is nowadays a peripheral matter. Therefore, the Ministry of Agriculture of the Czech Republic, together with the Fishing Associations, with the help of national and European resources, supports the development of fish farming, especially in the form of pond farming. Although Poland and Bulgaria are located by the sea, biomass from fisheries plays a negligible role; the main production of biomass comes from agriculture.

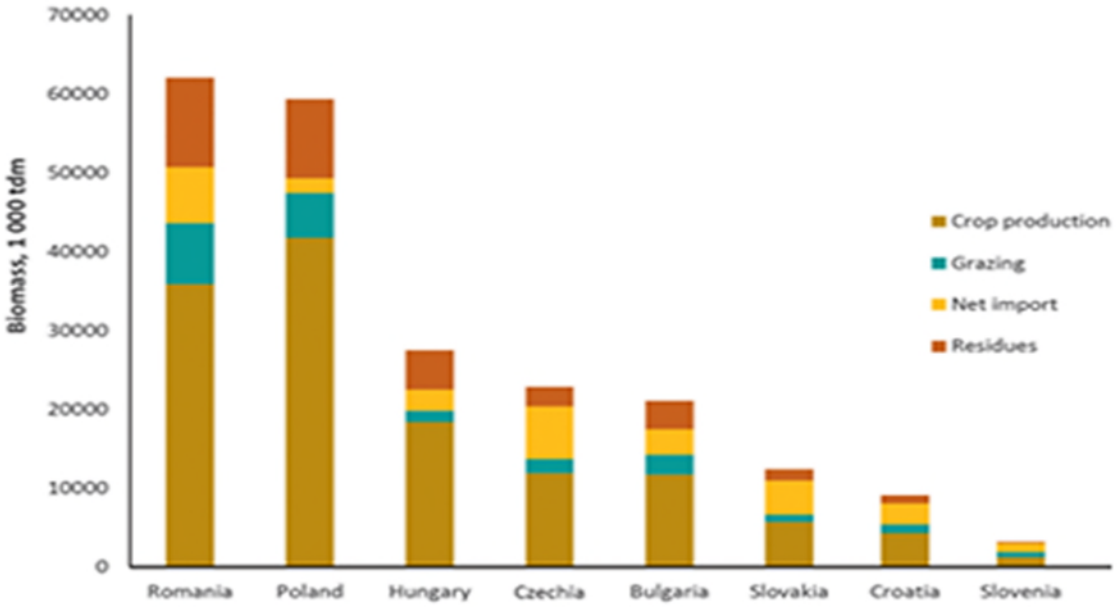

Figure 55. Sources of agricultural biomass in the CEE macro-region countries in 2018
Measure: 1 000 tonnes of dry matter, in net trade figures.
Source: Datam JRC, European Commission.

Use of Biomass

In the CEE macro-region, during 2017, a total of 171,536 tonnes of biomass (dry matter) from agricultural and woody sources were consumed for the production of energy, materials, and food. This data represents 19.36% of the total biomass consumption in the EU-27.
Clearly, the highest demand among the countries in the CEE macro-region coincides with those that have a larger area and a higher population. In these countries, biomass is primarily used for food and feed production, but there is also significant use for energy production. Croatia and Hungary have the largest share of consumption of biomass for food (over 70%). Romania and the Czech Republic have the largest share of consumption of biomass for energy purposes (33% and 32%). The share of consumption of biomass for biomaterials is rather minor and is around 12%. Slovenia uses the most biomass for biomaterials (21.1%), Croatia the least (2.7%). For details, refer to Figure 56 and Figure 57.

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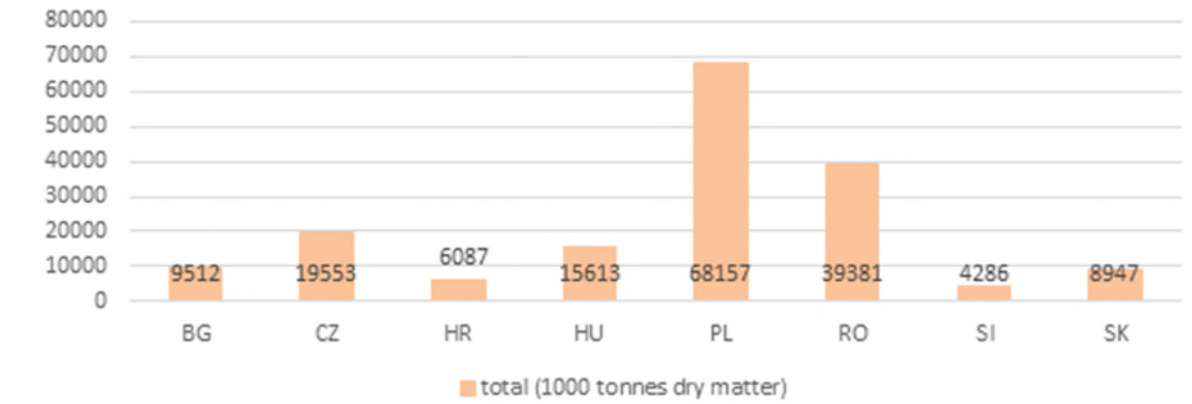

Figure 56. Total biomass consumption by country in Central and Eastern Europe macro-region 2017. Source: Datam JRC, European Commission.

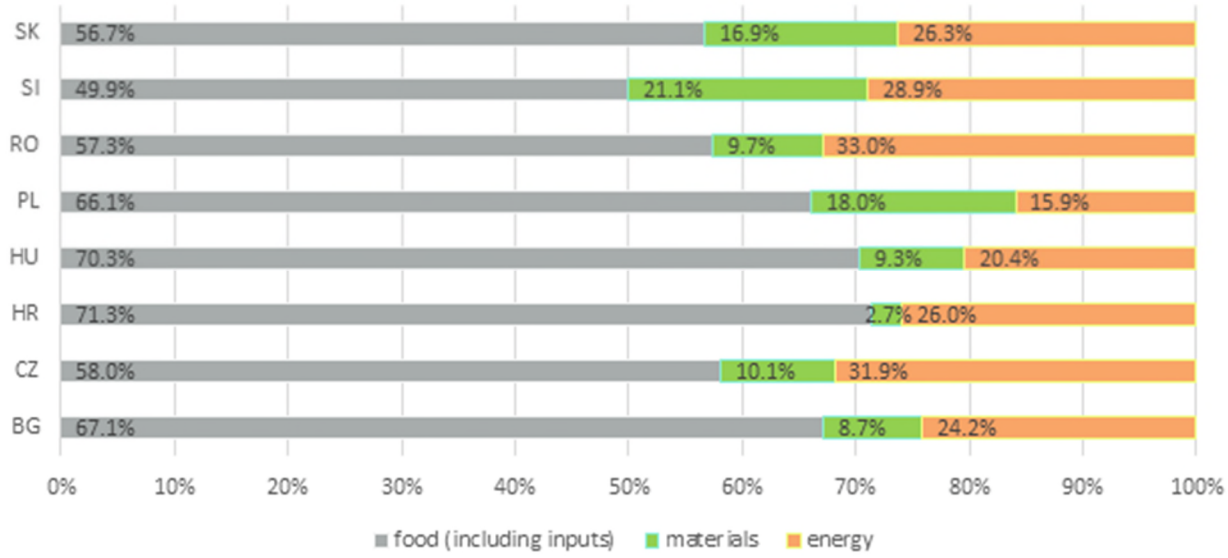

Figure 57. Biomass consumption for product categories in countries of the Central and Eastern Europe macro-region (2017).
Source: Datam JRC, European Commission.

Biomass Flows

Figure 58 shows a summary of the biomass flow data in 2023 for the CEE macro-region.[25] Most of the biomass is produced locally and only a small fraction is net-imported (less than 10%). The largest amount of biomass imported comes from agriculture. When it comes to its use, most of agriculture biomass is consumed locally and only a small fraction is exported. Most of the CEE countries have a large proportion (>30%) of losses of biomass for which a specific use cannot be estimated. If the losses or biomass for which a specific use cannot be estimated are not considered, approximately 70% (68.8%) of the available biomass

[25] Slight deviations to the figures above are possible, due to partly different reference years and additional attribution steps of data

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is used for food and feed, with biomass for energy and biomaterials accounting for 14% and 17% of the identified biomass uses, respectively.

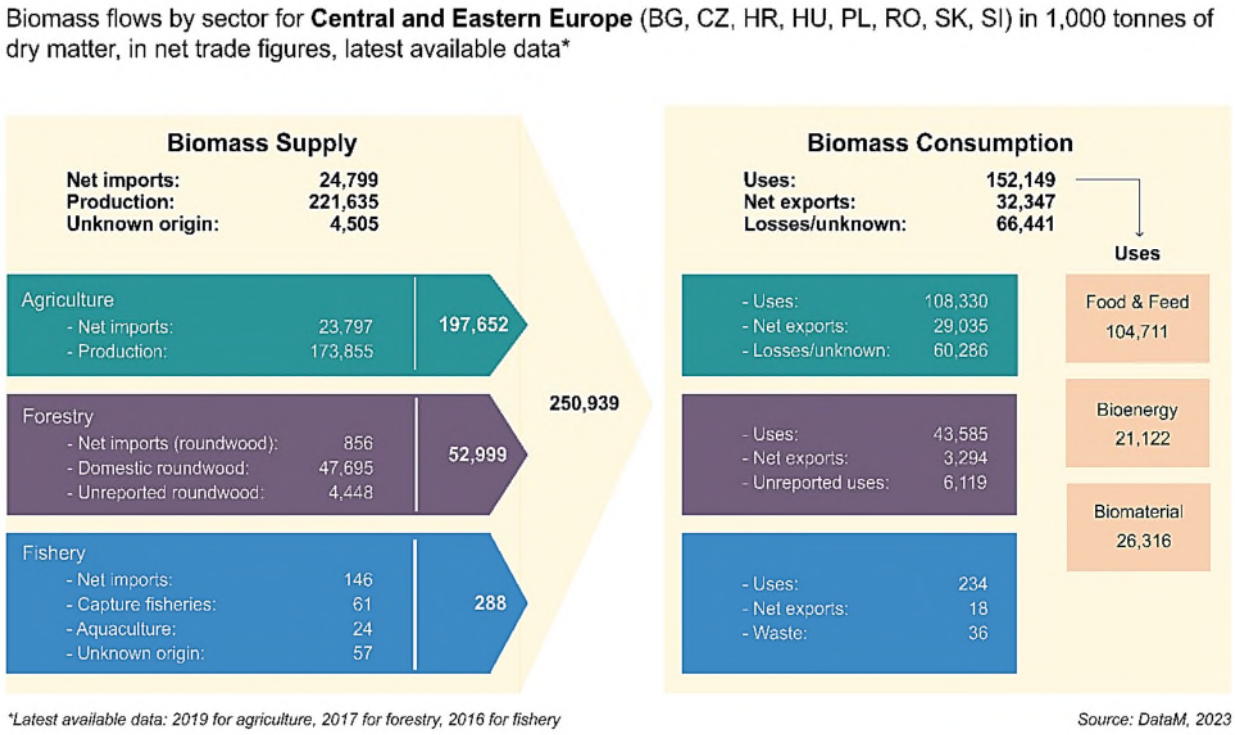

Figure 58. Biomass flows in CEE macro-region (Last available data).
Source: Datam JRC, European Commission.

5.1.2 Industrial deployment of bioeconomy and economic relevance

5.1.2.1 Industrial deployment

Open-Access Pilot Plants
Regarding open-access pilot and demo facilities, the Pilots4U network database shows a low number of such facilities in the MR. While around the half of the countries possess at least one facility, in the half of countries this does not exist yet.

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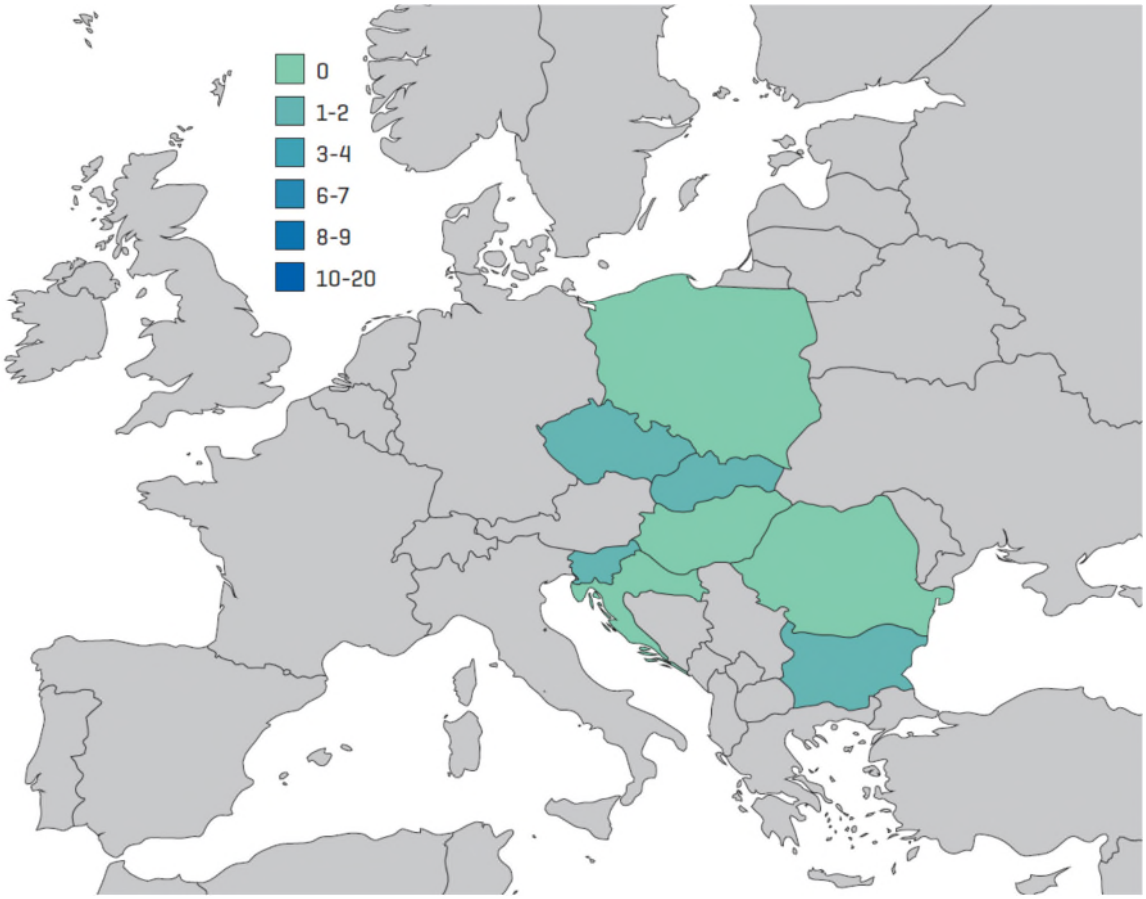

Figure 59. Distribution of number of open access pilotplants in CEE (2023).
Source: Pilots4U network.

Biorefineries

Biorefineries constitute a key element in order to produce fossil-free materials for a climate-neutral future. Chemical and material driven biorefineries produce primary bio-based high-value added chemicals and materials such as cosmetics, pharmaceuticals, food additives and others, high volume chemicals, and materials such as general bio-based polymers or chemical feed- stocks (i.e., building blocks).
The EU bio-based industry is quickly evolving, but in the countries of Central Eastern Europe, the number of biorefineries is lower than in other areas of the continent. In the CEE macro-region, there are 254 facilities, which account for 10.7% of the total 2,362 biorefineries in the EU-27. Figure 60 shows that a large portion (43.3%) of bio-based facilities of the CEE macro-region is concentrated in Poland and Czechia. Poland has the highest number of facilities (91), in the Czech Republic there are (45) half as many as in Poland. In the remaining states of the CEE macro-region, the number of facilities is around 25. The fewest facilities are available in Croatia (8).

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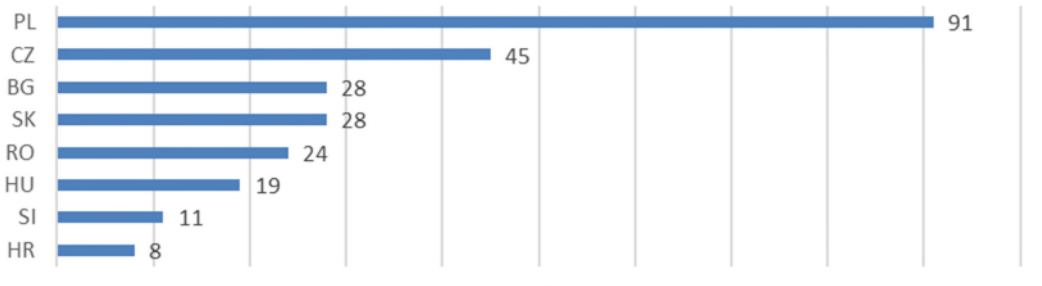
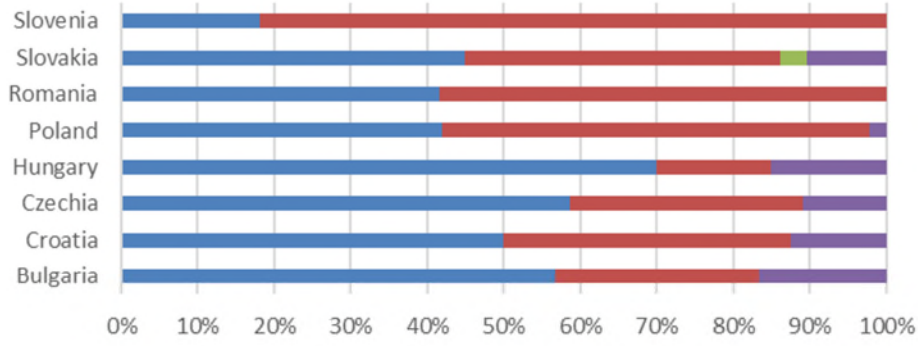


	HR	SI	HU	RO	SK	BG	CZ	PL
Number facilities	8	11	19	24	28	28	45	91

Figure 60. Number of bio-based industry facilities by country in Central and Eastern Europe. Source: Datam JRC, European Commission.

If those bio-based industry facilities are classified according to the origin of raw materials[26], facilities using raw materials from the primary sector, specifically from forestry and agriculture, predominate. On the other hand, the percentage of input raw materials coming from waste is much lower. Only Slovakia has facilities for grasses and short-rotation coppice and it is only 3.45% (Figure 61). But it is necessary to note that as plants can produce multiple products of different categories, the number of facilities, differentiated by input raw material, may exceed the total number of facilities per country.



	Bulgaria	Croatia	Czechia	Hungary	Poland	Romania	Slovakia	Slovenia
Agriculture	56,67%	50,00%	58,70%	70,00%	41,94%	41,67%	44,83%	18,18%
Forestry	26,67%	37,50%	30,43%	15,00%	55,91%	58,33%	41,38%	81,82%
Grasses and Short-rotation Coppice	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	3,45%	0,00%
Waste	16,67%	12,50%	10,87%	15,00%	2,15%	0,00%	10,34%	0,00%

Figure 61. Share of bio-based industry facilities by feedstock origin in CEE macro-region. Last available data to 2020.
Source: Datam JRC, European Commission.

[26] One industry facility may use different raw materials

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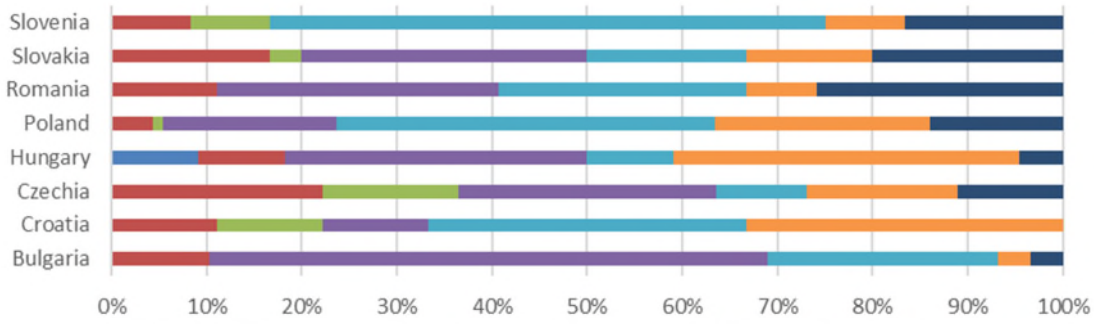
Figure 62 shows the share of bio-based industry facilities in CEE macro-region based on the product class they generate. There is a wide variety of products obtained from biomass, but the strongest industry is the pulp and paper sector followed by the liquid biofuels and starch & sugar sectors.



	Bulgaria	Croatia	Czechia	Hungary	Poland	Romania	Slovakia	Slovenia
biomethane	0,00%	0,00%	0,00%	9,09%	0,00%	0,00%	0,00%	0,00%
chemicals	10,34%	11,11%	22,22%	9,09%	4,30%	11,11%	16,67%	8,33%
composites and fibres	0,00%	11,11%	14,29%	0,00%	1,08%	0,00%	3,33%	8,33%
liquid biofuels	58,62%	11,11%	26,98%	31,82%	18,28%	29,63%	30,00%	0,00%
pulp&paper	24,14%	33,33%	9,52%	9,09%	39,78%	25,93%	16,67%	58,33%
starch&sugar	3,45%	33,33%	15,87%	36,36%	22,58%	7,41%	13,33%	8,33%
timber	3,45%	0,00%	11,11%	4,55%	13,98%	25,93%	20,00%	16,67%

Figure 62. Share bio-based industry facilities by product class in Central and Eastern Europe. As plants can produce multiple products of different categories, the number of facilities may exceed the total number of facilities per country.
Source: Datam JRC, European Commission.

5.1.2.2 Economic relevance

The bioeconomy for the purposes of mapping macro-regions is perceived in accordance with the EC definition, which defined the bioeconomy sector using NACE.
In order to estimate the number of people employed in the bioeconomy, employment in the following sectors was analysed for the CEE countries: Agriculture, forestry, fishing and aquaculture, food, beverage and tobacco, bio-based textiles, wood products and furniture, paper, bio-based chemical, pharmaceuticals, plastics and rubber (excl. biofuels), liquid biofuels and bio-based electricity. In the CEE macro-region, there are 6.62 million people employed in the bioeconomy. They represent 38.6% of the employed individuals in these sectors within the EU-27, although the inhabitants of the CEE countries are only 22.4% of EU27. This high employment number mainly occur because of the high importance of agriculture (4.32 million) in CEE. Agriculture contributes significantly to the bioeconomy in Central and Eastern Europe, with many small and large farms employing a significant number of workers. As Figure 64 presents this large employment in Agriculture mainly occurs in Romania and Poland.
These sectors followed by the food and beverage sector (1.08 million). Other relevant sectors include wood products and furniture (509.13k) (Figure 63).

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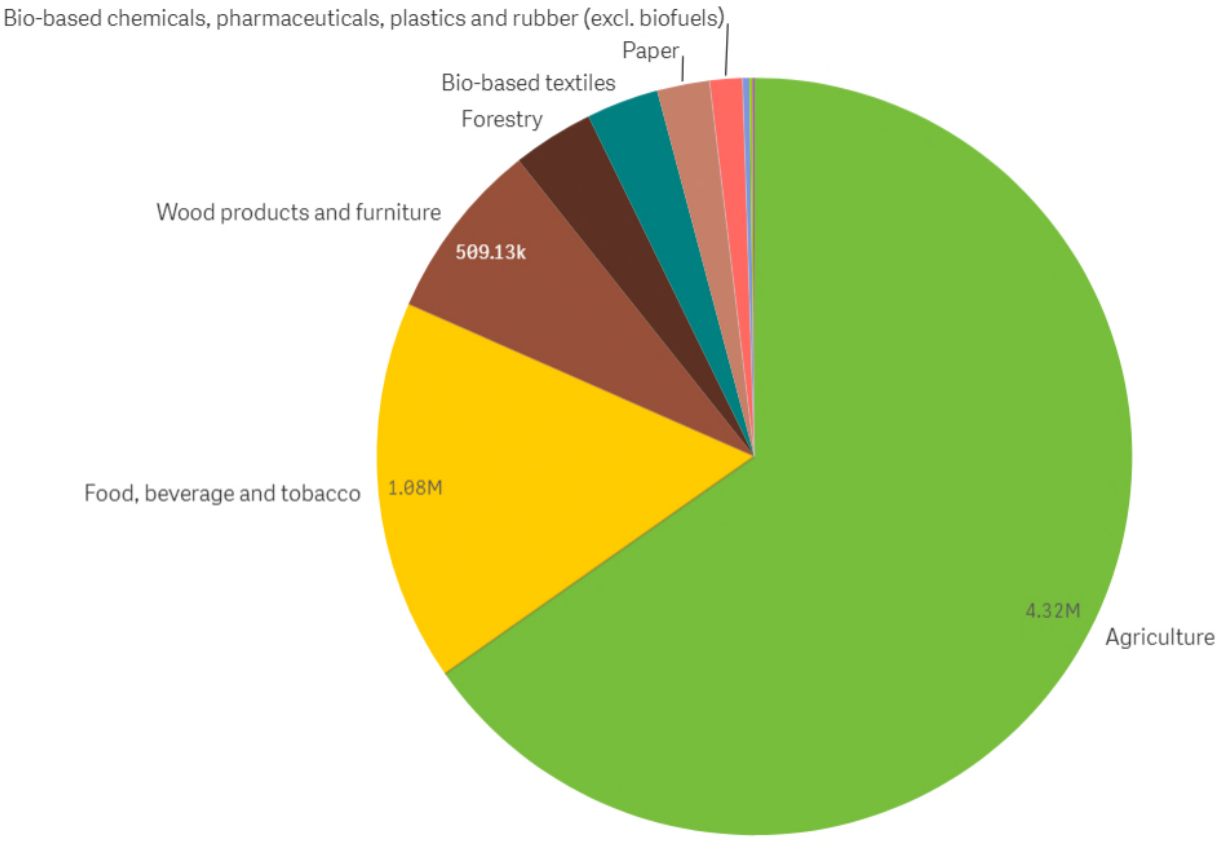

Figure 63. People employed per bioeconomy sector in central Eastern Europe (2020). Source: Datam JRC, European Commission.

According to data from last years (Figure 65, the colour code is the same as Figure 64), the number of employees in these sectors decrease.

The **added value of biomass** (Figure 66) produced in Central Eastern Europe is EUR 88.4 million. This corresponds to value added per person employed in biomass producing and converting sectors of only 13,000 EUR, compared to 39,000 EUR in the EU27. Together with the scarcity of biorefineries and bio-based industries producing more innovative product groups (e.g. bio-based chemicals, composites, bioenergy), this is an indicator that the biotechnical valorization of the biomass produced in the CEE countries is in its infancy.

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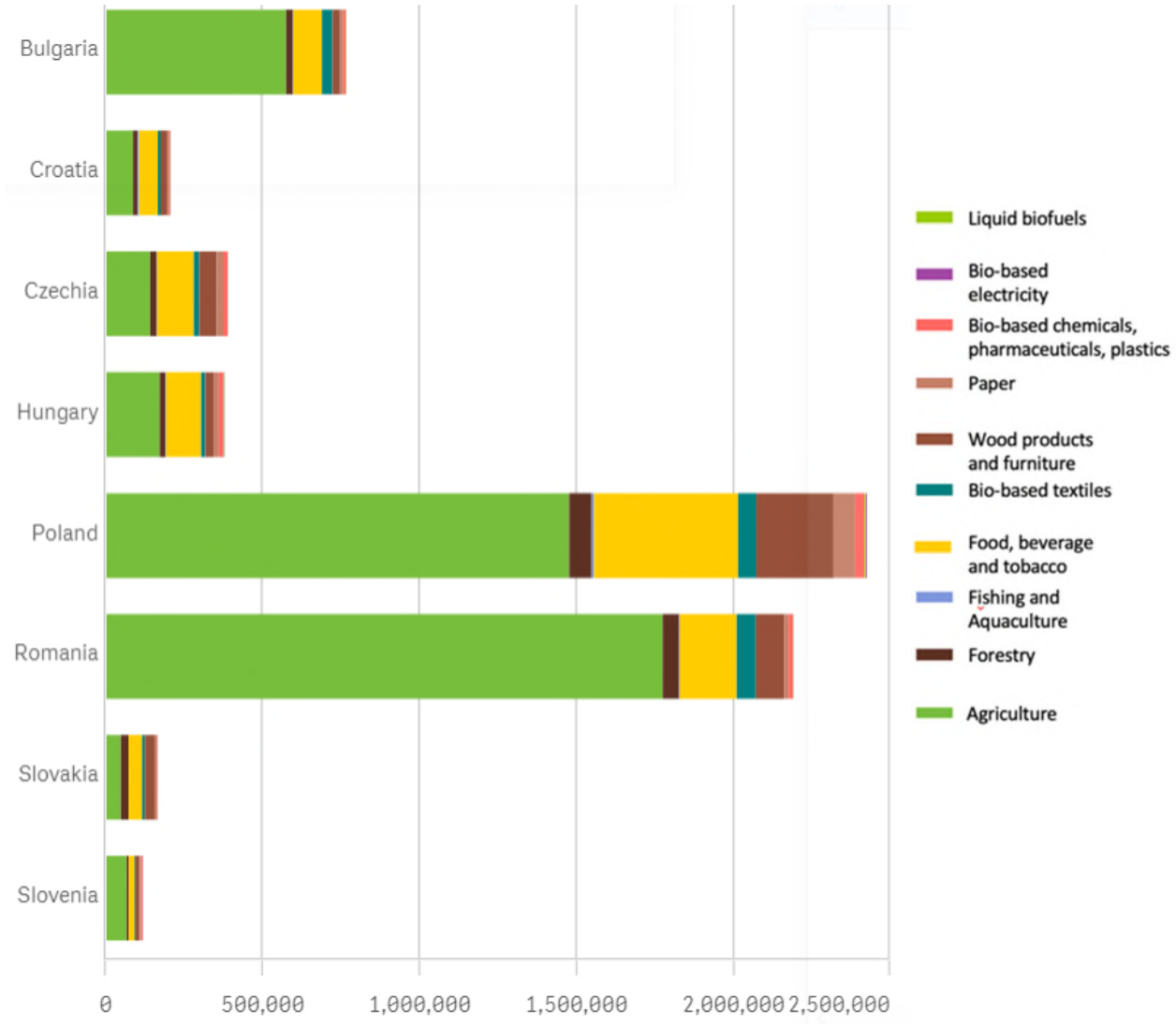

Figure 64. Number of people employed in bioeconomy sectors per country in 2020. Source: Datam JRC, European Commission.

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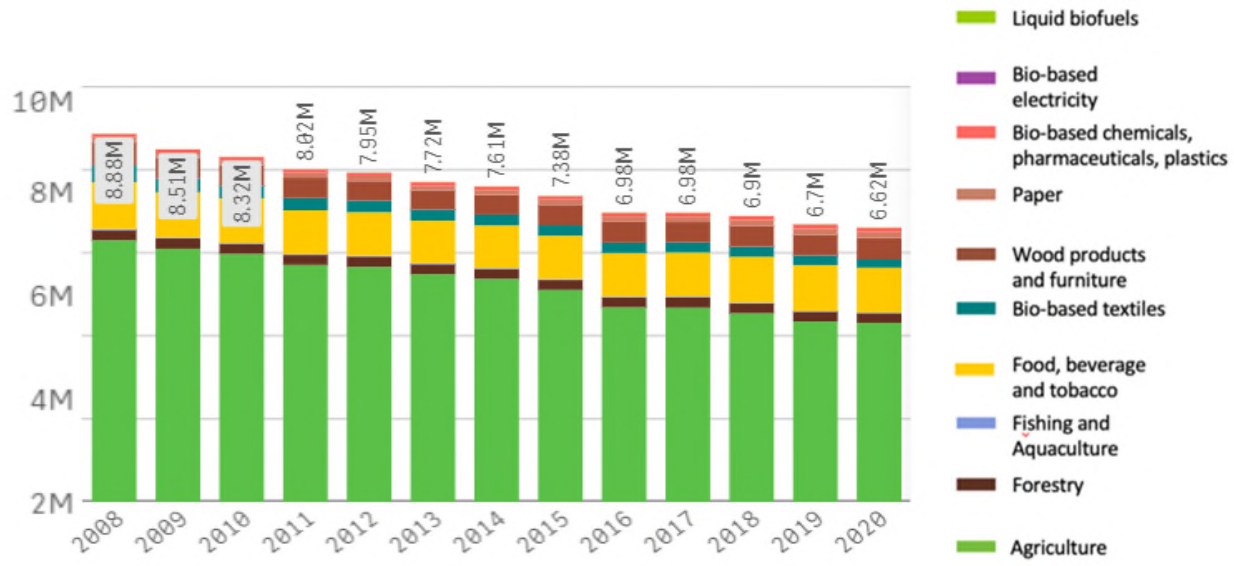

Figure 65. Development of people employed per bioeconomy sector in CEE macro-region (2008-2020). Source: Datam JRC, European Commission.

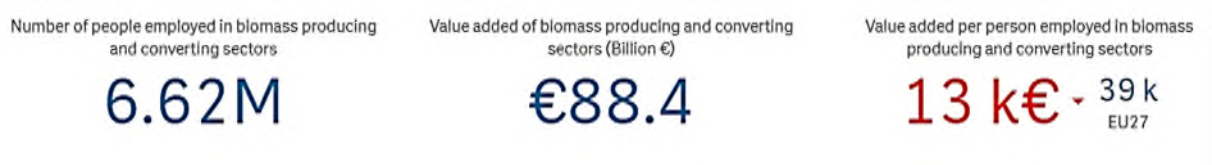

Figure 66. Value Added in CEE macro-region (2020). Source: Datam JRC, European Commission.

In the CEE macro-region, the total economic value of bioeconomy sectors is EUR 88.4 million (Figure 66). The sector with the highest added value of biomass is agriculture (EUR 31.43 million), followed by the food and beverage sector (EUR 27.14 million). Other relevant sectors include wood products and furniture, forestry and paper (Figure 67). The structure of economic added value in the bioeconomy sectors in the CEE macro-region has only marginally changed between 2008 and 2020 (Figure 69). The ranking of sectoral importance remained the same, with agriculture contributing the largest share to total value added (40.3% in 2008 and 38.5% in 2020, respectively), followed by food, beverages and tobacco (30.2% in 2008 vs 29.5% in 2020), wood products and furniture (10.8% in 2008 vs 11.5% in 2020) and forestry (5.8% in 2008 vs 6.7% in 2020). The contribution of all other sectors was individually lower than 5%.

The largest increases in last ten years occurred in the manufacturing of food, beverage and tobacco (+ EUR 7.1 billion), agriculture (+ EUR 3.7 billion) and the manufacturing of wood products and furniture (+ EUR 3.2 billion) (Figure 69). However, the manufacture of bioelectricity (in biogas stations) and liquid biofuels, fishing and aquaculture were the most dynamic sectors with growth of 296.6%, 158.4% and 123.3%, respectively, over the period (from a very low level). Among the bioeconomy industries, significant differences in the growth of value added were observed in almost all the reported industries (except for the manufacture of biotextiles). The most rapid average annual growth was recorded in the manufacture of liquid biofuels (9.0%), bio-based electricity (13.3%) and fishing and aquaculture (7.6%), followed by the manufacture of paper (5.2%). In the remaining industries, real value-added growth averaged 4% or less (calculation based on DataM, 2023).

Figure 65 shows the added value created by the bioeconomy sectors in the CEE by country in 2020. It is clear that the bioeconomy sectors in Poland created the most added values. Less than half the added value

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compared to Poland was created by the states of Romania, the Czech Republic and Hungary. In all countries, the added value was mainly created by traditional sectors.

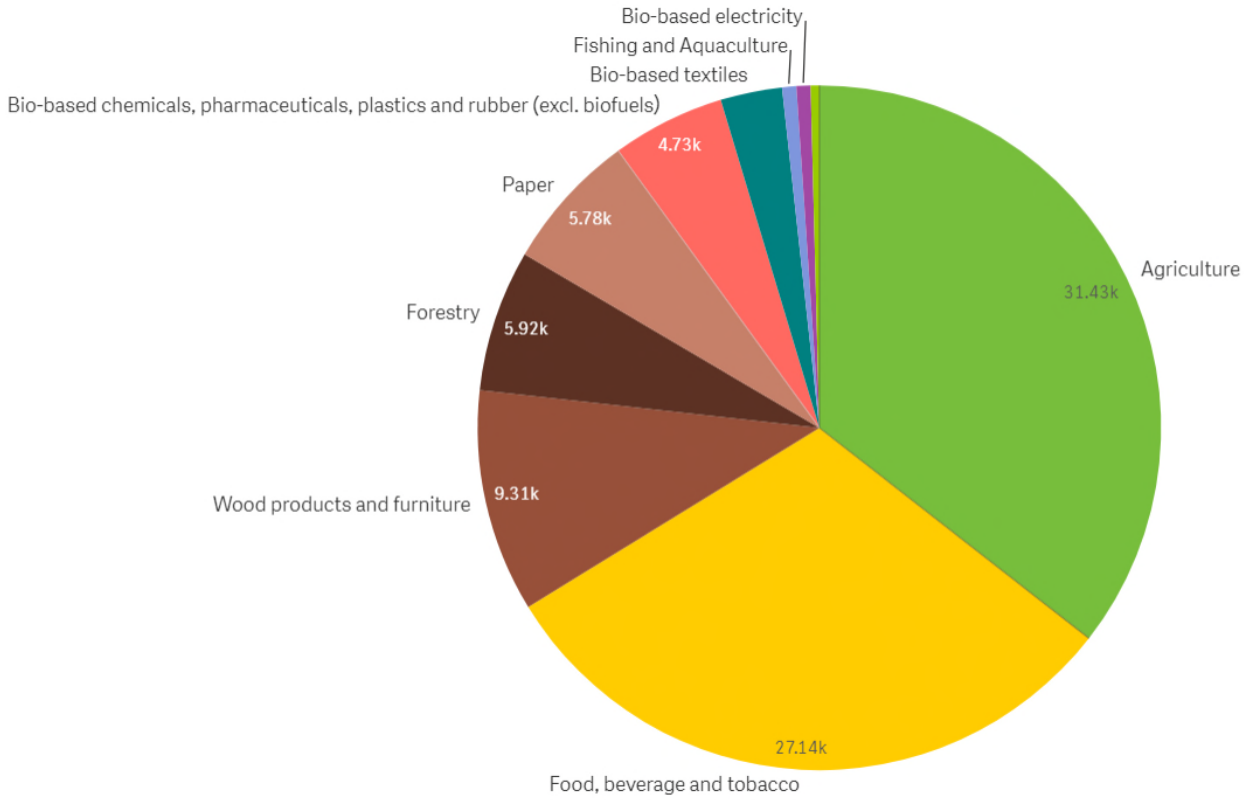

Figure 67. Economic added value per bioeconomy sector in CEE macro-region (2020). Source: Datam JRC, European Commission.

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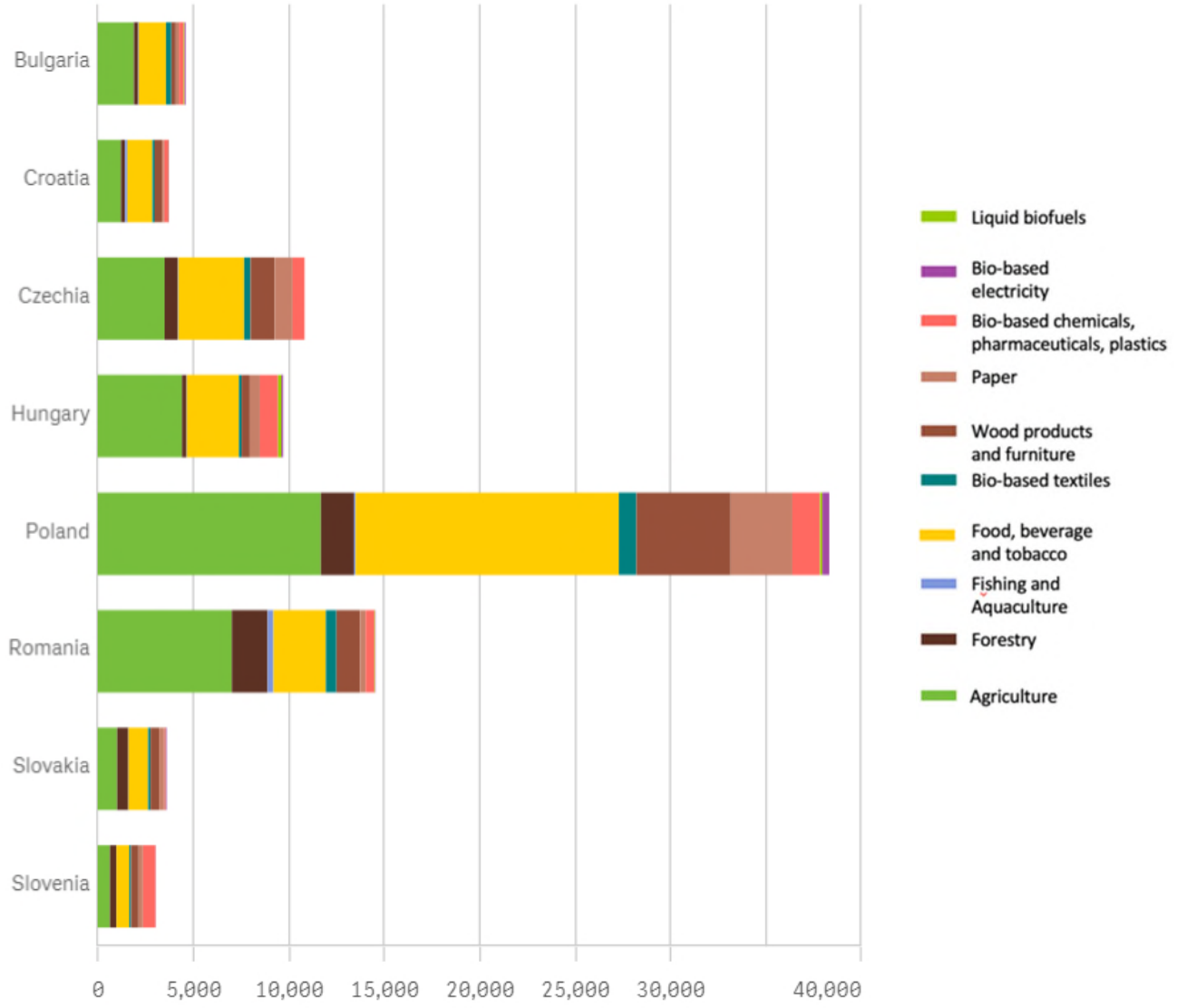

Figure 68. Value added created by bioeconomy sectors in CEE per country in 2020 (in million €). Source: Datam JRC, European Commission.

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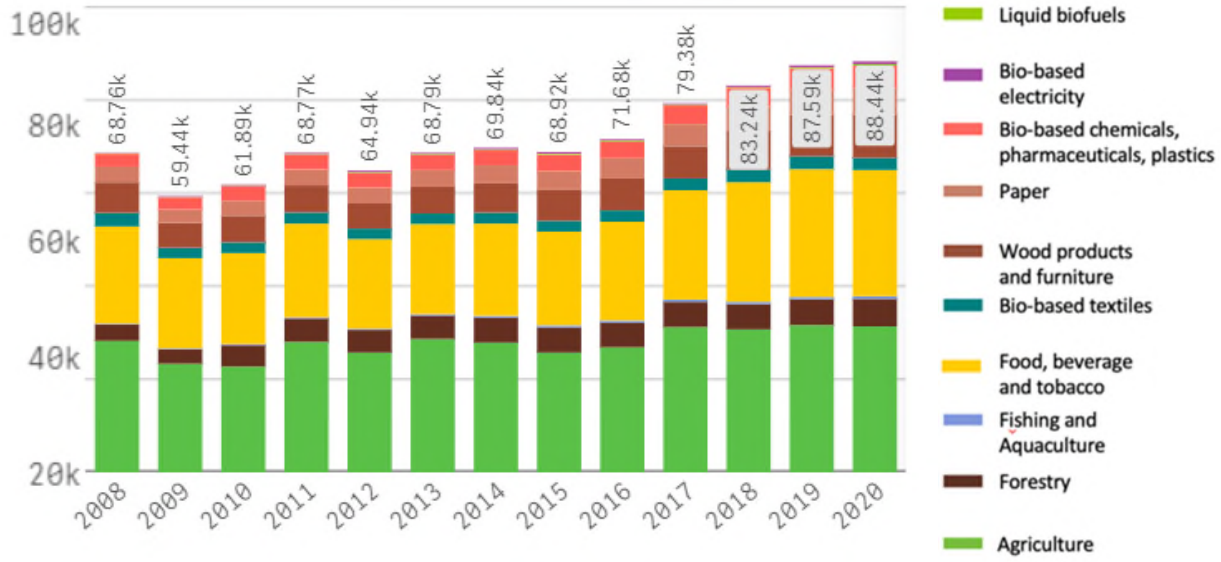

Figure 69. Development of economic added value per bioeconomy sector in CEE macro-region (2008-2020).
Source: Datam JRC, European Commission.

5.1.3 Actors

5.1.3.1 Academia, Research and Development

Research in bioeconomy, especially in CEE macro-region, encompasses both basic and applied aspects, reflecting the multidisciplinary nature of this field. Bioeconomy in the CEE macro-region focuses mainly on the utilization of biological resources for the production of food, energy, materials, and other products, and this breadth is reflected in the research approach. The box below presents the current status of bioeconomy R&D in general in CEE

While it can generally be said that research and development actors in the CEE macro-region cover the entire bioeconomy to varying degrees, it must be noted that the degree of focus and expertise varies in different sectors, depending on the specific strengths and priorities of each country. In Hungary, there is a more intense expert focus on agriculture, Poland generally tends to focus more on the food sector, Romania on forestry.
Specifically, several relevant R&D institutions operating in the CEE macro-region can be highlighted, which are among the prominent ones:

- Agricultural University Plovdiv (Bulgaria) - The university's Department of Biotechnology and Microbiology conducts research on bioprocessing, bioconversion, and bio-based products.
- University of Zagreb, Faculty of Food Technology and Biotechnology (Croatia) is a leading scientific research and teaching institution in the field of biotechnology, food technology and nutrition.
- Institute Ruđer Bošković (Croatia) is a multidisciplinary research centre engaged in research in the fields of material physics and chemistry, organic chemistry and biochemistry, molecular biology, and biomedicine, and exploring sea and environment.

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- Institute of Microbiology of the Czech Academy of Sciences (Czech Republic) - Conducts research on microbiology, including the production of biofuels, bioplastics, and biotechnological processes.
- Institute of Chemical Technology Prague (Czech Republic) - The institute focuses on research areas like bioinformatics, biotechnology, renewable energy, and environmental protection.
- Hungarian Academy of Sciences Centre for Agricultural Research (Hungary) - The centre's research institutes work on various aspects of bioeconomy, including bioenergy, bioengineering, and sustainable agriculture.
- Institute of Bioorganic Chemistry (Poland) - This institute is involved in bioorganic chemistry research, including the development of bio-based materials, biofuels, and biotechnological processes.
- Institute of Fermentation Technology and Microbiology (Poland) - The institute focuses on research related to fermentation processes and microbiology, including the production of biofuels and biochemicals.
- National Institute for Biological Sciences Romania (Romania) is dedicated to research in biodiversity and developing strategies for a sustainable exploitation of resources, studies of ecology, energy production using microorganisms, synthesis of biological compounds in culture media plants biology, water and soil ecology
- Slovak University of Technology in Bratislava (Slovakia) - The Faculty of Chemical and Food Technology at the university has research groups working on biotechnology, bioenergy, and sustainable development.
- National Agricultural and Food Centre (NPPC) (Slovakia) - NPPC conducts research on agricultural and food technologies, including biotechnology, sustainable agriculture, and agricultural waste management.
- National Institute of Chemistry (Slovenia) - The institute focuses on chemistry and related fields, including research on bio-based materials, biofuels, and biotechnological processes.

Box 6: Bioeconomy R&D landscape in CEE

The bioeconomy R&D landscape in the CEE macro-region is relatively well-developed, but it varies among countries within the region.

Some countries in the CEE macro-region, such as Poland, Hungary, and Slovenia, have made significant progress in developing their bioeconomy R&D sectors. These countries have established research institutions, centres and universities focused on bioeconomy-related research areas such as agricultural biotechnology, bio-based materials, bioenergy and waste utilization.

In addition to these countries, others like Czech Republic, Slovakia, and Romania are also making efforts to develop their bioeconomy R&D landscape. They have initiated projects, formed research networks, and established collaborations with international organizations to advance their bioeconomy-related research and innovation. In Croatia the Faculty of agriculture at University of Zagreb developed these activities. In Bulgaria are Plovdiv Agriculture University, also Trakia University which helped to develop the only regional bioeconomy strategy in Bulgaria, that of the Stara Zagora region.

However, there are still challenges that the CEE macro-region faces in fully developing its bioeconomy R&D landscape. These challenges include limited funding for research projects, lack of specialized infrastructure and equipment, and the need for more skilled researchers and experts in the field. Despite

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these challenges, the CEE macro-region demonstrates potential and is progressively investing in bioeconomy R&D activities to leverage the potential of bio-based industries.
In the CEE macro-region, there are several R&D institutions contributing to the overall R&D environment in the EU.
The key factors describe the specifics well (BIOEASTsUP, 2021b; EUROSAT, 2023 and SCAR, 2020):

1. Funding: RDI institutions in the EU benefit from a more developed and diversified funding landscape compared to those in the CEE macro-region. The EU provides substantial funding support for R&D projects and programmes, fostering collaboration and innovation across member states. In contrast, CEE countries often face funding constraints and rely heavily on national budgets, EU structural funds, and collaboration to support RDI activities.
2. Infrastructure and Resources: RDI institutions in the EU generally have access to more advanced research infrastructure, including state-of-the-art laboratories, data centres, and specialized equipment. EU member states have made significant investments in infrastructure development, enabling cutting-edge research and facilitating technology transfer. While CEE institutions have also made progress in this regard, their infrastructure may lag behind due to historical factors and resource limitations.
3. Collaboration and Networks: RDI institutions in the EU benefit from a large and diverse network of established research collaborations, both within the EU and internationally. This allows for the exchange of knowledge, expertise, and resources, leading to increased innovation and research output. While CEE institutions also engage in collaborations, their networks may be less extensive and diverse, limiting opportunities for cross-border cooperation.
4. Research Output: RDI institutions in the EU, particularly those in more developed research ecosystems, tend to have higher research output in terms of publications, patents, and commercialization of research results than CEE countries. The more established RDI infrastructure, funding mechanisms, and collaborative networks in the EU contribute to increased research productivity. However, CEE countries have been making significant efforts to enhance their research output, with some institutions achieving notable success in specific fields.
5. Specialization and Focus Areas: RDI institutions in the EU cover a wide range of disciplines and are often at the forefront of research in various fields. Due to historical and socioeconomic factors, CEE institutions may have areas of specialization that differ from those prevalent in the EU as a whole. For example, certain CEE countries have strengths in fields such as IT, software development, engineering, or biotechnology. Poland has a strong IT sector with a large pool of skilled IT professionals. It also has a thriving biotechnology sector and is home to numerous biotech companies and research institutions. The Czech Republic has a well-developed IT industry, particularly in software development and IT services. Prague, the capital, has become a hub for software development and tech start-ups. It also has expertise in engineering, including automotive engineering. Hungary has a growing IT sector and is known for software development and IT services. Budapest, the capital, attracts start-ups and innovative tech companies. The country also has a significant presence in biotechnology industries. Slovakia has a strong engineering sector, particularly in automotive engineering. Romania also has strengths in biotechnology, with several research institutions and biotech companies.

Despite these specifics, the CEE macro-region has been steadily improving its RDI capabilities and infrastructure, narrowing the gap with the EU.

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5.1.3.2 Industry

The CEE macro-region is not completely homogenous in terms of the bioeconomy industry. There are some differences between countries within the region. Some countries in the CEE macro-region have more favourable policies and regulations to support the bioeconomy industry, while others have been slower to implement such measures. Among other factors influencing the level of the bioeconomy industry is the level of investment and infrastructure development in the bioeconomy sector, the level of research and development activities and innovation within the bioeconomy sector, and market readiness and consumer awareness. This has an impact on the development and growth of the industry in that country.

The CEE macro-region has made significant progress in developing its bioeconomy, but it may not have fully covered all stages of the value chain. While there is substantial potential for growth and investment in the bioeconomy sector, certain stages may still require further development and attention.

There are dedicated influential bioeconomy industry/business associations in the CEE macro-region. Here the most prominent associations are listed:

1. Central and Eastern European Industrial Hemp Association (CEEIHA) - CEEIHA represents the interests of hemp-related industries in the CEE region. It aims to facilitate collaboration, knowledge exchange, and the development of sustainable bio-based products using hemp.
2. Central European Biotechnology Network (CEBN): CEBN is a regional network of bioeconomy stakeholders from Central European countries, including Poland, Czech Republic, Slovakia, Hungary, Slovenia, and Croatia. The network aims to foster collaboration and knowledge-sharing among stakeholders in thebe biotechnology sector.
3. Bulgarian Biotechnology Industry Association (BBIA) - BBIA is a leading association in Bulgaria that promotes the development and application of biotechnology solutions, including those in the bioeconomy sector. It supports innovation and the commercialization of biotech products.
4. Croatian Biotech Association (HrBA): Brings together biotechnology companies, research institutions, and other stakeholders to support the development and commercialization of biotechnology in Croatia.
5. Czech Association for Bioenergy: This association focuses on promoting and supporting the development of bioenergy within the Czech Republic. It brings together companies, research institutions, and individuals involved in the bioenergy sector.
6. Hungarian Bioeconomy Association (HUBA) - HUBA is a non-profit organization dedicated to promoting the bioeconomy in Hungary. It brings together professionals, researchers, and industry representatives to advance sustainable and bio-based economic practices.
7. Polish Chamber of Biofuels (Izba Biopaliw) – This chamber represents the interests of the biofuels industry in Poland. It works towards the development and promotion of sustainable bioenergy solutions, advocating for favourable policies and supporting research and innovation in the field.
8. Romanian Association of the Bio-Based Industries (ARBIO): Aims to develop and promote the bio-based industries in Romania, focusing on biofuels, bioplastics, and biomass utilization.
9. Slovak Association of Biotechnological Industries (SABI): Represents the interests of biotechnology companies in Slovakia and promotes their development and growth.
10. Slovenian Biotechnology Association (SBA): Focuses on advancing biotechnology and its applications in various sectors, including medicine, agriculture, and environmental protection.

In the CEE macro-region, there are both specializations and gaps when it comes to various aspects of the bioeconomy (BIOEASTsUP, 2021a):

1. Focus on Primary Production: One specialization in the CEE macro-region is the focus on primary production. Countries like Poland, Hungary, and Romania have a significant share of their economies dependent on agriculture and forestry. These countries have well-established

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agricultural sectors and are often considered to have a comparative advantage in primary production.

2. Lack of Valorization of Biomass Feedstocks: A gap in the CEE macro-region is the underutilization or lack of valorization of biomass feedstocks. While there is a significant amount of biomass available from agricultural and forestry activities, the region faces challenges in transforming this feedstock into high-value products. The lack of infrastructure and investment in biorefineries and bio-based industries hinders the efficient conversion of biomass into biofuels, biochemicals, and other value-added products.
3. Lack of Domestic Companies: Another gap is the limited number of domestic companies in the bioeconomy sector. Many CEE countries rely heavily on foreign-owned companies or international investors for technologies and expertise in the bio-based industries. This dependency on foreign entities reduces the region's ability to fully capture the economic benefits and intellectual property rights associated with bio-based innovation. This gap is due to the historical development of the countries of the CEE region, when at the end of the 1990s, when the restructuring and privatization of state-owned enterprises began, many enterprises were broken up into individual companies. This fragmentation into individual small producers places high demands on logistics and trading and the overall prosperity of companies. Foreign investors bringing the capital necessary for the modernization and restructuring of enterprises, progressive technologies, technical and managerial know-how and to facilitate the entry of products into foreign markets, etc. (Businessinfo.cz, 2009).
4. Foreign investment into production facilities in the bioeconomy sector. The CEE region offers favourable conditions such as abundant biomass resources, skilled labour and supportive government policies, making it an attractive destination for foreign investment in the bioeconomy sector. Important production facilities in the bioeconomy sector that have been established in the region and are owned by foreign companies. Examples include Cargill in Poland, owned by an American multinational corporation, which has established large production plants in Poland for the production of bioethanol and starch-based vegetable oils. Archer Daniels Midland (ADM), an American food processing and commodity trading company, has been operating in Hungary for almost 10 years. It has invested in the establishment of a corn processing facility in Hungary that produces ethanol, sweeteners and starch-based products. It employs around 31,000 people in Hungary. This company also made large investments in the Czech Republic, Poland and Slovakia.
    a. The Austrian company Lenzing Group, specializing in textile fibres and wood-based fibres, has a production plant in the Czech Republic for the production of special fibres such as TENCEL™ lyocell. In the Czech Republic, for example, it has teamed up with a national carrier and is helping to develop international logistics.
    b. Danone, a French multinational corporation of food products, has established a production plant in Romania for the production of dairy products from local ingredients and annually buys over 25,000 tonnes of milk. After investing EUR 3 million in a new production line in 2019, organic dairy products are also produced in Bucharest. Danone produces over a million yogurts a day at its plant in Bucharest. (romania-insider, 2023). The German company Hochland, which operates in the same sector, began to expand in the early 1990s with direct investments in CEE (e.g. in Poland in 1991, Romania in 1998). Clariant International, a Swiss specialty chemicals company, has built a production facility in Bulgaria to produce bioethanol obtained from agricultural waste. British Sugar, a subsidiary of Associated British Foods, has established a production plant in Slovakia for the production of sugar and other sugar-based products.
    c. Over the past 30 years, Evonik's plant EVONIK FERMAS S. R. O. in Slovakia has developed into a strategic centre for biotechnology with a team of highly qualified experts. In June 2022, Evonik began construction of the world's first commercial rhamnolipid

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production facility. The new biosurfactant plant is a triple-digit million-euro investment in Evonik's biotech hub in Slovakia. (Evonik, 2023)

5. Lack of Start-up Companies and Entrepreneurship: There is also a lack of start-up companies and entrepreneurship in the bioeconomy sector within the CEE macro-region. Compared to other regions, such as Western Europe or North America, there are relatively fewer bioeconomy-related start-ups and limited access to venture capital and support systems for entrepreneurs in the region.
6. Lack of R&D/Innovation in Companies: Many companies in the CEE macro-region also face a gap in terms of research and development (R&D) and innovation in the bioeconomy sector. Limited investment in R&D activities and a lower level of collaboration between research institutions, universities, and industry hinder the development of innovative and sustainable bio-based solutions.

Overall, while the CEE macro-region has some specialization in primary production, there are gaps in biomass valorization, domestic companies, start-ups and R&D/innovation. It is also typical for the region that the actors involved know each other very well and are largely "driven by profit" (that is, the most important thing for the actors remains the generation of turnover and income and they do not take externalities into account).

5.1.3.3 Civil Society

Several NGOs in the CEE macro-region play a major role in the public discourse on bioeconomy and have a say in bioeconomy policy. Some of these NGOs include:

1. Regional Environmental Centre for Central and Eastern Europe (REC): REC works towards environmental conservation and sustainable development in the CEE macro-region. It actively engages in the bioeconomy discourse and supports the development of policies that promote sustainability and innovation.
2. Greenpeace Central and Eastern Europe: Greenpeace is a well-known global NGO that campaigns for environmental protection. It actively pursues the dialogue on bioeconomy, pushing for sustainable and socially responsible bio-based practices and policies in the CEE macro-region.
3. Institute for Sustainable Development and International Relations (IDDRI): Although based in France, IDDRI conducts research and provides policy recommendations on sustainable development, including bioeconomy, globally. It has expertise on the CEE macro-region and contributes to the policy discourse on bioeconomy in CEE countries.

These NGOs, among many others, play a significant role in shaping the public discourse and influencing bioeconomy policies in the CEE macro-region.

Level of perception of bioeconomy by civil society

In the CEE macro-region, there may be pockets of resistance or lack of acceptance towards certain bioeconomy initiatives. However, this global view of the macro-region is not true in all countries. E.g. in Croatia, the situation has improved considerably which is especially evidenced by the prepared Bioeconomy Strategy and Action plan 2035 or in a Hungary, where has been published in April document Towards a National Circular Economy Strategy for Hungary. The negative perception of civil society aspects of the bioeconomy in the CEE macro-region is mainly conditioned by the following two factors:

- Economic concerns: Some stakeholders may be sceptical about the economic viability of bioeconomy projects, especially if the traditional industries they are associated with are threatened.
- Lack of awareness, knowledge: The concept of the bioeconomy and its potential benefits is not widely known and understood by all stakeholders, leading to scepticism or resistance. Since there

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is no national strategic document in many countries that would explain bioeconomies, there is still a reluctance to discuss the bioeconomy. The majority of the region reports that the concept of bioeconomy is still not known to the general public and stakeholders that they do not understand it and do not know what it includes.

It is important to note that the degree of lack of acceptance and criticism varies from country to country in the CEE macro-region. Factors such as political (not a political priority), social (concerns about food security, fear of breeding - genetically modified organisms), economic (financial demands for capacity building) and environmental circumstances (large-scale production of biomass for biofuel production) influence attitudes towards bioeconomy initiatives in every country of macro-region.
The role of citizens is crucial in the social acceptance of the sustainable bioeconomy across the CEE macro-region. Particular emphasis will be given to networking and awareness raising in order to encourage a sustainable transition. Open communication between all the stakeholders of the sustainable bioeconomy is also essential.

5.1.4 Bioeconomy Policies in the Central and Eastern Macro-Region

The state of play regarding bioeconomy strategies, action plans, and policy implementation in the CEE macro-region countries is quite variable. While some countries have made significant progress in developing and implementing bioeconomy policies, others are still in the early stages. In the vast majority of the Central and Eastern countries national bioeconomy strategies have not yet been developed. There are no formal bioeconomy inter-ministerial groups set yet in most of the countries. There is a political interest in general terms in innovative projects (among others also in the bio-based sector). Special interest in bioeconomy is, however, still missing due to the lack of understanding of the importance of the whole sector. Moreover, the political level is still accentuating the traditional sector approach as the added value of bioeconomy is not tangible.
There is also a terminological issue that is perhaps rooted in political development. There is no equivalent of policy in the national languages, the translation in many cases (Czech, Croatian, Hungarian) means politics as an activity of political parties and politicians. The involvement of civil society and stakeholder engagement is rather missing.
Overall, while progress has been made in some CEE countries regarding the development and implementation of bioeconomy strategies, action plans, and policies, there is still room for improvement in others. It is a dynamic field, and countries in the region are increasingly recognizing the importance of the bioeconomy for sustainable development, innovation, and economic growth. Leading role play the Ministries of Agriculture that are supported by the BIOEAST Initiative. More details about BIOEAST Initiative see in chapter 3.2.
Poland has developed its Bioeconomy Development Programme, which sets out a clear vision and roadmap for promoting bioeconomic activities, including the development of bio-based industries, sustainable agriculture, and renewable energy. The country has also established institutions and funding programmes to support bioeconomy research and innovation.
Hungary is another country in the region that has made substantial progress in the field of bioeconomy. It has developed a document called “Towards a National Circular Economy Strategy for Hungary”, focusing on sustainable agriculture, forestry, and the utilization of biological resources. Hungary has also established dedicated bioeconomy research centres and launched initiatives promoting bio-based innovation and entrepreneurship.
Other countries in the CEE macro-region are still in the early stages of developing bioeconomy strategies and plans. Slovakia has initiated discussions and consultations on the topic but has not yet finalized a comprehensive strategy. Similarly, Romania is in the process of developing a Bioeconomy Strategy, with a focus on sustainable agriculture, forestry, and the circular economy. A more detailed analysis (Table 26)

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shows that the bioeconomy is anchored in many national strategies of the countries of the CEE macro-region.
The level of policy implementation also varies across the CEE macro-region. Hungary and Croatia have taken concrete steps to implement their bioeconomy policies, such as establishing funding schemes, supporting bio-based industries, and promoting collaboration between industry and research institutions. However, the level of actual implementation varies depending on the political will, resources, and capabilities of each country. In the Czech Republic, the strategy is not always connected to the action plan nor to any policy instrument, hereby the strategy is a declaratory document, but the implementation is lagging behind.

Table 26 Political anchoring of the bioeconomy in the countries of the CEE macro-region

	National BE definition	**National BE strategy**	**Other national bioeconomy-related strategies**
Bulgaria	Not defined. However, the Institute for Economic Research at the Bulgarian Academy of Science is completing a paper that defines bioeconomy (due 31 October 2023) https://www.iki.bas.bg/razvitie-na-bioikonomikata-v-balgariia-vazmozhnosti-i-regionalni-specifiki	Not available in terms of sectors, goals, monitoring. However, some of the strategic documents include parts that refer to or address partially circular economy, “industry for healthy life, bioeconomy and biotechnologies”, low-carbon industry or similar	Draft Integrated Energy and Climate Plan of the Republic of Bulgaria; National Development Strategy 2030; Strategy and Action Plan for the transition to a circular economy of the Republic of Bulgaria for the period 2022-2027; Innovation Strategy for Smart Specialization
Croatia	Definition is based on the Croatian Smart Specialisation Strategy	Bioeconomy Strategy and Action plan 2035 are under development	CAP Strategic Plan, Integrated Energy and Climate Plan for the Republic of Croatia 2021-2030, Waste Management Strategy of the Republic of Croatia, National Law on Forests, Nature Protection Strategy and Action Plan of the Republic of Croatia 2017 - 2025, Rural Development Programme, Smart Specialisation Strategy and Action Plan, National Aquaculture Development Plan, The Agricultural Strategy, Energy Development Strategy, Croatian National Development Strategy 2030, Low Carbon Development Strategy, Waste Management Plan
Czechia	Definition by Agri ministry	Concept of bioeconomy in the Czech Republic from the perspective of the Ministry of Agriculture for the years 2019-2024	Strategic Framework Czech Republic 2030, Strategy of the Ministry of Agriculture with a view to 2030, Draft National Energy and Climate Plan of the Czech Republic

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Hungary	Based on circular economy strategy	Towards a National Circular Economy Strategy for Hungary	National Climate Change Strategy 2, Food Industry Programme of Hungary 2016-2050, National Energy and Climate Plan for Hungary 2030, National Clean Development Strategy 2020-2050, National Forestry Strategy 2016-2030, https://2010-2014.kormany.hu/download/6/b9/30000/RENEWABLE ENERGY_REPUBLIC OF HUNGARY NATIONAL RENEWABLE ENERGY ACTION PLAN 2010_2020.pdfNational Energy Strategy 2030, National Waste Management Plan (2021-2027), Smart Specialization Strategy, National Development 2030 - National Development and Territorial Development Concept
Poland	No official definition of bioeconomy, or bio-based economy or bio-based industry	Bioeconomy Development Programme - the main bioeconomy priorities listed in the Road map	National Smart Specialisation Strategy; BIOSTRATEG Strategic and Research programme "Environment, Agriculture and Forestry"; "The Strategy for Sustainable Development of Rural Areas", "Agriculture and Fisheries", "Plan for Rural Areas" (bioeconomy as one of the priority projects named Agriculture for Ecology); "National Energy and Climate Plan for the years 2021-2030"
Romania	There is no formal/official definition but there is a general tendency to adopt the EC definition of the bioeconomy	Developing a bioeconomy strategy focusing on sustainable agriculture, forestry and circular economy	Romanian RDI Strategy; Strategy for the development of the agri-food sector on average- and long-term 2020-2030; Smart specialization domains financed by structural funds within Competitiveness Operational Programme; Draft Integrated National Energy and Climate Change Plan for 2021 - 2030
Slovenia	The term "bioeconomy" is defined according to the EC's interpretation, in country's strategic documents; individual attributes of bioeconomy are recognized in national circular economy and green economy strategies; bioeconomy principles can be recognized in four (of nine) priority areas of the Smart specialization strategy of Slovenia	NA	Slovenia's Smart Specialization Strategy; Slovenian Development Strategy 2030; Framework Programme for the Transition to a Green Economy; Draft Integrated National Energy and Climate Plan for Slovenia; Roadmap towards the Circular Economy in Slovenia
Slovakia	No formal definition	Initiated discussions and consultations on the topic but have not yet finalized a comprehensive strategy	Research and Innovation Strategy for Smart Specialization of the Slovak Republic; Strategy of the Economy policy until 2030; Greener Slovakia – The Strategy of the Environmental Policy of the Slovak Republic until 2030; Proposal for an Integrated National Energy and Climate Plan

Source: European Commission Knowledge for policy (2023).

Due to the lack of definition in what bioeconomy means there is also no uniform primary competence of the ministries responsible for bioeconomy policy. If the bioeconomy is discussed at the national level, then this agenda falls under the various ministries in the countries of the Central and Eastern European macro-region. At the same time, the focus of the ministries also affects the main focus-sectors of the bioeconomy

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in the given country. According to the list below, it is clear that, overall, the CEE macro-region perceives the bioeconomy in small nuances.

Table 27 Departments responsible for bioeconomy policy in CEE macro-region countries

Bulgaria	Ministry of Agriculture, Food, and Forestry
	Ministry of Economy
Croatia	Ministry of Agriculture
	Ministry of Economy, Entrepreneurship and Crafts
Czech Republic	Ministry of Agriculture - *primarily, but also*
	Ministry of Education, Youth and Sport
	Ministry of Industry and trade
	Ministry of Environment
	Ministry of Transport
Hungary	Ministry of Agriculture
Poland	Ministry of Agriculture and Rural Development
	Ministry of Climate and Environment
Romania	Ministry of Agriculture and Rural Development
	Ministry of Environment, Waters, and Forests
Slovenia	Ministry of Agriculture, Forestry, and Food
	Ministry of Economic Development and Technology
Slovakia	Ministry of Agriculture and Rural Development
	Ministry of Economy

Source: Interviews with political representatives of the CEE macro-region (2023).

In the CEE macro-region, some countries have established advisory bodies such as high-level expert groups, bioeconomy councils or bioeconomy committees to improve their bioeconomy policy-making processes. These advisory bodies typically include representatives from academia, industry, civil society and government who bring a diverse range of expertise and perspectives. For example, in the Czech Republic, the Czech Academy of Agricultural Sciences (an advisory body to the ministry made up of experts and scientists) helps the Ministry of Agriculture solve issues related to the bioeconomy. At the same time, an informal inter-ministerial group was established for the national bioeconomy solution, where, together with the Ministry of Agriculture, the bioeconomy is discussed from the point of view of industry, trade, energy, research, education, biodiversity protection or infrastructure development.

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Although many countries of the CEE macro-region have a similar structure of advisory bodies, almost zero experience with forecast-based policy and the informal setting of inter-departmental groups make difficult to fully utilize their expert potential.
A common feature of the CEE macro-region is also the fragmented and unanchored coordination of the bioeconomy among many ministries and other departments that do not share information and do not coordinate and cooperate in common way. In particular, it is evident by the existence of many contact points, which are often different for BIOEAST, Horizon Europe, SCAR, CBE-JU, national programmes often fragment national/macro-regional coordination by sector.

Policy Instruments
While CEE is still less developed and on a different stage regarding bioeconomy strategies and implementation measures compared to other macro-regions (Voicilas, 2020). Some shift to more activities in the bioeconomy can be observed. There are several initiatives and programmes, which support applied R&D and technology transfer in the bioeconomy. Through research funding schemes, innovation centres or incubators financial and technical support to research projects are provided. In the Czech Republic, the Czech Academy of Agricultural Sciences serves not only as a tool to advance agricultural research, development or education, but also as scientific advisory body to the Ministry of Agriculture. Another important tool of the Czech government is the technology agency that was founded in 2009 and supports research, experimental development and innovation. As a further key characteristic of the region are the European Structural and Investment Funds (ESIF), which play a paramount role for these countries (Buday et al., 2020). Romania also advanced its role in the bioeconomy in sectors, such as agriculture, food industry or rural development. But also in this country, only a few policy measures are implemented. However, the Romanian Research and Innovation Fund (FUIR) is a further national component of Romania's innovation system that funds several sectors, including the bioeconomy. With the BIOSTRATEG Strategic and Research Program, Poland has initiated further development of environmental issues, agriculture and forestry. The programme covers different strategic problem areas, such as food security and food safety, rational management of natural resources, prevention and adaptation to climate change, protection of biodiversity and forestry and wood industry.[27] Although not directly dedicated to bioeconomic scientific research, the programme promotes the implementation of new products, techniques and technologies in sectors, playing an increasingly important role in the bioeconomy. Another institution that provides funding in Poland is the National Centre for Research and Development, which fosters via its strategic programmes new technologies in the field of energy. Under the realm of this programme, also the use of biodegradable raw materials and waste products is funded.
In conclusion, the landscape of policy instrument in Central and Eastern Europe for bioeconomy still remains a bit unclear, as many government measures and instruments are not directly dedicated to bioeconomy development, just associated to sectors that play a role in the bioeconomy. Similar to the other MR, the CEE countries have implemented mostly supply-side measures (with the exception of biofuels) with national and European funding programmes as the most preferred policy instrument.

5.2 Policy process and policy coordination in selected MR countries

Overall, political coordination and participation of various stakeholders is essential for the successful development and implementation of bioeconomy strategies in the CEE macro-region. These stakeholders should include government institutions, industry representatives, research organizations, environmental organizations, farmers and local communities. This collaborative approach ensures that strategies are comprehensive, inclusive and sustainable, promoting economic growth, environmental protection and social development.

[27] https://bioagra.pl/en/biostrateg/

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It is therefore appropriate to mention here that the BIOEAST initiative is very helpful in the coordination and political process. The BIOEAST initiative is a policy initiative that aims to support the development of knowledge-based and collaborative circular bioeconomy in order to strengthen inclusive growth in the BIOEAST countries (i.e. Central and Eastern EU) as well as create new value-added jobs, especially in rural areas, and maintain or even enhance environmental sustainability. BIOEAST's approach is to support the ministry that takes the lead according to a sectoral policy, e.g. agriculture or policies related to the circular economy. The BIOAEST Initiative is a key player in the bioeconomy development in Central and Eastern macro-region; as the only initiative BIOEAST was appraised by the EU Council in Agriculture and Fisheries (Council of the European Union, 2023) as a role model for the support the development of sustainable and circular bioeconomy systems.
The value and validity of the initiative for BIOEAST member states has already been confirmed five times at the political level by signing a joint declaration. Also EU representatives evaluated the achievements and importance of the BIOEAST Initiative in several strategic documents, mainly the EU Bioeconomy Strategy (European Commission Directorate-General for Research and Innovation, 2018), the European Council (2019) Conclusion on an Updated Bioeconomy, the European Council (2020) Conclusion on the Farm-to-Fork Strategy, European Commission (2022) Bioeconomy Strategy Progress Report and on several occasions (e.g. the High Level Bioeconomy Conference in October 2022).
Nevertheless, further progress still remains to be achieved regarding a stronger recognition of bioeconomy policies by decision makers and stakeholders, by strengthening the political level which is still weak, disrupted, and partial in the countries CEE macro-region. For this purpose, national BIOEAST HUBs should have been established in all BIOEAST countries (for now, only the national BIOEAST HUB in CZ has been established). The BIOEAST Initiative aims to accelerate the development of the bioeconomy in the CEE countries. As part of this initiative, BIOEAST HUBs are being established to foster collaboration (horizontal and vertical, i.e. between ministries, academia and industry etc.) and knowledge sharing within the BIOEAST region (cross-country) and in respective CEE country where the Hub is located too.
The national BIOEAST HUBs can deliver change, support the involvement of civil society and stakeholders in bioeconomy, increase awareness of bioeconomy and encourage stakeholders to get involved in the policy making process. The first national BIOEAST HUB was established in line with the BIOEAST Governance paper (memorandum of association) and the support of the Ministry of Agriculture in the Czech Republic – BIOEAST HUB CZ.

5.2.1 Characterization of horizontal coordination between different ministries/departments

In the countries of the CEE macro-region, there is no single organization responsible for the development and implementation of bioeconomy measures (except in Hungary, where the Ministry of Agriculture takes care of bioeconomy). Therefore, cooperation and coordinated efforts among different actors are essential. Ministries and public institutes selected to participate in related matters play a significant role in the country's bioeconomy. In fact, the Ministry of Economy and the Ministry responsible for the primary sector stand out in each country Table 27). Due to the diverse responsibilities of different ministries and departments related to the bioeconomy policy, there is a need for horizontal coordination. This is because various sectors such as agriculture, energy, environment, and education are interlinked and rely on public support for development.
In the CEE countries, the bioeconomy is thus viewed through individual segments. Ministries such as Agriculture, Environment and Water Management, Energy, Economy and Education and Science are responsible for various aspects of the bioeconomy. For example, the Ministry of Agriculture and the Ministry of Environment and Water Management support primary sectors such as agriculture, fisheries and forestry. The Ministry of Energy focuses on energy, including bioenergy, while the Ministry of Economy supports other branches of the bioeconomy.

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It is also important to mention that different ministries have different levels of activity and leadership. Examples of outstanding leadership are visible in Bulgaria, the Ministry of Innovation and Growth collaborates with the Ministry of Science and Education to manage a national programme for research and innovation. The Research Council of Bulgaria also manages science development programmes and promotes sustainable economic growth. In the Czech Republic, the Ministry of Agriculture cooperates with the Ministry of the Environment on the impact on biodiversity and reducing emissions. These activities are not coordinated in any way and arose rather ad hoc for the need to solve the given issue (in the case of Bulgaria to manage the R&D&I programme, in Czech Republic to impact on biodiversity).
At this point it is appropriate to mention that due to Bulgaria´s political instability and consecutive caretaker governments with no continuously functioning parliament, important strategic documents related or concerning bioeconomy, their operationalisation and the actual start of these programmes have been partially delayed in Bulgaria.

5.2.2 Role of stakeholder involvement in bioeconomy policy making

Stakeholder involvement in CEE macro-region bioeconomy policy making includes various sectors and institutions but the extent of its influence on policymaking and the success of the involvement process are not clearly pronounced. There is a need to focus on involving stakeholders and evaluating the effectiveness of involvement mechanisms for successful bioeconomy policy making. This is precisely one of the main tasks of BIOEAST HUBs.
The role of stakeholder involvement in bioeconomy policy making was analysed for the Czech Republic and Bulgaria, by conducting expert interviews.
Stakeholder Involvement Process: Various stakeholders are involved, including public research institutions, universities, industrial clusters and private companies. However, the connection between R&D actors and the bioeconomy-related sectors is not strong. Public research institutes such as the Agricultural Academy and Bulgarian Academy of Sciences, as well as private institutes and higher education institutions, contribute to research and innovation in bioeconomy-related sectors but the link weakens when the research results are to be transformed into commercialised solutions.
Stakeholder Groups: Efforts to involve hard-to-reach stakeholder groups are sporadic and there is no specific bioeconomy policy or programme in this regard. The results from the effort of these groups are often poorly communicated or hard to find. There is a notable tendency on involving stakeholders from various sectors, like agriculture, forestry, energy, and tourism, to promote bioeconomy development. Some specific EU-financed projects temporarily (while the project lasts) intensify the interaction between the stakeholders but they heavily depend on external funding to become long-term collaboration with continuous effort and outcomes.
Outcome and Influence: The political commitment and public funding in the primary sector are significant assets for bioeconomy development. The extent of influence of stakeholder involvement on bioeconomy policymaking is difficult to assess because of disperse information on bioeconomy initiatives, especially related to the involved stakeholders.

5.2.3 Dealing with goal conflicts

As one of the less developed regions in Europe, CEE lacks not only bioeconomy development, but also a broad discussion of the various implications the bioeconomy can have regarding existing goal conflicts. It should also be noted that due to the missing development of the bieoconomy concept in these countries, goal conflicts are rather addressed in single sectors, which show some developments towards bioeconomic practises.
By looking deeper into these sectors, some conflicts arise in CEE countries. In Poland, for instance, the government’s plans to substitute coal with biomass shows broad support. The scientific community, however, is warning that the use of forestry for biomass should not imply damages on nature and

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biodiversity. For efficient climate protection the scientific community, therefore, calls for better biodiversity protection in line with EU strategies, such as the European biodiversity strategy or the EU forest strategy. In Bulgaria, conflicts between traditional agricultural small-scale farming practises and new emergent neo-liberal paradigms currently exist. For instance, critics out into question neoliberal principles, such as attracting investment, economic efficiency or growth, which do not make any difference for local communities, as they are excluded from new intensive agricultural production . Nonetheless, in Slovenia, bioeconomy related goal conflicts have emerged in the context of alternative uses of biomass and risk of over-exploitation of renewable carbon sources. Moreover, in Slovenia negative public opinion regarding the energy use of biomass and negative perceptions of support policies exist.
One of the main challenges, therefore, in the bioeconomy policy progress in central and Eastern Europe is the lack of coordinated and coherent approach among the countries. Although some countries are in the process of developing bioeconomy strategies and policies, there is often limited and insufficient harmonization of these policies. Harmonized and coherent policies, however, are the perquisite for addressing effectively existing goal conflicts in the aforementioned sectors. Furthermore, the CEE macro-region faces specific challenges related to the legacy of traditional industries, such as coal and heavy manufacturing. Shifting towards a bioeconomy requires significant restructuring and retraining of the workforce, as well as the development of new value chains and markets. This might lead also to social conflicts among the workforce, which need to be integrated equally in new emergent bioeconomy sectors. This transition can be challenging and complex, particularly in regions heavily dependent on traditional industries, and may face resistance from stakeholders who fear job losses and economic instability. To address these challenges, greater collaboration and cooperation among CEE countries is needed. This can include sharing best practices, harmonizing policies and standards, and jointly developing regional bioeconomy strategies.

5.3 Applied R&D and Technology Transfer

Applied research and development (R&D) play a crucial role in advancing the bioeconomy in the CEE macro-region. Research institutions, universities, and private companies should collaborate to conduct R&D activities aimed at developing innovative bio-based products, improving production processes, and optimizing resource use. This includes research into bioenergy, bioplastics, biofuels, and other bio-based materials.
Technology transfer is another key aspect of promoting the bioeconomy in the CEE macro-region. It involves transferring knowledge and technologies from research institutions to businesses for commercialization and widespread adoption. This can be done through licensing agreements, spin-off companies, or collaborative partnerships between academia and industry. Technology transfer helps bridge the gap between research and market, enabling the effective implementation of bio-based innovations and supporting the growth of bioeconomy sectors.

5.3.1 Policy Instruments for Applied R&D and Tech transfer in selected MR countries

Several initiatives and programmes have been established in the CEE macro-region to support applied R&D and technology transfer in the bioeconomy (some of them are mentioned above). These include research funding schemes, innovation centres, and incubators that provide financial and technical support to research projects and facilitate the transfer of technologies to the market. They are described in more detail for the Czech Republic and Bulgaria in chapter 3.3.1.
The European Union’s Horizon 2020 programme has allocated significant funding for bioeconomy-related research and innovation projects in the CEE macro-region. This funding supports collaborative research efforts and helps accelerate technology transfer and commercialization. For example, the following projects were successful with this orientation:

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- The project BioEASTsUP received funding under Horizon 2020 to develop a strategy for sustainable bioeconomy in the CEE macro-region. This project aims to promote collaboration among CEE countries in bioeconomy research and innovation.
- The Batches project, funded by Horizon 2020, focuses on the development of sustainable biomass supply chains in the CEE macro-region. It aims to increase the efficient use of biomass resources for bioenergy and bioproducts, reducing environmental impacts and promoting the circular economy.
- The Agri-Renaissance project, funded by Horizon 2020, aims to transform agriculture and forestry practices in the CEE macro-region by promoting the transition to a sustainable bioeconomy. This project focuses on enhancing resource efficiency, reducing emissions, and promoting circularity in the agriculture and forestry sectors.

Additionally, partnerships between research institutions, industry, and government bodies have been formed to promote knowledge exchange and facilitate technology transfer. These partnerships not only support the development of bio-based industries but also create opportunities for job creation and economic development in the CEE macro-region.

In the following, the situation in the Czech Republic and Bulgaria and the implemented policy instruments for applied R&D and technology transfer are described in more detail.
The Czech Republic has been experiencing a steady increase in R&D investment in recent years. The government aims to achieve an R&D intensity of 3% of GDP by 2030 (Government of the Czech Republic, 2021), which is relatively high in comparison to other countries in Central and Eastern Europe. Czechia has made significant progress in recent years in terms of Research and Development (R&D) funding and support by the following instruments which support R&D&I in general and are not specific for bioeconomy:

1. National Funding Programmes: Czechia offers various national funding programmes to support R&D activities across different sectors. The main funding agency is the Technology Agency of the Czech Republic (TA CR). Their mission is to support applied research, experimental development, and innovation in the country. TA CR administers several funding programmes for several ministries (Ministry of the Interior, Ministry of Industry and Trade and Ministry of Agriculture). TA CR administers several funding programmes, such as the DELTA, Kappa, Sigma, Gama and ERA-NET. E.g. Programme DELTA aims at supporting international cooperation in the field of applied research through joint projects of Czech entities supported by TA CR and foreign partners with the expected support of foreign institutions. Its main objective is to increase the number of outputs and results in areas that are promising for the future of the participating countries. Another objective is also to promote the transfer of international knowledge, share good practices, and facilitate the penetration of foreign markets.
2. European Structural and Investment Funds (ESIF): Czechia benefits from European Union funding through ESIF to support R&D projects. These funds are allocated across different operational programmes, including Research, Development, and Education.
3. Collaborative Projects: Collaborative projects involving industry, academia, and research organizations are a crucial part of R&D funding in Czechia. These projects often receive funding from multiple sources, including national funds and EU programmes. Collaboration between different organizations helps bridge the gap between research and development and commercialization.
4. Technology Centres: Czechia has established several technology centres that provide support and funding for R&D efforts. These centres act as intermediaries between academia and industry, fostering collaboration and providing resources for technology development. Because the

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bioeconomy is not a specifically defined branch in the Czech Republic and research is defined by the main traditional areas, it is not possible to define the degree of focus of the centres on the bioeconomy - it depends on the individual projects tackled.

Table 28 Czech Technology Centres

CzechInvest	As the national investment promotion agency, CzechInvest offers support and funding opportunities for R&D projects. They provide grants, incentives, and guidance to both domestic and foreign companies.
Technology Agency of the Czech Republic (TA CR)	TA CR aims to promote innovation and R&D activities in Czechia. They offer various grants and funding programmes for research projects, with a focus on applied research and technology development.
South Moravian Innovation Centre (JIC)	JIC is a technology centre located in Brno, the second-largest city in Czechia. They provide support and funding for R&D projects in the South Moravian Region, focusing on areas like IT, biotechnology, and nanotechnology.
Central European Institute of Technology (CEITEC)	CEITEC is a scientific centre based in Brno, focusing on life sciences and advanced materials research. They offer funding and infrastructure support for R&D projects in these areas.
Vysocina Innovation Centre (VIC)	VIC is a technology park located in Jihlava, in the Vysocina Region of Czechia. They support R&D efforts by providing funding, consulting services, and access to their specialized infrastructure and laboratories.

Source: BIOEAST HUB CZ (2023).

Despite these efforts, there are still challenges in securing adequate funding for R&D projects in Czechia. These challenges include:

- Limited Budget: The overall funding available for R&D in Czechia is relatively limited compared to more developed economies.
- Lack of Private Sector Investment: While public funding is available, there is a need to increase private sector investment in R&D, particularly for projects at higher TRL levels. Encouraging more industry participation and collaboration can help bridge this gap.
- Alignment with Market Needs: To attract funding for projects, it is crucial to ensure that research efforts align with market needs and have potential for commercialization. This requires better coordination between research institutions, industry partners, and funding agencies.

The Czech Republic does not have completely divided powers in R&D&I management, general lack of cooperation between individual actors; no clear position and role of Technology Agency of the Czech Republic in relation to other providers of support for RDI and ministries without a budget allocation for R&D&I and low practical fulfilment of research priorities, absence of long-term strategic and problem oriented programmes of R&D – these are problems indicated in the National Research, Development and Innovation Policy (Government of the Czech Republic, 2021). National Research and Innovation Strategy for Smart Specialisation of the Czech Republic indicates the non-systematical approach that would consistently address the research of crucial scientific and social challenges in the long term and thus could become the bearers of breakthrough findings (Government of the Czech Republic, 2016).

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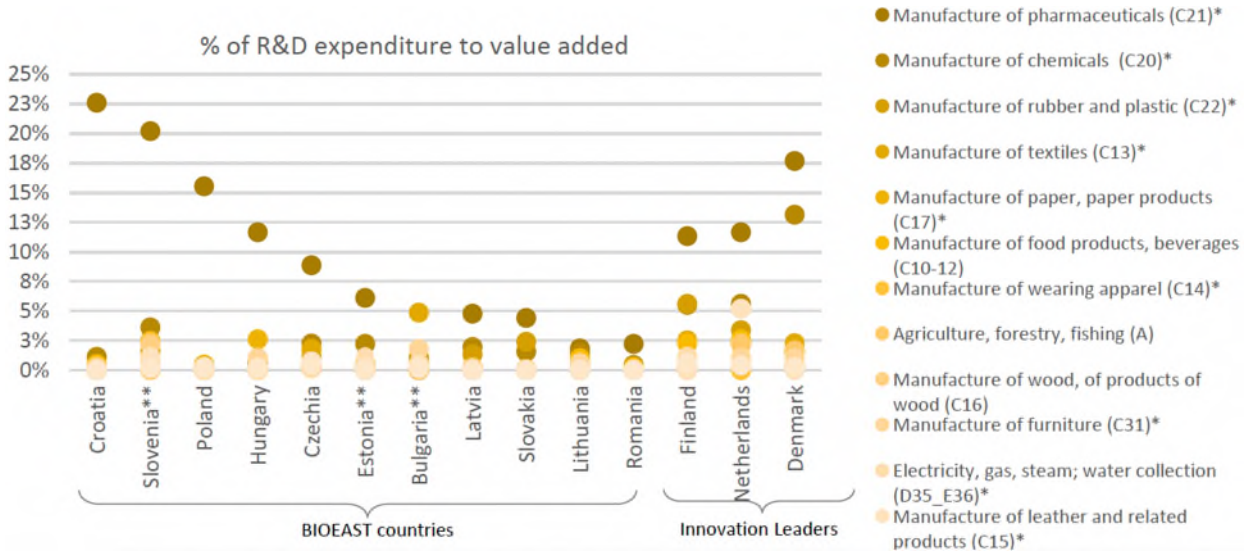

Figure 70. Business R&D intensity in main fully and partly bio-based industries in BIOEAST countries in an international comparison, 2017.
Source: BIOEASTsUP (2021b).

As it is seen in Figure 70, moreover, in an international comparison, the Czech Republic's business sector R&D intensity is low in almost all reported fully and partly bio-based industries (ranging from 0.03% in electricity, gas, steam and water collection to 2.26% in manufacture of chemicals in 2017), except manufacture of pharmaceuticals (9.46%). Particularly low the Czech Republic' s business sector R&D activities were in manufacturing activities that are characterised by high and medium-high R&D intensities globally, i.e. in manufacture of pharmaceuticals and chemicals (that are partially included in the bioeconomy) respectively. Czech Republic has a low level of business R&D activities. Less than 0.3% of enterprise sector expenditure on R&D to value added is in the following industries: electricity, gas, steam, and air conditioning supply; water collection, treatment, and supply; manufacture of wood and of products; manufacture of paper and paper products; manufacture of wearing apparel. That may lead to problems in developing innovation- and knowledge-based bioeconomy (BIOEASTsUP, 2021b).
In the following, the situation in Bulgaria is described in more detail.
Bulgaria's R&D funding situation is characterized by low overall R&D intensity, a dependence on foreign funds, and disparities in funding distribution across sectors. While the government and foreign funds play a significant role, the fragmentation of funds and low business investment in R&D pose challenges. The bioeconomy sector exhibits varying R&D intensities across industries. The development of Bulgaria's bioeconomy and bioeconomy-related innovation requires targeted efforts to improve funding distribution, increase business engagement, and foster collaboration among research institutions to enhance the country's innovation ecosystem.
The funding situation in Bulgaria's R&D landscape is characterized by challenges and disparities. Bulgaria's gross expenditure on R&D (GERD) as a percentage of GDP has shown fluctuations, rising from 0.5% in 2000 to 0.95% in 2015, then falling to 0.76% in 2018. This falls far short of the EU's target of 3% and Bulgaria's own target of 1.5% GERD. The business investment in R&D and innovation remains low, with business sector R&D intensity at just over 0.5% in 2018, much lower than innovation leaders like Sweden (2.4%) and Denmark (2%) (see in Figure 70). While business R&D intensity has been increasing over time, the government sector's expenditure on R&D intensity has been decreasing. Foreign funds, including EU structural assistance funds, have been a significant source of R&D financing, contributing 56.7% of the total public funding, highlighting Bulgaria's dependency on external sources. Nonetheless,

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the composition of the country's industrial landscape also comes into play, as the research and development investments in sectors like pharmaceuticals significantly surpass those in more conventional industries, including agriculture, food, and pulp and paper. Furthermore, it is a widely recognized fact that innovations related to agriculture and food primarily occur within their associated supply sectors, encompassing areas like machinery, equipment, and the chemical industry.

In terms of specific policy funding schemes and activities, Bulgaria's R&D and innovation system has seen notable growth over the past two decades. Government and foreign funds have been major contributors to R&D financing, with the government allocating funds mainly to research institutes and higher education institutions. However, the fragmentation of these funds across multiple institutions has led to challenges in maintaining research quality and in commercialisation of research results. Within the bioeconomy sector, Bulgaria's business activity in R&D has been low, and R&D intensity varies across industries. The manufacture of textiles, chemicals, and pharmaceuticals have shown higher R&D intensity, while sectors like electricity and agriculture have lagged behind. The development of a knowledge-based bioeconomy in Bulgaria relies on various sciences, including life sciences, engineering, and bio-technology. Despite progress, there remains a gap in achieving higher TRLs, and the country's R&D intensity and funding distribution need further attention to enhance innovation and research outcomes.

National funding programmes: In the absence of dedicated bioeconomy strategies, Bulgaria leans on various programmes that offer funding opportunities to clusters, companies, and R&D institutions, thereby supporting essential segments of the bioeconomy value chains. R&D enterprises and knowledge dissemination organizations receive backing through the National Innovation Fund. Additionally, the National Science Fund of Bulgaria (BNSF) extends financial support to projects and initiatives aimed at promoting and advancing scientific research.

European Structural and Investment Funds (ESIF): Bulgaria leverages European Union funding from the European Structural and Investment Funds (ESIF) to support various R&D projects. These resources are distributed among different operational programmes like National Development Programme Bulgaria 2030 or the National Recovery and Resilience Plan which encompass research, development, and education. However, it is important to note that these funds do not include specific funding programmes directly targeting the bioeconomy or supporting concrete sectors within the bio-based industry. These instruments typically focus on topics related to structural transformation and the shift from a fossil resource-based economy to a sustainable bio-based economy, including areas like food production, bio-based energy, renewable bio-based materials, such as flax and straw insulation, bioplastics, natural fibre-reinforced plastics, lactic acid-based solvents, rapeseed oil for road construction binding, vegetable oil-based paints and varnishes, and vegetable oil-based inks, among others.

Collaborative R&D Projects: These initiatives, uniting industry, academia, and research entities, play a vital role in Bulgaria's research and development funding landscape. They frequently secure funding from various channels, encompassing both national resources and EU initiatives. This cross-sector collaboration effectively bridges the transition from research to commercialization, addressing economic growth in more general terms. A good example is the development of the only regional Strategy for Development of the Bioeconomy in Stara Zagora Region in Bulgaria combining effort of the local development agency and Trakia University in an EU-funded international project (BE-Rural).

Technology centres: Bulgaria has established several technology centres that play a pivotal role in supporting and financing R&D initiatives. These centres serve as intermediaries, facilitating collaboration between academia and industry while providing resources for technology development. They often present funding opportunities for various projects.

Trakia University boasts a team of specialists with diverse expertise, which can significantly influence the transition towards sustainability.

The Center of Technologies, as the flagship R&D entity at the University of Plovdiv in Bulgaria, is dedicated to advancing Bioeconomy & Biotechnologies. Their vision is to pioneer new frontiers in

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Bioeconomy & Biotechnologies, delivering both public and private benefits at national, EU, and global levels.
Furthermore, the Agricultural University in Plovdiv is taking the lead in establishing a Regional Bioeconomy Hub in Plovdiv, focused on bio-based solutions, technologies, and best practices for recycling organic products and substances.
Despite some progress in the past programming period and diversifying channels for R&D in recent years, Bulgaria's policy instruments for applied R&D and technology transfer should:

- Boost overall R&D intensity, particularly in the business sector, with incentives, grants, and tax breaks to encourage local industries.
- Consolidate government and foreign funds into strategic initiatives for greater technology development impact.
- Address disparities in R&D intensity among industries, tailoring policies to each sector's unique challenges and opportunities. Promote collaboration through matchmaking, exhibitions, and accelerator programmes to facilitate knowledge exchange and technology transfer.

5.3.2. Structures and Challenges for Applied R&D and Tech transfer in the CEE MR and selected MR countries

Applied research is also carried out, which emphasizes the practical application of scientific knowledge to create concrete solutions for economic, environmental, and social challenges. This research is directly related to the development and innovation of technologies, processes, and products that have an impact on both industry and society. Due to the greater connection of applied research to practice, the link to the bioeconomy is more obvious. A number of applied research grants often mention links to bioeconomy as a criterion for the success of a project proposal or is the bioeconomy directly a call topic. From these grants can be named Horizon Europe, CBE JU - Programs for the Green Deal, Program LIFE - Environment and climate action or some national programs: OP TAK - Technologies and Applications for Competitiveness in Czech Republic or Romanian National recovery and resilience Program.
R&D in the CEE macro-region does cover the entire bioeconomy, but there are also sectoral specificities and foci within it. The specific foci and strengths are particularly in the following areas of the bioeconomy:

- Agricultural research: Many countries in the CEE macro-region have a strong agricultural heritage and expertise. Research and development in crop improvement, sustainable farming practices, and biotechnology for enhancing agricultural productivity are significant in these countries.
- Forestry and wood industry: The CEE macro-region has vast forest resources, and R&D in this sector focuses on sustainable forestry management, utilization of wood biomass for energy, and development of innovative forest-based products.
- Energy: Renewable energy and biofuels are important aspects of the bioeconomy in the CEE macro-region. R&D efforts are directed towards developing and improving bioenergy technologies, biomass processing, and biofuel production from various organic feedstocks.
- Environmental biotechnology: The CEE macro-region places emphasis on R&D in environmental biotechnology for tackling pollution, waste management, and conservation. This includes research on bioremediation, wastewater treatment, and biological solutions for environmental challenges.

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Although there is a gap between academic research and business activities in CEE countries and a lack of understanding and cooperation, some examples can be named demonstrating the efforts made by Central and Eastern European countries to support applied research and development and technology transfer. It is worth mentioning in particular:

- Poland: The Technology Transfer Platform (TTP) is a national initiative in Poland aimed at facilitating the commercialization of research results and knowledge transfer from universities and research institutes to industry. TTP provides support in the form of grants, mentoring, and networking opportunities to help researchers and companies collaborate and work together to develop and market innovative technologies.
- Hungary: The Hungarian Scientific Research Fund (OTKA) funds applied research projects with the goal of promoting knowledge transfer and commercialization of research results. OTKA provides financial support to public and private research institutions and encourages cooperation between academia, industry, and other stakeholders.
- Czech Republic: The Czech Republic has established a network of Technology Transfer Centers (TTCs) in universities and research institutions across the country. These centres provide services and support to researchers and businesses in areas such as patenting, licensing, marketing, and funding. They also organize technology transfer events and facilitate collaboration between academia and industry.
- Romania: The National Authority for Scientific Research and Innovation (ANCSI) in Romania has implemented the Technology Transfer Program (TTP) to promote the commercialization of research results. TTP provides funding for collaborative projects between universities, research institutes, and companies to develop prototypes, conduct market research, and establish spin-off companies based on innovative technologies.
- Slovenia: The Technology Park Ljubljana is a leading technology transfer organization in Slovenia. It supports the establishment and growth of technology-based companies by providing infrastructure, mentoring, and access to funding and business networks. The Technology Park also facilitates collaboration between companies and research institutions to promote applied R&D and technology transfer.

In the CEE macro-region individual national research and innovation agencies are particularly involved in the transfer of applied research technologies. Each country in the macro-region has some national agencies responsible for promoting and funding research and innovation. These agencies often provide grants, funding programmes, and support for applied research projects and technology transfer initiatives. A big role in technology transfer is played by the universities themselves, which have established Technology Transfer Offices (TTO). In particular, TTOs are concerned with identifying and protecting intellectual property rights, licensing or commercializing technologies, and facilitating technology transfer partnerships between academic institutions and businesses.
This structure also includes business incubators and accelerators. There are a number of them in the macro-region and they operate rather in small regions of individual countries. Their main task is to provide support and resources to start-ups and entrepreneurs. These organizations often offer mentoring, funding, access to networks and assistance in commercializing innovative technologies. In the last decade, several technology parks have been established in the CEE macro-region to promote cooperation and innovation. These parks bring together companies, research institutions and start-ups in a shared space and provide access to facilities, infrastructure and networking opportunities leading to applied R&D and technology transfer. It is worth mentioning in particular: Sofia Tech Park (Sofia, Bulgaria), IT Park and TechnoPark Brno (both in

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Brno, Czech Republic), The Knowledge and Innovation Community of Warsaw (Warsaw, Poland), Gdańsk Science and Technology Park (Gdańsk, Poland), Kraków Technology Park (Kraków, Poland), Łódź Special Economic Zone (Łódź, Poland), West Pomeranian Technology Park (Szczecin, Poland), Wrocław Technology Park (Wrocław, Poland) or Technology Park Varaždin (Varaždin, Croatia).
In the CEE macro-region, various industrial clusters and networks have been formed that bring together companies, research institutions and other stakeholders from specific sectors. These clusters facilitate collaboration, knowledge sharing and joint research projects, thereby promoting applied R&D and technology transfer within relevant industries. Some examples of industrial clusters and networks dedicated to the bioeconomy can be mentioned:

Table 29 Clusters and networks dedicated to the bioeconomy in CEE macro-region

Biotech Cluster-Silesia (Poland)	A cluster focused on biotechnology and bioeconomy established in the Silesia region of Poland. It aims to support the development of innovative biotech companies and promote collaboration.
Czech Biotechnology Cluster (Czech Republic)	A cluster in the Czech Republic that focuses on biotechnology and bioeconomy. It brings together research institutes, universities, and companies to enhance cooperation and knowledge exchange.
Biopolis (Hungary)	A bioindustry cluster located in Hungary, Biopolis aims to support the development of the country's bioeconomy sector. It focuses on research, innovation, and commercialization of biotech products.
Biovalley Hungary	A network of stakeholders in the bioeconomy sector in Hungary. It aims to facilitate collaboration, technology transfer, and innovation within the biotech industry.
BioTechMed Cluster (Slovakia)	A cluster in Slovakia focused on the fields of biomedicine, biotechnology, and bioeconomy. It aims to promote research, cooperation, and innovation within the bio-based industries.
Bio-based Industries Consortium Poland (BIC Poland)	BIC Poland serves as a platform for collaboration between academia, industry, and public institutions in the bio-based industries sector. It aims to support research, development, and investments in the bioeconomy.

Source: BIOEAST HUB CZ (2023).

Regional Development Agencies in the CEE macro-region promote economic growth and innovation. These agencies often support applied research projects, encourage collaboration between academia and industry, and provide funding or grants for technology transfer initiatives.
There are several major challenges in applied research and technology transfer in the bioeconomy in the CEE macro-region. These challenges include (BIOEASTsUP, 2021b):

1. Limited funding: One of the main challenges is the limited funding available for applied research and technology transfer in the CEE macro-region. This hampers the establishment of research infrastructure, recruitment of skilled researchers, and execution of innovative research projects.
2. Lack of collaboration: There is often a lack of collaboration between academia, industry, and government sectors in the CEE macro-region. This hinders the effective transfer of technologies from academia to industry and slows down the adoption of bio-based solutions by companies.

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3. Knowledge and skill gaps: The CEE macro-region faces knowledge and skill gaps in the bioeconomy sector. This includes a shortage of trained professionals in fields such as biotechnology, biochemistry, and process engineering, which limits the region's capacity to develop and transfer advanced technologies.
4. Regulatory barriers: The bioeconomy operates under regulatory frameworks that can differ across countries in the CEE macro-region. These differences create barriers to technology transfer and hinder the scaling up of bio-based solutions. Harmonization and alignment of regulations is needed to facilitate the transfer and adoption of technologies.
5. Limited commercialization support: The CEE macro-region often lacks the necessary infrastructure and support systems to facilitate the commercialization of bio-based technologies. This includes access to pilot and demonstration facilities, business incubators, and technology transfer offices. These facilities and support systems are crucial for bridging the gap between research and market implementation.
6. Weak IP protection: Intellectual property (IP) protection is a critical aspect of technology transfer and commercialization. However, there can be weak IP protection mechanisms in some countries in the CEE macro-region, which can discourage investment in research and development, as well as hinder technology transfer and commercialization efforts.
7. Limited awareness and education: There is a need for increased awareness and education about the potential of the bioeconomy and the benefits of bio-based technologies in the CEE macro-region. This includes raising awareness among policymakers, industry stakeholders, and the general public, as well as providing education and training programmes to foster a skilled workforce in the bioeconomy sector.

Addressing these challenges requires a collaborative effort among stakeholders, including academia, industry, government, and funding organizations. Investing in research infrastructure, promoting collaboration, providing funding and support systems, harmonizing regulations, strengthening IP protection, and increasing awareness and education are among the strategies that can help overcome these challenges and promote applied research and technology transfer in the bioeconomy in the CEE macro-region.

In the following structures and challenges for applied R&D and tech transfer are described in more detail for selected CEE MR countries.

In the context of applied R&D and technology transfer, Bulgaria faces several challenges and has specific actors and structures relevant to its bioeconomy innovation ecosystem. The increase in R&D expenditure has led to the expansion of R&D personnel, particularly in the business enterprises sector. However, compared to innovation leaders like Denmark and the Netherlands, Bulgaria's R&D personnel-based intensity remains lower (TechTour, 2023). The distribution of R&D personnel across sectors indicates a significant increase in the business sector, while the government sector's R&D personnel decreased. The manufacture of textiles, apparel, leather, chemicals, and pharmaceuticals industries have notable R&D personnel and expenditure.

Specific actors and collaboration initiatives that can play a role in applied R&D and technology transfer include innovation brokers (the Bulgarian Fund Manager of Financial Instruments in Bulgaria EAD (FMFIB) operating as a Fund of Funds (FoF); it allocates targeted public funds from European Union programmes and national co-financing, using special financing schemes (financial instruments), public-private partnerships (PPPs) (Plovdiv University "Paisii Hilendarski" platform Vita Plus for PPP modelling), and research networks (such as Competency Centre for the Sustainable Use of Bio-Resources and Waste from Medicinal and Aromatic Plants for Innovative Bioactive Products, Competency Center "Clean technologies for a sustainable environment – water, waste, energy for a circular economy"). These entities

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are crucial for bridging the gap between academia and industry, facilitating technology transfer, and fostering collaboration.
However, challenges exist, including the lack of skilled labour, regulatory uncertainty, and economic constraints, which hinder the innovation and technology absorption capacity of businesses. SMEs particularly face difficulties related to policy implementation.
While there is an increase in innovation activity, particularly in industries like pharmaceuticals and chemicals, Bulgaria's innovation performance is still relatively low compared to innovation leaders. Business-science collaboration is underdeveloped, resulting in a low number of public-private co-publications. Furthermore, Bulgaria's patent application numbers are low compared to EU averages and the CEE macro-region (Zhechkov and Mahieu, 2017). This suggests that while there is growth in patent applications, there's still a long way to go to catch up with leading innovators in Europe.
Regarding structures and infrastructures, Bulgaria's progress in R&D and innovation has been significant, but challenges persist. The R&D personnel expansion is positive, but its distribution and intensity need further improvement, especially in promoting innovation in sectors with low R&D intensity. The bioeconomy-related infrastructure, such as pilot plants, might need further development to support innovation. Tech transfer offices and businesses' awareness of the potential of the bioeconomy could be improved. Financing gaps and efficiency concerns in tech transfer and R&D funding distribution should also be addressed.
In conclusion, Bulgaria's applied R&D and technology transfer landscape involves specific actors like innovation brokers and PPPs, but challenges persist in terms of business innovation capacity, patent applications, and business-science collaboration. Strengthening these areas, promoting collaboration, enhancing infrastructure, and addressing funding and efficiency issues are critical for Bulgaria's bioeconomy innovation ecosystem to thrive.
The development of knowledge-based bioeconomy and bioeconomy-related innovation relies on various sciences, namely life sciences, agricultural sciences, ecology, biotechnology, food science, engineering, information and communication technologies and other related fields. The research sector in the Czech Republic is represented by the agricultural research institutes (20), bioeconomy slightly dedicated universities (6) (Table 29) and the Czech Academy of Science. The research organisations oriented to the applied research are also actively involved in the technology transfer. They are represented by the Association of Research Organisations that supports the engagement and involvement of SMEs and also large entrepreneurs. The Association of Research Organisations is a member of the BIOEAST HUB CZ (www.bio-hub.cz). BIOEAST HUB CZ is promoting the implementation of bioeconomy, technology transfer of new innovative bioeconomy solutions and is also developing new bioeconomy business models. Despite that, links between academia and business are insufficient to support knowledge and technology transfer (European Commission Directorate-General for Research and Innovation, 2020).

The network of bioeconomic universities in the BIOEAST macro-region (see the map in Figure 71) BIOEAST Uninet was founded in 2022 under the auspices of the BIOEAST initiative. Its main objective is to maximize efforts in increasing knowledge sharing, networking, mutual learning, development of joint activities and events.

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Table 30 Czech bioeconomy-related R&D&I organisations

research institutes	Agricultural Research, Ltd.
	Agriresearch Rapotin, Ltd.
	Agritec Plant Research, Ltd.
	Agrotest Fyto, Ltd.
	Crop Research Institute
	Dairy Research Institute, Ltd.
	Food Research Institute Prague
	Forestry and Game Management Research Institute
	Hop Research Institute Co., Ltd.
	Institute of Agricultural Economics and Information
	National Museum of Agriculture
	OSEVA Development and Research, Ltd.
	Potato Research Institute Havlíčkův Brod, Ltd.
	Research and Breeding Institute of Pomology Holovousy, Ltd.
	Research Institute for Soil and Water Conservation
	Research Institute of Agricultural Engineering
	Research Institute of Animal Science
	Research Institute of Brewing and Malting, Plc.
	SELTON Research Centre, Ltd.
	Veterinary Research Institute
universities	Ostrava University of Mining and Technology
	Palacky University in Olomouc
	Mendel University in Brno
	South Bohemian University in České Budějovice
	Czech University of Life Sciences in Prague
	West Bohemian University in Pilsen

Source: BIOEAST HUB CZ (2023).

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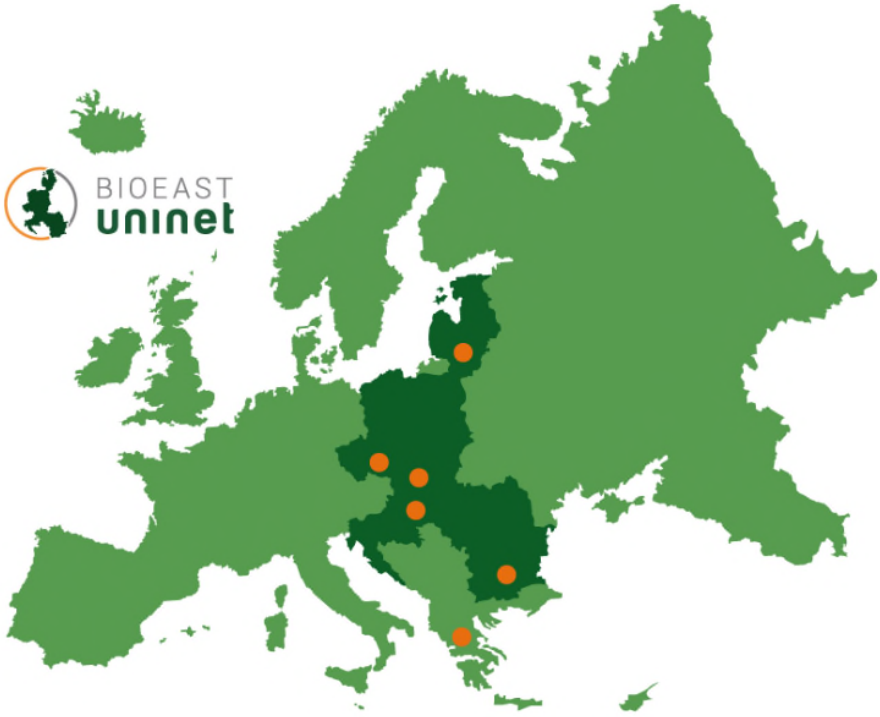

Figure 71. Map of BIOEAST UNINET universities.
Source: www.bio-hub.cz (2023).

Table 31 Bioeconomy-related CEE universities organised in Uninet

BIOEAST UNINET universities	
Mendel University in Brno	Czech Republic
University of Debrecen	Hungary
Slovenská poľnohospodárska univerzita v Nitre	Slovak Republic
Josip Juraj Strossmayer University of Osijek	Croatia
Agriculture University Plovdiv	Bulgaria
Vytautas Magnus University	Lithuania

Source: www.bio-hub.cz (2023).

In **Croatia**, these three top research centres of scientific excellence are mainly focused on the bioeconomy:

- Ruđer Bošković Institute: Bioprospecting of the Adriatic Sea
- Faculty of Agriculture in Zagreb: Biodiversity and Molecular Plant Breeding
- Faculty of Electrical and Computer Engineering, Zagreb: advanced scientific methods on data and cooperative systems (DATACROSS).

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Based on the interview with the Polish representative it was mapped that in Poland, agricultural and food processing research are carried out by the research institutes subordinated to the Ministry of Agriculture and Rural Development, and by the Polish Academy of Sciences and universities. The Ministry of Agriculture manages 12 research Institutes, among them five carried out research on field crops including organic farming, and those are: (1) Institute of Soil Science and Plant Cultivation (IUNG), (2) Plant Breeding and Acclimatization Institute (IHAR), (3) Institute of Natural Fibres and Medicinal Plants (IWNiRZ-PIB), (4) Institute of Plant Protection (IOR), (5) Institute of Technology and Life Science. Horticultural field crops research is conducted by the Institute of Horticulture (INHORT) (6). Bioproducts and bio-processing research is carried out by institutes subordinated by The Ministry of Development and Technology, mainly in Łukasiewicz Research Network and universities. The Ministry of Climate and Environment manages the research institutes related to forestry and environment protection. Research on animal production is conducted by two institutes: (7) Institute of Animal Production (IZ) and (8) National Veterinary Institute (PIWET). Two research institutes carry out work on fisheries: (9) Inland Fisheries Institute (IRS) in Olsztyn and (10) Marine Fisheries Research Institute (MIR). The agricultural economic analysis and research including FADN data[28] are provided by the (11) Institute of Agricultural and Food Economics. Research on agri-food biotechnology, safe food production and storage is provided by the (12) Institute of Agriculture and Food Biotechnology of the Polish Academy of Sciences (PAN), strategic research on rural areas is conducted at the Institute of Rural and Agricultural Development of the Polish Academy of Sciences in Warsaw (IRWiR PAN), while Institute of Agrophysics in Lublin conducts soil-plant-atmosphere related system interaction science and strategic planning and policy. There is also one non-public research unit, POLBIOM, which carries out several bioeconomy projects.
In Poland, the Centre for Advisory Service in Brwinów (CDR) is responsible for transfer of knowledge and innovations in the agricultural sector, with branches located in Kraków, Radom, Poznań and Warszawa. The Centre is a training umbrella for 16 Regional Agricultural Advisory Centres, including state agencies and other public entities supporting development of agricultural and rural sector, sectoral farmers and food producers' organisations, research and educational centres, and other institutions actively involved in knowledge transfer aimed at agriculture and rural development.

5.4 Cross-sectoral Collaboration

5.4.1 General overview of cross-sectoral collaboration

Cross-sectoral collaboration in the bioeconomy in the CEE macro-region refers to the collaboration between different sectors, such as agriculture, industry, research, and policy-making, to foster the development and utilization of bio-based resources and technologies. The CEE macro-region countries have valuable bio-based resources, including agricultural residues, forests, and natural materials (chapter 3.1.1), which can be converted into biofuels, bio-based products, and biomaterials.
Overall, cross-sectoral collaboration in the bioeconomy in the CEE macro-region is essential for promoting sustainable economic development, reducing dependence on fossil fuels, and creating a more resilient and circular economy. It requires the active involvement and coordination of stakeholders from agriculture, industry, research, and policy-making to unlock the full potential of the region's bio-based resources.
The strategies of the individual countries of the CEE macro-region as well as various regional/sectoral conceptual documents mention the importance of cooperation between the public and private sectors. However, the mapping results show that this idea of cooperation often remains only on a theoretical level.

[28] FADN data refers to the Farm Accountancy Data Network, which is a database of detailed financial and economic information on agricultural holdings in the European Union. The data is collected and compiled by national authorities in each EU member state, and provides a comprehensive overview of the structure, performance, and income of agricultural enterprises. FADN data is used by policymakers, researchers, and farmers to analyse and monitor the trends and developments in the agricultural sector.

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If cross-sector cooperation occurs, it is rather a connection for a purpose, e.g. to obtain a financial grant. The implementation of various EU-funded programmes, such as Horizon 2020 and the European Structural and Investment Funds, has likely supported collaborative initiatives in the bioeconomy sector across the region. Therefore arise a sector-specific collaborations, such as partnerships between agricultural producers and biofuels manufacturers, or research collaborations between universities and biotechnology companies. The interaction of the public and private sectors takes place in the CEE macro-region mainly with the help of the BIOEAST initiative, which together with research, business, and public sectors, and also non-governmental non-profit organizations collaborate to identify opportunities and challenges in the area of the circular economy. Thanks to its activity, this platform thus facilitates the exchange of knowledge, experience and resources and supports the development of innovative solutions and joint projects.

5.4.2 Policies supporting Cross-sectoral Collaboration in Bulgaria

Agriculture and forestry play significant roles in **Bulgaria's bioeconomy**, contributing to the Gross Value Added (GVA) and biomass production. Challenges in labour productivity and uneven development of the circular bioeconomy are present. Collaboration opportunities exist among different sectors, and efforts are being made to enhance the role of bioeconomy in national strategies (chapters 3.1.3 and 3.2).

In **Bulgaria** there is no concrete policy supporting cross-sectoral collaboration in bioeconomy. In general, the aim of the existing policies and strategies is to promote innovation, research, and collaboration across different sectors, with a specific focus on enhancing the competitiveness of the economy and addressing various challenges related to sustainable development, energy efficiency, and resource utilization. These policies encompass a range of strategies, targets, and initiatives to foster cross-sectoral collaboration and drive the development of the economy as a whole. In the absence of a strategy/policy specially dedicated to bioeconomy, the institutions are compelled to collaborate across sectoral boundaries, particularly in areas like digitalization of the agricultural sector or knowledge transfer from the ICT sector. For instance, the Ministry of Agriculture and Forestry is responsible for various bioeconomy sectors, including agriculture, forestry, and food manufacturing. Simultaneously, other ministries, such as the Ministry of Education, the Ministry of Economy and the Ministry of Innovation and Growth (fostering innovations across sectors being its mandate), are also involved in addressing bioeconomy-related issues. This cross-sectoral collaboration is driven by the need to align and implement strategies that transcend traditional sector boundaries, demonstrating a focus on priorities towards other innovative fields that may also concern the bioeconomy.

The country's strengths lie in its relatively high biomass production and competitive bio-based products, including agriculture, food and beverage production, biofuels, furniture, bio-based textiles. However, there is a gap in bio-based cross-sectorial collaboration, and stakeholders like biomass producers and processors, intermediaries and academia lack strong ties with each other to utilise the potential it holds. There are, however, cross-sectorial organisations that provide collaboration opportunities to the actors in the Bulgarian bioeconomy, mainly in sharing knowledge, looking for collaborators, informing on networking opportunities, sometimes even in influencing policies that affect the interests of a particular industry at national level. The cross-sectoral collaboration is also most often limited at local-regional or national level without the vision for cross-border level where collaboration opportunities may exist with the neighbouring Romania or Greece.

Bulgaria has a weak cross-sectoral collaboration though it is emerging as a key trend, supported by projects and national and EU policy frameworks. One example is the start of the EU Regional Valleys for Bioeconomy launched on 13 October 2023.

Several collaborative structures have been implemented, such as e.g. Bulgarian Digital Agri-hub (https://edih.agrohub.bg/). AgroHub.BG is a European Digital Innovation Hub (EDIH) for the South-Central Region in Bulgaria, approved under the "Digital Europe" programme with the AgroDigiRise project. It is implemented by a consortium with a diverse profile and experience - industry organizations, scientific, research and development units, training institutions, technology companies and start-ups,

importers of agricultural machinery, expert business development organizations, united to work for a more modern, efficient and digitized agri-food sector. Associated partner is the Municipality of Plovdiv.
In order to support the cross-sectoral collaboration in the bioeconomy, various initiatives have been implemented in Bulgaria:

1. Knowledge sharing and networking: Organizations, such as research institutes, universities, and industry associations, can facilitate knowledge sharing and networking events to bring together stakeholders from different sectors. This can enable the exchange of information, ideas, and best practices and foster collaboration. National contact points of EU programmemes and hubs (Europe Direct, Horizon Europe, LEADER of the EU CAP Network) hosted by universities, local development agencies, clusters or industry associations support the bioeconomy knowledge exchange from and/or towards Bulgarian stakeholders and support cross-sectoral collaboration.
2. Policy coordination: Governments in the CEE macro-region can develop coherent and supportive policies to encourage cross-sectoral collaboration in the bioeconomy. This can include providing financial incentives, streamlining regulations, and establishing dedicated bioeconomy task forces or working groups. In Bulgaria, such is the targeted support to the regions that are most dependent on fossil fuels by recultivation of the exhausted coal mining terrains based on biotechnology (CSD, 2020).
3. Research and development: Collaboration between academia, research institutes, and industry is crucial for developing innovative bio-based technologies and products. Joint research projects, technology transfer programmes, and public-private partnerships can facilitate cross-sectoral collaboration in R&D activities related to the bioeconomy. The Agricultural University of Plovdiv is an R&D&I innovation hub with its Technology Transfer Office and Valley of Deeptech Innovations in Bulgaria. Trakia University, another bioeconomy knowledge hub, supports development of technologies for production of fertilisers from wastewaters from the local wastewater treatment plant.
4. Value chain integration: Cross-sectoral collaboration can also be encouraged by integrating different stages of the bioeconomy value chain. This can involve partnerships between farmers, processors, manufacturers, and distributors to create a vertically integrated bio-based value chain. An example for such collaboration in Bulgaria are the small energy production capacities in Razlog and Bansko (for utilising generated by the local wood processing industry waste), Svishtov from bark (Bulgarian National Long-Term Programme for Encouraging Biomass Use 2008-2020). The BGBIOM – Bulgarian Biomass Association, the Bulgarian Association of Organic Producers, Bulgarian Association Circular Economy and Biotech BACEB provide cross-sectoral collaboration platforms and services for their stakeholders.
5. Capacity building: Training programmes, workshops, and skill development initiatives can be organized to enhance the knowledge and skills of stakeholders in the bioeconomy. This can promote cross-sectoral collaboration by enabling individuals to understand and work effectively across different sectors. Many cross-sectoral organisations like the Bulgarian Association Circular Economy and Biotech BACEB, Institute for Technology Transfer and Innovations (ITTI), the Bulgarian Agency for SMEs provide capacity building on horizontal skills, networking, market research and other competencies on demand.
6. Demonstrator projects: Collaborative and large-scale bioeconomy projects can serve as showcases of cross-sectoral collaboration in the CEE macro-region. These projects can demonstrate the economic and environmental benefits of utilizing bio-based resources and technologies, attracting further investment and collaboration. Such demonstrator project is the Stamboliysky facility for producing electricity from utilising paper production waste.
7. An initiative to follow with interest is the Bulgarian Digital Agri-hub (https://edih.agrohub.bg). AgroHub.BG is a European Digital Innovation Hub (EDIH) for the South-Central Region in

Bulgaria, approved under the “Digital Europe” programme with the AgroDigiRise project. It is implemented by a consortium with a diverse profile and experience - industry organizations, scientific, research and development units, training institutions, technology companies and start-ups, importers of agricultural machinery, expert business development organizations, united to work for a more modern, efficient and digitized agri-food sector. Associated partner is the Municipality of Plovdiv.

To realize this potential, Bulgaria needs a visionary bioeconomy strategy, investment incentives, and improved collaboration across sectors. Overcoming challenges like limited awareness, networking gaps, and technology transfer issues is essential for a sustainable and efficient shift toward bioeconomy growth.

5.4.3 Policies supporting Cross-sectoral Collaboration in the Czech Republic

As of now, there is limited available data specifically on the amount or status of biomass produced and transformed in the Czech Republic. However, we can provide an overview of the country’s biomass sector and its potential (Doležal, 2020).

1. Biomass Potential: The Czech Republic has considerable potential for biomass production due to its agricultural land and forestry resources. The country has a significant agricultural sector, with crops such as wheat, barley, rapeseed, and corn being cultivated. Forests cover around one-third of the country’s land area, providing a reliable source of woody biomass.
2. Biomass Utilization: Biomass is used in the Czech Republic for various purposes, including heat and electricity generation, as well as biofuels production. It is commonly used in small-scale heating systems (e.g., residential boilers) and larger-scale district heating plants. Additionally, some power plants and combined heat and power (CHP) plants utilize biomass as a renewable energy source.
3. Renewable Energy Policies: The Czech Republic has implemented policies to promote renewable energy, including biomass. The country has set targets to increase the share of renewable energy in its final energy consumption. Biomass has been recognized as a strategic fuel source for meeting these targets.
4. Support Mechanisms: The Czech government provides support mechanisms to incentivize the production and utilization of biomass. These include feed-in tariffs, investment subsidies, tax benefits, and renewable energy certificates. These measures aim to encourage the growth of the biomass sector and attract investments in biomass production and conversion technologies.
5. Lack of Specific Data: Despite the potential and government support, specific and comprehensive data on the amount and status of biomass production and transformation in the Czech Republic is limited. It is challenging to find up-to-date, detailed figures on the total biomass produced, converted, and utilized in the country.

Although the bioeconomy is not a priority in the Czech Republic, and in recent years the Czechia has been actively developing sectors that ensure the self-sufficiency and competitiveness of the state, at the same time, sectors that are part of the bioeconomy are also developing. Several significant roles and sectors contribute to the Gross Value Added (GVA) and biomass production in the country.

- Agriculture and Forestry: Czechia has a rich agricultural and forestry sector, which plays a crucial role in biomass production and the bioeconomy. Agricultural activities include crop cultivation, livestock farming, and horticulture. The forestry sector focuses on sustainable timber production, and both sectors contribute significantly to biomass feedstock for bioenergy and bioproducts.
- Bioenergy: Bioenergy production, especially from biomass, is an essential component of Czechia’s bioeconomy. The country has been increasingly utilizing biomass resources, such as wood chips, agricultural residues, and organic waste, to generate heat, electricity, and biofuels.

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Biomass power plants and biogas facilities contribute to the GVA by providing renewable energy and reducing greenhouse gas emissions.

- Sustainable Fisheries: The Czech Republic is starting to have a developed fishing sector, especially with a focus on freshwater fish farming. Fishing has a long historical tradition in some parts of the country. Fishing is perceived more as a means of increasing biological diversity and ecosystem stability, as an adaptation measure to the landscape against climate change. However, it must be noted that fishing has been very actively supported by the Ministry of Agriculture in recent years. Nevertheless, it remains a very marginal economic activity and their contribution to GVA is marginal.
- Biotechnology: Czechia has a strong biotechnology industry, which is an important sector within the bioeconomy. The country has several research institutions and companies dedicated to developing innovative biotechnological solutions, including bio-based materials and bioactive compounds. These advancements contribute to both the GVA and biomass production through the utilization of bio-based resources and processes.
- Waste Management and Circular Economy: The bioeconomy in Czechia also emphasizes waste management and the principles of the circular economy. Waste-to-energy facilities, composting plants, and biogas digesters play a crucial role in converting organic waste into valuable resources. By utilizing biodegradable waste streams, Czechia reduces landfilling, minimizes environmental impact, and enhances resource efficiency.
- Research and Development: Czechia's bioeconomy is further supported by robust research and development activities. Universities, research institutes, and private companies engage in research projects focused on bio-based materials, renewable energy, biotechnology, and sustainable agriculture. These efforts contribute to the development of innovative technologies, processes, and products, thereby driving the growth of the bioeconomy and GVA.

In **Czech Republic**, several policy instruments, funding, and support measures are implemented to support and improve cross-sectoral collaboration. The key initiatives are:

1. Strategic Frameworks: The Czech government has developed strategic frameworks such as the National Development Plan, Smart Specialization Strategy, and the Czech Republic Innovation Strategy. These frameworks promote cross-sectoral collaboration by outlining priorities and providing guidelines for policy integration and cooperation between different sectors.
2. Funding Programmes: The European Structural and Investment Funds (ESIF) play a significant role in supporting cross-sectoral collaboration in Czechia. Programmes, such as the Operational Program Research, Development, and Education, provide financial support to research and innovation projects that involve collaboration between academia, industry, and other sectors.
3. Technology Transfer Offices: The government has established Technology Transfer Offices (TTOs) in universities and research institutions to facilitate knowledge and technology transfer between academia and industry. TTOs provide support for technology commercialization, intellectual property management, and collaboration with external partners.
4. Cluster Initiatives: The Czech government promotes the development of cluster initiatives, which bring together businesses, research institutions, and other stakeholders within specific industries or regions. These clusters foster cross-sectoral collaboration by enabling knowledge sharing, joint projects, and innovation. An example of existing and functioning clusters can be e.g. the Association of Research Organizations (AVO), BIOEAST HUB CZ or Platform for the bioeconomy of the Czech Republic.

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5. Business Support Services: Various organizations and initiatives provide support services to foster cross-sectoral collaboration among businesses. For example, the CzechInvest agency offers assistance in finding potential business partners, foreign markets, and funding opportunities. The Czech Chamber of Commerce and Confederation of Industry also provide resources and networking platforms for companies across different sectors.
6. Research and Innovation Centres: Research and Innovation Centres (RICs) have been established to encourage collaboration between academia, industry, and public institutions. RICs serve as platforms for joint research projects, technology development, and knowledge exchange, thereby promoting cross-sectoral collaboration.
7. Training and Capacity Building: The government invests in training and capacity building programmes to enhance collaboration skills and competencies. These programmes focus on areas such as project management, intellectual property rights, technology transfer, and cross-sectoral communication.
8. Policy Coordination and Integration: The Czech government emphasizes policy coordination and integration across sectors to support cross-sectoral collaboration. The Ministry of Industry and Trade, Ministry of Education, Youth and Sports, Ministry of Health, and other relevant ministries work together to align policies, strategies, and funding schemes to facilitate collaboration and address shared challenges.

These policy instruments, funding programmes, and support measures aim to create an enabling environment for cross-sectoral collaboration in Czechia. By providing financial resources, infrastructure, knowledge sharing platforms, and policy coordination, these initiatives aim to foster innovation, economic growth, and societal development through effective collaboration between different sectors.
Cross-sectoral collaboration in Czech Republic is mainly affected by insufficient infrastructure. The country lacks sufficient infrastructure for the processing and conversion of bio-based materials into value-added products. This includes the lack of bio-based processing facilities, biorefineries, and biomass logistics infrastructure. As was mentioned above, the current policy and regulatory framework in Czechia is relatively inadequate in supporting the development and adoption of bio-based materials. This includes the lack of clear and stable policies, as well as limited financial incentives and support schemes. Another limit is a lack of collaboration and knowledge exchange between different stakeholders involved in the bio-based sector, including policymakers, researchers, industry players, and agricultural producers. This hampers the development of innovative solutions and the sharing of good practices. The high investment costs associated with setting up bio-based processing facilities, as well as the relatively low profitability of bio-based products compared to conventional alternatives, pose financial barriers to the provision and processing of bio-based materials in Czechia. The lack of public awareness and understanding of the benefits and potential of bio-based materials can hinder their wider adoption. This includes limited consumer demand for bio-based products and a reluctance to invest in bio-based projects.
Addressing these barriers would require a combination of policy interventions, infrastructure investments, research and development efforts, and public awareness campaigns to promote the adoption of bio-based materials in Czechia.

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5.4.4 Mapping cross-sectoral collaborative structures

The objective of cross-sectoral collaboration in the field is to leverage the expertise, resources, and perspectives of different sectors to address the complex challenges and opportunities presented by the bioeconomy. The countries recognize that bioeconomy encompasses a wide range of industries and disciplines, and collaborating across sectors is crucial for achieving sustainable development, innovation, and economic growth. The key cross-sectoral collaborative structures are listed in Table 32 below. The selection criteria were their role in policy making/development, implementation, data and knowledge sharing, their monitoring and evaluation role and stakeholder involvement.

Specific barriers and challenges faced by collaborative structures in facilitating material exchange/flow in the bioeconomy in CEE macro-region (BIOEASTsUP, 2021b):

1. Lack of awareness and understanding: Many stakeholders in the bioeconomy are not aware of the potential benefits and opportunities of cross-sector collaboration. There is a lack of clear understanding of how collaboration can improve the exchange and flow of materials, so there is a reluctance to engage in collaborative efforts.
2. Fragmentation and secretive approaches: Different sectors within the bioeconomy operate in isolation, with limited interaction and knowledge sharing. This fragmentation hinders the efficient exchange and flow of materials and hinders collaboration between stakeholders.
3. Different goals and priorities: Stakeholders from different sectors have different goals and priorities, making it challenging to align interests and facilitate collaboration. For example, agricultural producers focus on maximizing crop yields, while manufacturers prioritize cost efficiency.
4. Regulatory and policy barriers: Inconsistent regulation, complex permitting processes and a lack of supportive policies create barriers to material exchange and collaboration. Harmonizing regulations and implementing supportive policies that encourage collaboration can help overcome these challenges.
5. Limitations in infrastructure and logistics: Inadequate infrastructure and logistics systems hinder the efficient exchange and flow of materials in the bioeconomy. This includes insufficient transport networks, storage facilities and processing capacity. For working collaborative cooperation, it is necessary to solve these infrastructure problems first.
6. Intellectual Property and Confidentiality: Collaboration often involves sharing intellectual property and proprietary information. Concerns about protecting intellectual property rights and maintaining confidentiality often act as barriers to collaboration, especially in a highly competitive industry.
7. Financial constraints: Collaborative efforts in the bioeconomy often require investments in research, development and infrastructure. Limited financial resources hinder the creation and maintenance of collaborative structures. Therefore, collaborations are often created only for the purpose of obtaining a grant, after which the collaboration breaks up and ceases.

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Table 32 Mapping cross-sectoral collaborative structures in Bulgaria and the Czech Republic

Cross-sector collaborative structure	Objectives	Role	Sectors	Type of actors involved
AgroHub https://edih.agrohub.bg	Development of the agri- and food sector potential for access to technological solutions and services supporting the digital transformation	Information hub, support to farmers and companies for process automation, resource efficiency, smart production	Agro and food, ICT	SMEs, producers, local governance from South-Central Region in Bulgaria
BESCO – The Bulgarian Entrepreneurial Association https://besco.bg/	A NGO that acts as a bridge between start-ups, private and institutional investors, the government and other stakeholders in the innovation industry.	Upgrade the current Bulgarian legislation and propose contemporary market-driven policies based on innovation and progressive thinking, access to talent, access to capital	Multi-sector	SMEs, consultancies, investors, policymakers
Export Hub Bulgaria www.exporthub.bg	Market entry support, events, knowledge transfer & market information, access to programmes for export potential development for Bulgarian SMEs.	Knowledge transfer, supporting SMEs to access international markets	Multi-sector	SMEs, Bulgarian Executive Agency for Small and Medium Size Enterprises; academia, industry,
Tech Tour www.techtour.com	Community platform that connects tech entrepreneurs with investors, experts, coaches, and regions to realize their bold ambition and build successful partnerships.	Event management, market information, community building, stakeholder involvement	Sustainability, Digital, and Health-tech	SMEs, public & private investors, corporate, institutional and independent industry stakeholders
Agrarian University – Plovdiv www.au-plovdiv.bg/en	National centre of agricultural science and education in Bulgaria.	TTO, research, sectorial development support, scientific support to policy making. Support and cooperation in the implementation of research programmes and projects focused on knowledge-based enhancement of Bulgarian agricultural development, tourism and the country's integration into the European economic space	Agriculture, food, tourism	Academia, early start-ups at ideation stage, industrial communities, governing institutions

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BIOEAST HUB CZ www.bio-hub.cz	Knowledge hubs, a bridge between SMEs and the government	Presents BE opportunities, supports more efficient use of biological resources, sustainable development of the EU encourage the involvement to the international cooperation programmes, promotes BE in national strategies and grant programmes, connects the national (mirror, shadow) thematic working groups	Multi-sector	SMEs, policymakers
Czech Academy of Agricultural Sciences www.cazv.cz	Scientific and knowledge body, Advisory body for Ministry of Agriculture	Contributing to the design and development of the bioeconomy strategy, Advisory body for Ministry of Agriculture	Agro, water, forestry	Academia
Bioeconomy platform of the Czech Republic https://bioeconomy.czu.cz/en	Knowledge hub	Transferring and fostering the national bioeconomy and its competitiveness	Agro, forestry	SMEs, academia
National Cluster Association www.nca.cz	Community platform that connects tech entrepreneurs with investors, experts, etc.	Support national stakeholders with relevant information	Multi-sector (rather industry)	SMEs, start-ups
Association of research organizations www.avo.cz	SMEs and large entrepreneurs supporting institution	Supports the engagement and involvement of SMEs and large entrepreneurs, provided methodology for SMEs how to use the potential of bioeconomy innovation	Multi-sector	Research institutions
Technology Centre Prague www.tc.cz	Supporting institution about EU grants	Support national stakeholders with relevant information (mainly about EU grants, missions and research programmes)	Multi-sector	Policymakers, academia, SMEs, start-ups
Czech Biofuels Technology Platform www.biopaliva-ctpb.cz	Community platform that connects SMEs and stakeholders in field of agro and energy sector	Support national stakeholders with relevant information	Agro industry, energy	SMEs and large entrepreneurs

Source: TechTour & BIOEAST HUB CZ (2023).

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5.5 Financing

5.5.1 Policy Instruments for Financing in selected MR countries

The policy instruments available to develop the bioeconomy innovation ecosystems in the CEE macro-region are conditioned by the national priorities for the available national funds, the size of the national ecosystem and the awareness about the funding and support schemes. Support for the stakeholders is not always financial but may as well aim at supporting their growth, as in the case of the companies, through acceleration, product commercialisation, market internationalisation and networking opportunities for the entire ecosystem. The focus here is mainly on company financing in the CEE macro-region as the available policy instruments and funding opportunities are primarily oriented towards supporting the growth, acceleration, and market uptake of innovation.

The bioeconomy stakeholders in the CEE macro-region find most often funding and investment opportunities from:

- Horizon Europe
- The European Innovation Council and SMEs Executive Agency (EISMEA) and its programmes such as Eurostars SME Programme, the EIC Fund, Pathfinder.
- EIT - the European Institute for Innovation and Technology and its programmes focused on food, raw materials, climate and mobility
- The European Cohesion Fund operationalised at local level through National Operational Programmes
- The European Regional Development Fund, also through National Operational Programmes
- The European Social Fund also but to a lesser extent.

The National Operational Programmes are more generalist encompassing various sectors and the support is usually on horizontal topics such as digitalisation, development of soft skills, knowledge and information hubs.

When it comes to financing for bioeconomy innovative projects, Horizon Europe remains the main European Union Programme. Horizon Europe is the EU's major research and innovation funding programme that the CEE innovators use in their endeavours for growth and market expansion. Through Horizon Europe the companies have access to collaboration networks, apply their research in line with EU policies and global challenges, while also benefitting from support for dissemination of their research results and technologies. Local innovators find in Horizon Europe a multipurpose instrument with diverse opportunities which supports ground-breaking innovations that may not otherwise materialise in the limited national or even regional markets, helps them design and achieve ambitious and measurable goals; the mandatory open access to publications, and presents the companies with a new approach to partnerships focused on EU policy objectives and industry collaboration.

In participating in the various EU-funded programmes, the companies boost their competitiveness – often a grant from the programmes of the European Investment Council (EIC) is a good reference for future investors and maximizes investment impact in the European Research Area.

5.5.2 Company Financing

Foreign direct investment on a larger scale is absent in the CEE Farm2Fork and wood chains, apart from food in Bulgaria, Czech Republic, Hungary, Poland and Romania, agriculture in Czech Republic (OECD, 2023). Current trade patterns in the bioeconomy in terms of exports of raw commodities and imports of processed goods reveal untapped potential in terms of integration into international value chains. There is a need to enable environment-prioritising investments related to the stronger integration of the value chain and value capture (Lovec and Juvancic, 2021).

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In the BIOEASTsUP project, a peer review focused on technology transfer concluded that funding for bioeconomy ventures is perhaps one of the biggest issues: private investors are still rather reluctant to invest into new start-up or spin-off companies within the BIOEAST macro-region. (BIOEASTsUP, 2021b). Although this information was an output for the BIOEAST macro-region, these findings were confirmed within interviews done for ShapingBio purposes. The entire CEE macro-region is struggling with the fact that the bioeconomy is not anchored as a priority in the states (chapter 3.1.3), and therefore these investments are perceived as uncertain. Private investors focus on profit and construction turnover, and these investments into bioeconomy seem risky due to insufficient support from the government. Furthermore, for policy makers and higher education management, the development of educational/training modules seems to be a good solution for changing attitudes in the region.

Private investments in the bio-based industry are limited, pushing companies in bioeconomy to rely on their own resources or seek equity from specialized investors or corporate partners as they grow in size and technological sophistication. While the European Union offers grants through specific bioeconomy programmes like EIC, Eurostars, EIT, these grants are limited for companies, favouring those that are technologically advanced. As companies in the bioeconomy industry scale up their projects to more advanced development stages, they encounter a diminishing availability of grants due to the larger project sizes – also confirmed by the respondents in the ShappingBio D 1.1 (2023). Additionally, the presence of public funding does not always attract sufficient private capital, primarily because sector-specific risks often exceed the risk absorption capacity of public funding instruments (EIB 2017).

For the CEE macro-region the volume and type of financing rounds is comparatively modest with limited variety of the funding rounds (Figure 72). This reflects the immaturity of the ecosystems and the greater disparities between the countries. The grants are a notable part of the financing rounds in Bulgaria, Croatia, Poland, Czech Republic and Slovakia. This may be a sign of more awareness of companies in these countries on funding opportunities from public national or EU sources. Poland with the most developed market has the most prominent amount and number of deals (Figure 73). Countries with comparatively high potential in bioeconomy development like Romania and Bulgaria experience less active financing both in terms of number of financing rounds and financing amounts.

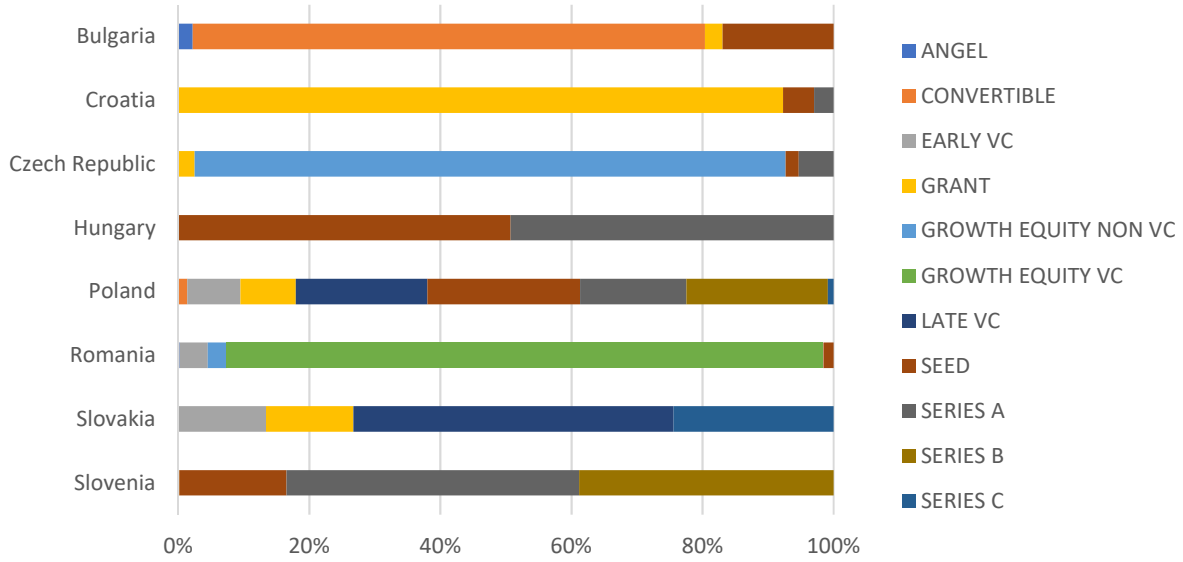

Figure 72. Type of financing rounds in the countries of CEE macro-region. Source: Dealroom.co (2023).

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The companies in the CEE macro-region receive funding from private investors located predominantly outside their countries. Only private investors from Poland are in the top 20 investors by number of deal participation. Otherwise, there are reported active private investors in Bulgaria, Croatia, Czech Republic, Poland, Romania, Slovenia and Slovakia with 160 investment rounds in total.
It is notable that there are big differences in the amounts per investment round (Figure 73) for early-stage companies. For example, the investment amounts in Hungary are proportionately bigger for early-stage companies in comparison with Poland where more companies are financed but with smaller amounts of overall investment.

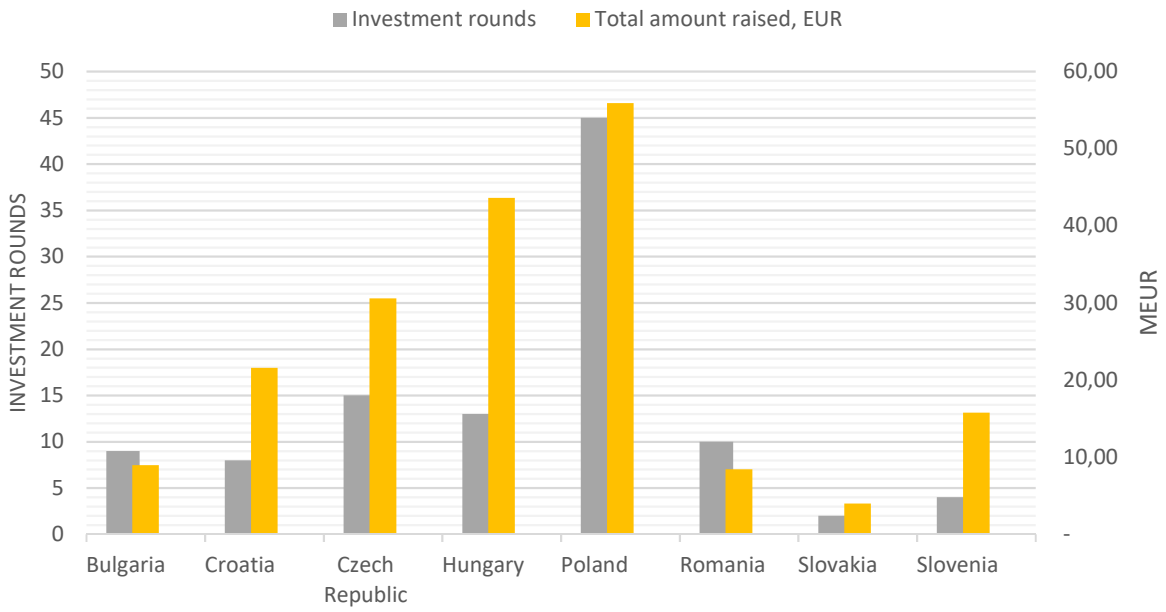

Figure 73. Early-stage funding rounds & amounts in the CEE macro-region.
Source: Dealroom.co (2023).

The total amount raised per country for all investment deals is presented in Figure 74. The difference to the data in Figure 73comes from the more mature investment deals that in later company development stages might be in significant amounts but take place less often. An example is the biggest deal in the CEE macro-region in the Czech Republic for the amount of approximately EUR 280 million in December 2021.

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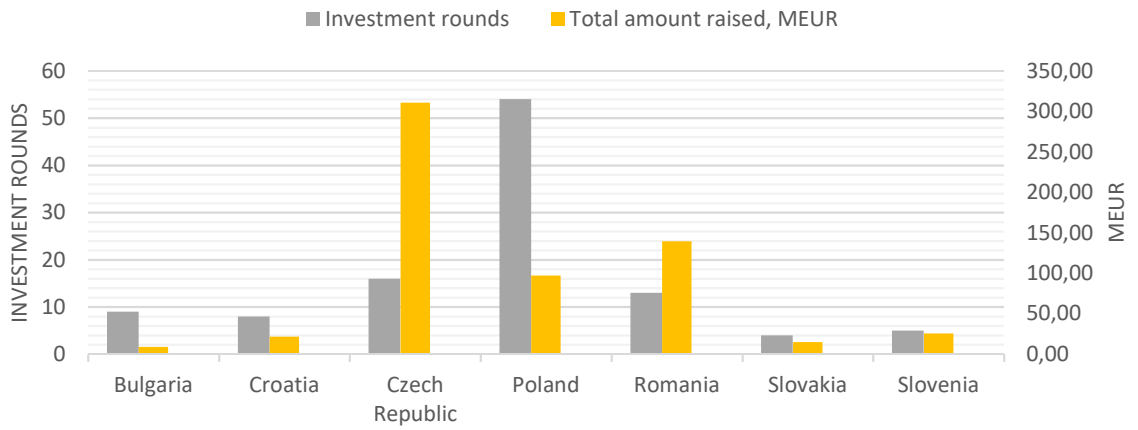

Figure 74. Total reported amount raised by country in CEE macro-region.
Source: dealroom.co (2023).

5.5.3 Enhancing Funding Accessibility for the Bioeconomy in selected MR countries

The existing funding and investment options, both at CEE macro-region national and EU level, aim to address the needs of their target groups, including SMEs in the bioeconomy. These programmes provide funding opportunities for research and innovation, which can benefit SMEs by promoting growth, competitiveness, and technological development. However, the effectiveness of these programmes may vary depending on the specific circumstances in each country and the size and maturity of their ecosystems. In some cases, access to funding may be limited for more technologically mature companies due to lack of focus on bioeconomy, limited opportunities on the local market, and bureaucracy on the way to obtaining funds.

Awareness of programmes like EIC among SMEs is essential for them to fully benefit from these opportunities. While efforts are made to disseminate information about these programmes, some SMEs may still lack awareness due to limited outreach or resources. Key obstacles for SMEs to access these funds may include the complex application processes, competition for limited grants, and sector-specific risks that deter private investors from participating in investment syndicates with public funds.

Something fundamentally missing from the SMEs' side could be a more strategic approach to seeking and applying for funding. SMEs may benefit from improving their project maturity, developing stronger business plans, and seeking partnerships or collaborations to enhance their competitiveness in securing funding from EU programmes. The local SME development agencies, publicly or privately financed accelerators, industry clusters, and other intermediaries may be the interlocutors that bridge the gap by facilitating collaboration, knowledge-sharing, and access to resources, thereby helping SMEs and the private sector navigate the complex bioeconomy landscape and effectively seize funding opportunities. Additionally, SMEs may need better access to support services and resources to navigate the application process effectively.

There are various opportunities at European-level policies in the bioeconomy that align with the needs of CEE macro-region companies (chapter 3.5.1). However, there is a pressing need to enhance the coordination of these programmes within a unified strategic framework and strengthen the financial mechanisms to ensure the enduring stability of bioeconomy investments. The EU Funds, together with the private capital, possess the flexibility to support investments structured for medium to long-term sustainability, thus merging and securing resources from national policies into a comprehensive funding framework that addresses both programming and financial requirements.

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5.6 SWOT-Analysis of the CEE Macro-Region

Table 33 SWOT Analysis of the CEE Region

Strengths	**Weaknesses**
- High quality and amount of biomass - Value added has been increasing since 2016 (mainly in the field of agriculture) - Well established macro-regional political BIOEAST Initiative, achieving policy involvement & engagement of a wide range of stakeholders in a top-down process - Total expenditure on R&D is increasing, the research in the field of bioeconomy has sectoral specificities and foci (especially research activity in innovative food products and beverages, paper and pulp production, pharmaceuticals, biological chemicals and plastics is growing) - Highly qualified researchers in several areas of the bioeconomy - Projects and networks are created and international cooperation exists and is supported - The participation of SMEs in research projects is growing, and new possibilities for financing these projects are emerging	- Inadequate utilization and valorization of biomass - Unclear or inconsistent bioeconomy policies and regulations, including unclear competences - Lack of infrastructure for development and scale-up of technologies in the bio-based industrial sector (pilot plants, open pilot facilities, etc.) - Low attractiveness of research careers for domestic and abroad talents - Innovation performance is low (below the EU average), specialization in low-tech sectors of the bioeconomy (i.e. food products, agriculture, forestry, wood and furniture, paper) - Low level of awareness of opportunities for circular technology solutions and business models - Lack of programmes for financing, support of bio-industry and cooperation between industry and research, weak focus of public funding on bioeconomy
Opportunities	**Threats**
- Growth in demand (private & public) for bio-based products and technologies - Growing biomass demand by the EU bioeconomy which could be served and valorized by CEE countries - Still untapped source of biomass for the bioeconomy by valorisation of residual biomass from primary production, urban biowaste and wastewater - Bioeconomy as vehicle to rejuvenate traditional incumbent industries - Learning from more advanced countries, e.g. through cooperations	- Geopolitical conflicts - Political instability leading to inhibition of the development of bioeconomy policy - Lack of political commitment on national and/or regional level - Reduction in foreign investment (due to global economic slowdown, lack of qualified workforce, regulatory environment, political instability, competition) - Brain drain of qualified workforce (due to insufficient investment in new technologies, poor infrastructure, slow digitization, lack of job opportunities and lower salaries)

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5.7 Conclusions for the CEE Macro-Region

Bioeconomy refers to the sustainable use of renewable resources for the production of food, energy, and other products, while minimizing waste and environmental impact. The Central and Eastern European (CEE) macro-region possesses of a large primary production sector, which produces a large scale of biomass and in combination with the food sector a significant part of EU bioeconomy employment is represented there. Moreover, the actors landscape in the bioeconomy is somewhat evolving on third and partly industrial side, as well as initiatives (e.g. BIOEAST) to bring different relevant stakeholder groups together.

However, the main challenge to the CEE macro-region in developing a bioeconomy is the lack of necessary infrastructure and investment, aggravated by the absence of coherent dedicated bioeconomy policy frameworks which go beyond traditional sectors.

The CEE macro-region has traditionally relied on fossil fuels and has limited experience and infrastructure in bio-based industries. This lack of infrastructure includes the absence of adequate facilities for biomass processing, limited research and development capabilities, and a low level of private sector investment.

Furthermore, the transition from a fossil fuel-based economy to a bio-based economy requires significant upfront investments in research, development, and infrastructure. The CEE countries, given their comparatively lower GDP per capita and limited financial resources, face challenges in attracting and mobilizing the necessary investment.

Lack of bioeconomy value chains show characteristics typical of CEE macro-region countries: a low level of productivity in primary production, the unused potential of residues and by-products in production, processing and consumption, the absence of biorefinery capacities and the low level of awareness of opportunities for circular technological solutions and business models. The latter is present both on the side of industry, and on the side of public development policies. In this context, it is expedient to cooperate with the countries of the CEE macro-region, which are facing similar challenges, in developing appropriate solutions.

Furthermore, the CEE macro-region has diverse agricultural systems, with varying levels of efficiency and productivity. This heterogeneity poses a challenge in promoting the bioeconomy as a one-size-fits-all solution may not be suitable for all countries or regions within the CEE macro-region. Developing tailored strategies that take into account the specific challenges and opportunities of each country is crucial.

Additionally, there may be cultural and societal challenges in changing traditional practices and mindsets towards a bio-based economy. This includes changing the mindset of policymakers, industries, and farmers who have been accustomed to conventional methods and may be resistant to change.

Another significant challenge is the lack of skilled workforce and knowledge transfer. The bioeconomy requires expertise in fields such as biotechnology, bioinformatics and artificial intelligence, synthetic biology, agriculture, chemistry, and engineering. However, the CEE countries face a brain drain of skilled professionals, resulting in a shortage of qualified personnel needed to drive the bioeconomy forward. Moreover, knowledge transfer from advanced bioeconomy countries to the CEE macro-region is limited, making it harder for local institutions and industries to develop the necessary skills and know-how.

Lastly, there may be regulatory and political challenges that hinder the development of a bioeconomy. This includes unclear or inconsistent policies, regulations, the lack of dedicated bioeconomy strategies, missing action plans in nearly all countries of the macro-region. Overall, countries also face complex and unclearly structured publicly funded programmes and incentives related to bio-based industries can create uncertainty for investors and entrepreneurs. Harmonizing regulations and creating a favourable policy environment that promotes and incentivizes bio-based industries can help overcome this challenge.

The missing monitoring system to indicate the benefit of bioeconomy, which illustrates that the bioeconomy is not a priority in the countries of the region, is one of another key obstacles. Within the ShapingBio project and others, there is an effort to capture several partial indicators, but the complete picture is missing. A macro-regional Bioeconomy Observatory is missing.

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6 Macro-Region Western

6.1 State of Play of the Bioeconomy in the Western Macro-Region

The western macro-region is composed of seven countries: Austria, Belgium, Germany, France, Ireland, Luxembourg and the Netherlands, see Figure 75.

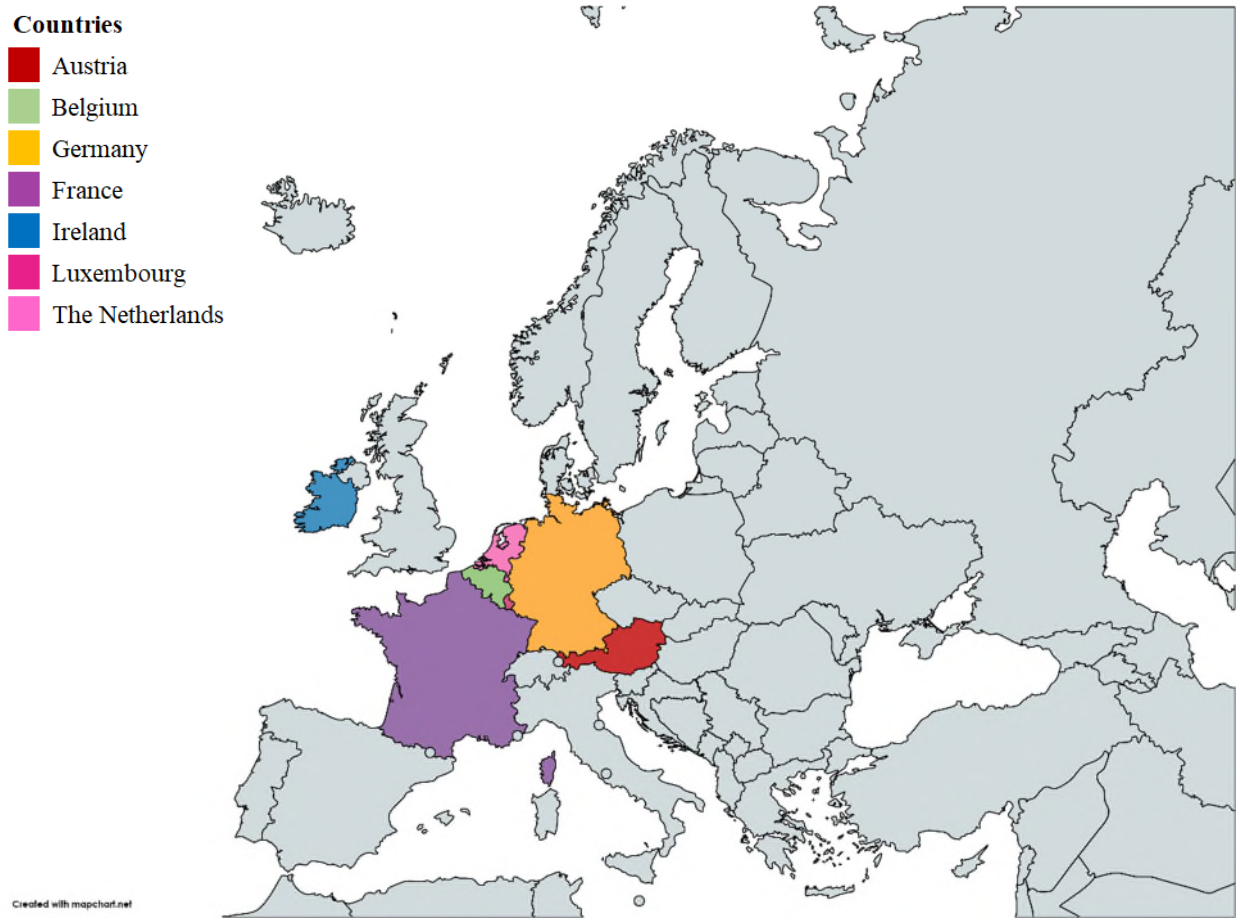

Figure 75. Countries of Western macro-region.
Source: mapchart.ne (2023).

The countries of the western macro-region represent 29.36% of the total land area of the EU-27. France is the largest country in the EU and Luxembourg is placed in the last position compared to the rest of the countries. Regarding the number of inhabitants, the western macro-region accounts for 43.68% of the total population of the EU-27. Germany and France are ranked at the top. However, Luxembourg and Belgium, are placed in the last positions in terms of the number of inhabitants. Details about Area and inhabitants with regards to the share are found in Table 34.

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Table 34 Area and inhabitants of western Macro-region

Country	Area (sq. km)	Share of EU-27	Inhabitants (2022)	Share of EU-27
Austria	82,519	2.01%	8,978,929	2.01%
Belgium	30,452	0.74%	11,617,623	2.61%
Germany	353,296	8.61%	83,237,124	18.63%
France	633,886	15.44%	67,871,925	15.19%
Luxembourg	2,586	0.06%	645,397	0.14%
Ireland	68,655	1.67%	5,060,004	1.13%
Netherlands	34,188	0.83%	17,590,672	3.94%
Total MR	1,205,582	29.36%	195,001,674	43.68%
Total EU-27	4,103,987	100%	446,735,291	100%

Source: Eurostat

6.1.1 Production and industrial use of biomass

In the following chapter the primary production supply and the demand for the use of biomass, as well as the biomass flows are illustrated.

Primary Production

In the primary sector, which encompasses agriculture, fishing, and forestry, agriculture stands as the predominant force in the economies of the nations within the western macro-region.

As per the 2020 data provided by the Food and Agriculture Organization (FAO), the countries of Western Europe boast a collective arable land area spanning 6896.7 sq. km (FAO, 2020). Nonetheless, as depicted in Figure 76, which shows the amount of agricultural land, there has been a gradual decline in recent years in the area of cultivable land. The decline results from suboptimal agricultural practices damaging soil fertility, compounded by rising population and resource demands.

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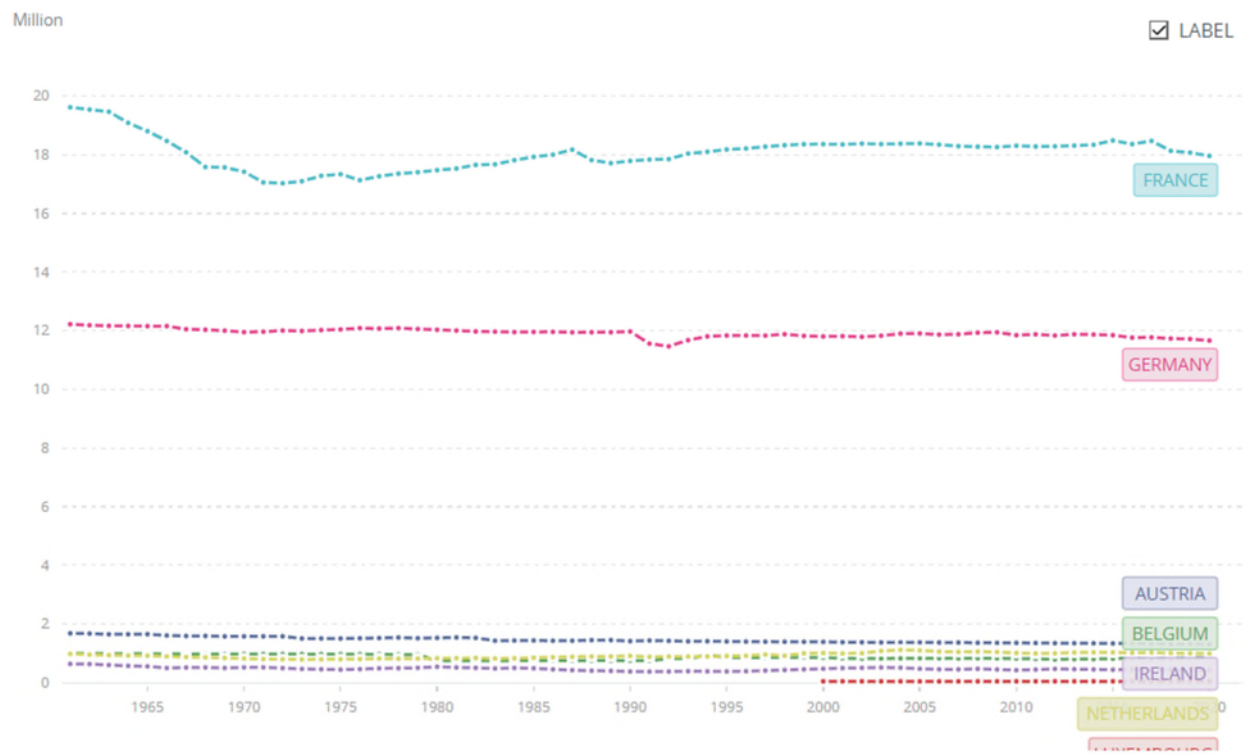

Figure 76. Arable land (hectares) in Western Europe (2020).
Source: Food and Agriculture Organization (FAO).

Figure 77 and Figure 78 pertain to Biomass Production within Primary Production Systems, encompassing agriculture, fishery, and forestry. The total biomass supply sourced from agriculture, forestry and fishery is around 512 245 tonnes of dry matter within Western Europe (see further details in Figure 81). Within the Western macro-region, the agriculture sector takes the lead in contributing to the majority of biomass production. Presently, a Western macro-region country, Austria, is placing a significant emphasis on wood-based bioeconomy, due to its strong reliance on the forestry sector within its economy. As a result, it is anticipated, that the proportion of biomass production derived from wood sources will experience growth in the forthcoming years.

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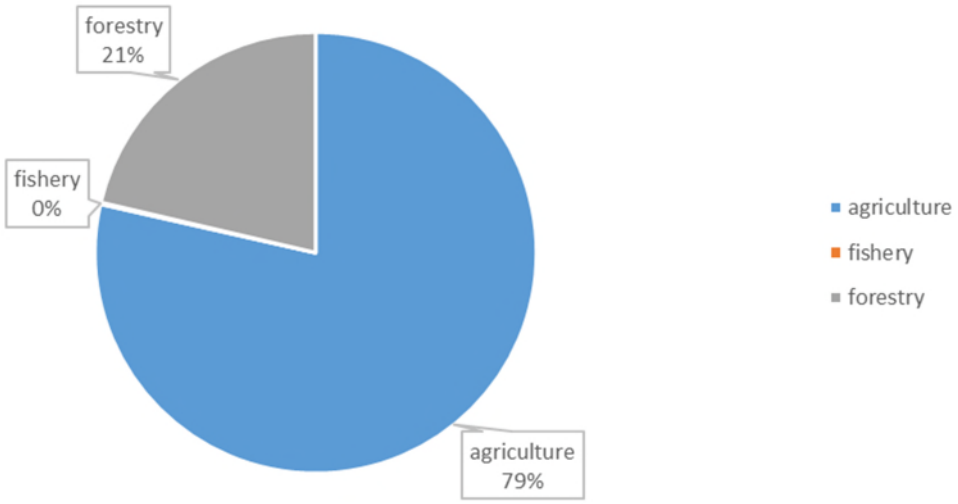
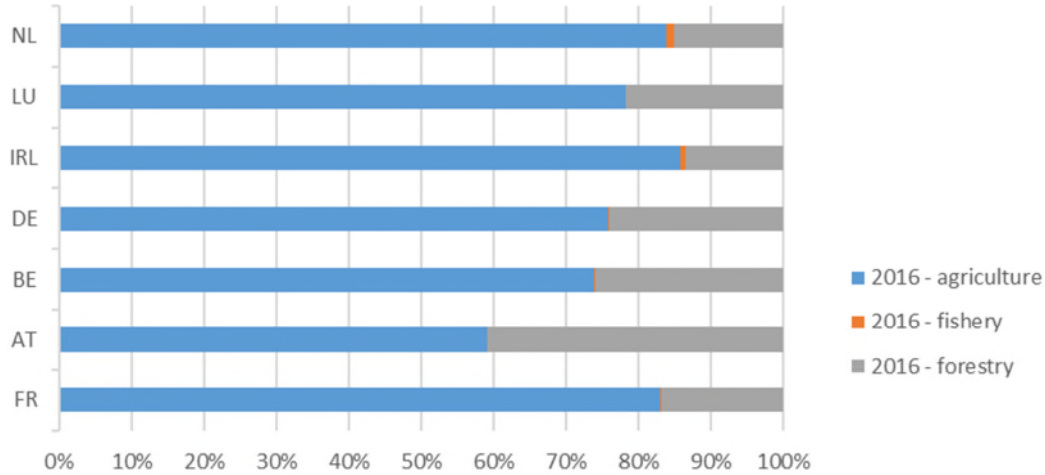


Figure 77. Biomass Production from Primary Production Systems in Western Europe (last Available data).
Source: Datam JRC, European Commission.



	FR	AT	BE	DE	IRL	LU	NL
2016 - agriculture	82,96%	59,15%	73,89%	75,80%	85,74%	78,18%	83,88%
2016 - fishery	0,12%	0,00%	0,06%	0,05%	0,64%	0,00%	0,96%
2016 - forestry	16,92%	40,85%	26,05%	24,14%	13,62%	21,82%	15,17%

Figure 78. Biomass Production from Primary Production Systems in Western Europe (2016)
Source: Datam JRC, European Commission.

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Use of Biomass

In the western macro-region, during 2017, a total of 340,000 tonnes of biomass (dry matter) from agricultural and woody sources were consumed for the production of energy, materials, and food. This data represents 28.82% of the total biomass consumption in the EU-27, see Figure 79 and Figure 80. Clearly, the highest demand among the countries in the western MR coincides with those that have a larger area and a higher population. In these countries, biomass is primarily used for food and feed production (68%), but there is also significant use for energy production (14%) and biomaterials (16%). As can be seen from Figure 80 Austria differs from the average with much lower percentage (40%) on food and feed production and much higher amount for biofuels over 40% and a slightly higher percentage for biomaterials (19%).

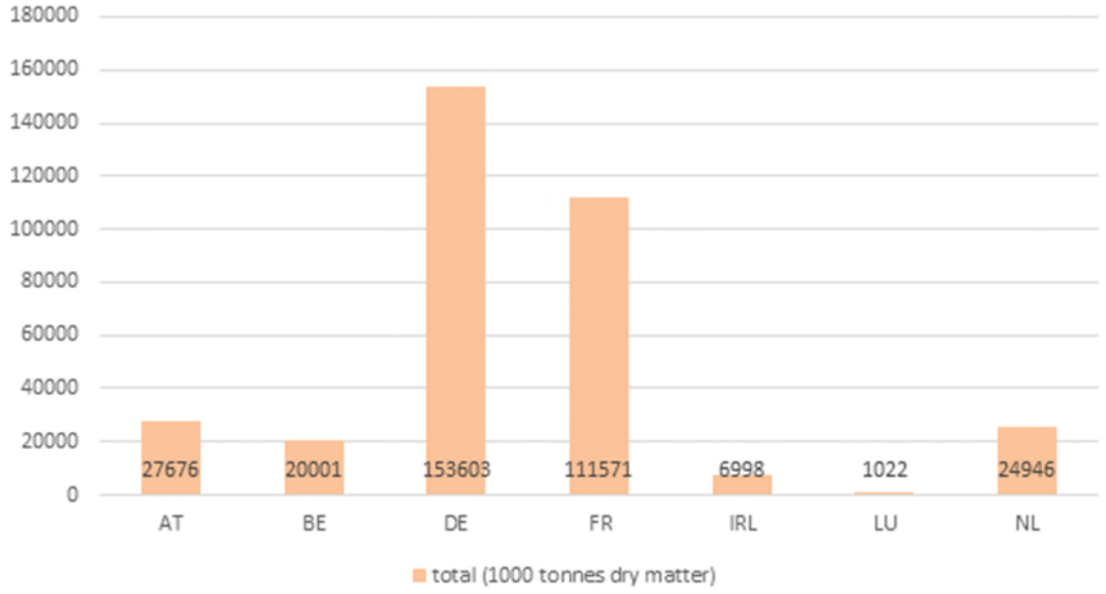

Figure 79. Total biomass consumption by countries in Western Europe (2017).
Source: Datam JRC, European Commission.

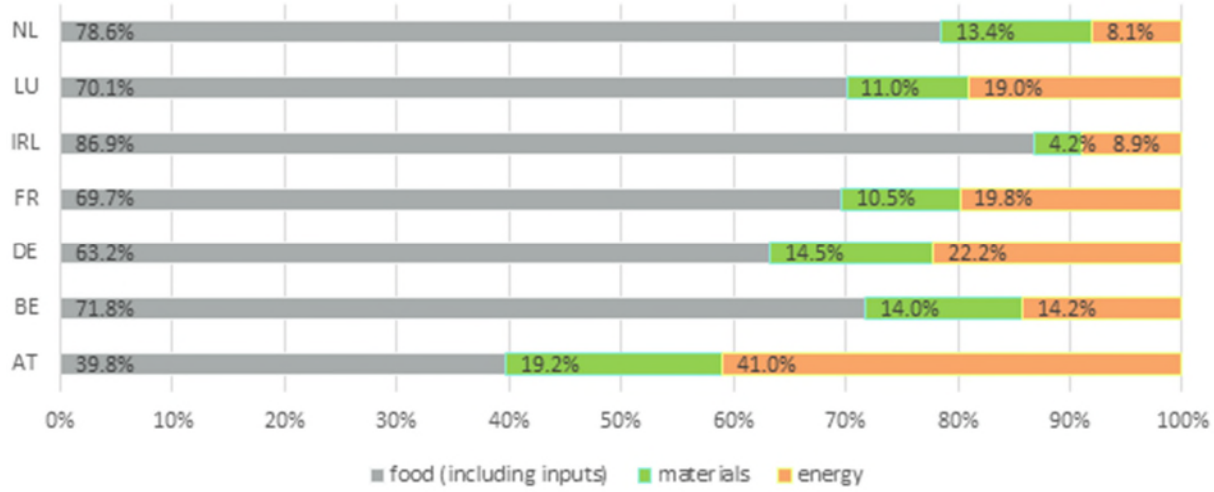

Figure 80. Biomass consumption for product categories in countries in Western Europe (2017).
Source: Datam JRC, European Commission.

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Biomass Flows

Figure 81 provides a total overview of the latest biomass flow data in Western Europe.[29] As mentioned earlier, the biomass supply originates from the agriculture, forestry, and fisheries sectors and undergoes conversion into various products related to food and feed, bioenergy, and biomaterials. For the biomass consumption a high amount of agricultural biomass is lost or its usage is unknown in terms of its consumption. This amount even exceeds the net import values of about 17%, making the Western macro-region a net importer of biomass.

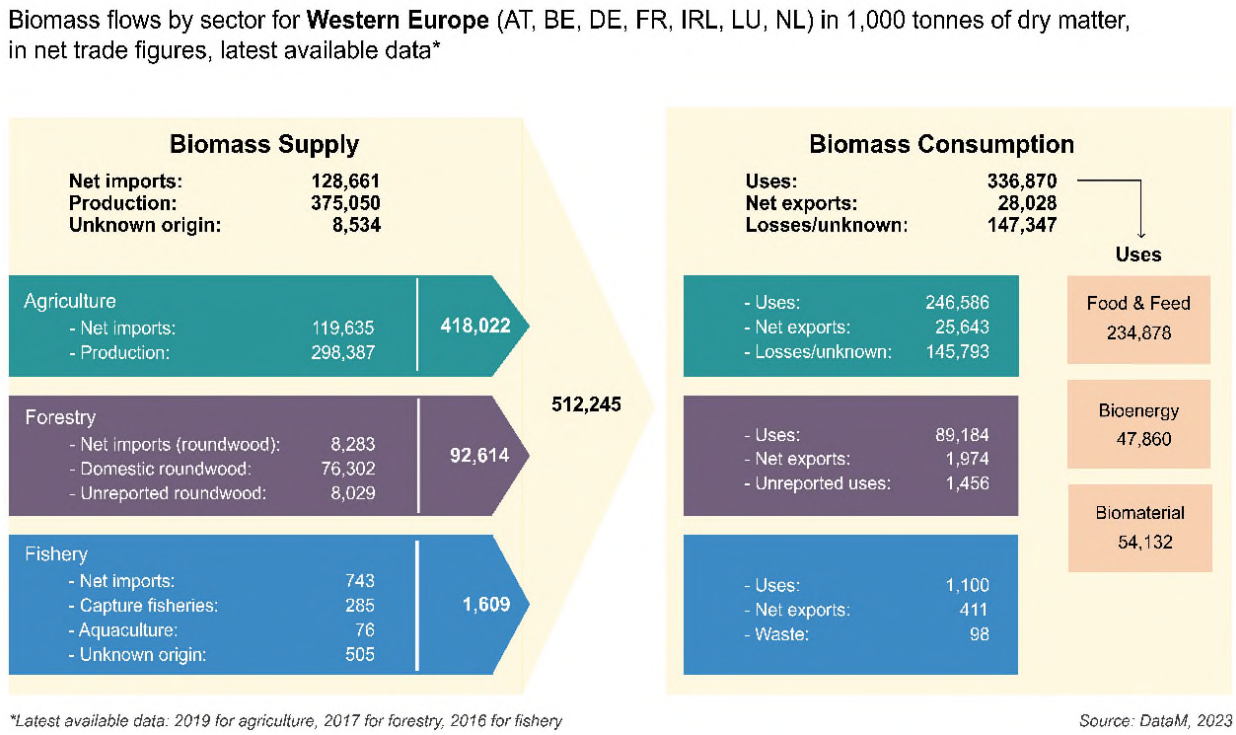

Figure 81. Biomass Flows in Western Europe (2023).
Source: Own compilation based on data from Datam JRC, European Commission.

6.1.2 Industrial deployment of bioeconomy and economic relevance

6.1.2.1 Industrial deployment

Open-Access Pilot Plants

Regarding open-access pilot and demo facilities, the Pilots4U network database shows a comparably high availability of those facilities compared to the other MR. All larger MR countries have at least a few facilities.

[29] Slight deviations tot he figurs above possible, due to partly different reference years and additional attribution steps of data

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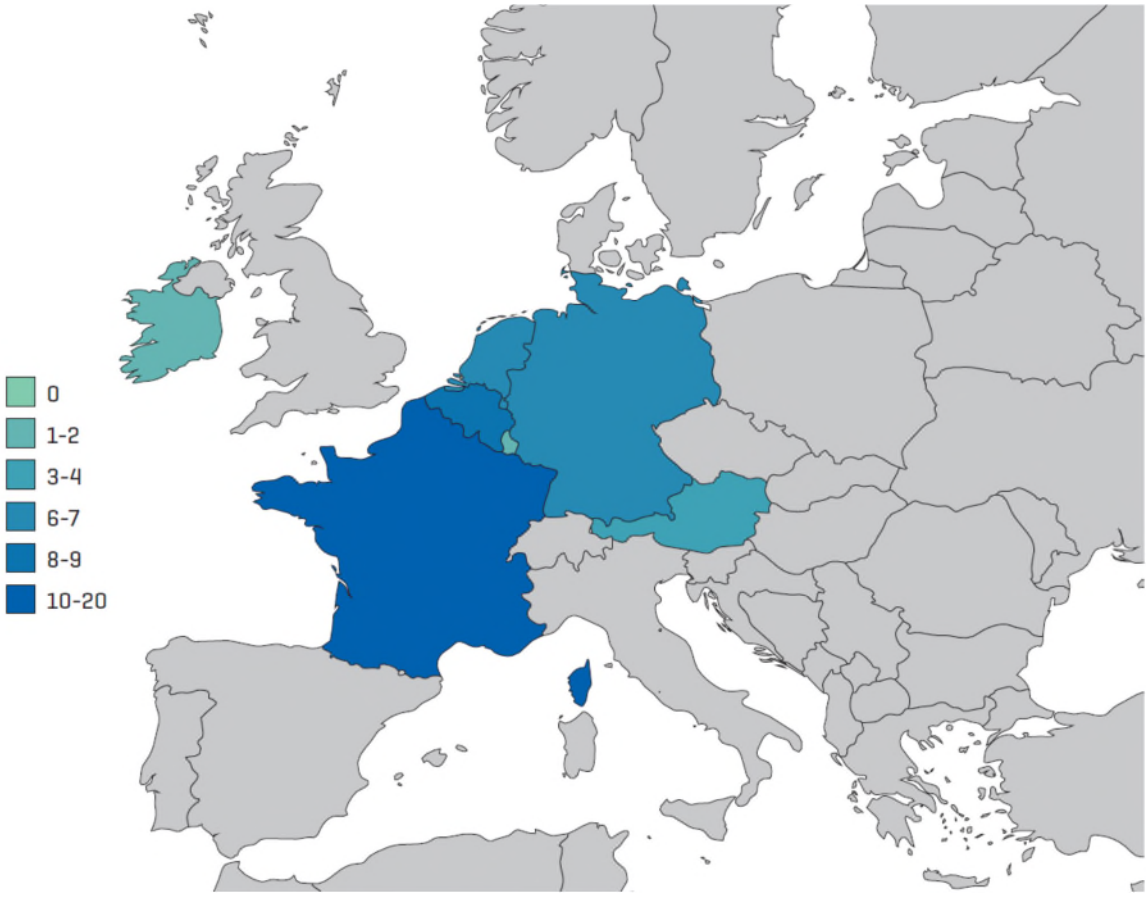

Figure 82. Distribution of number of open access pilotplants in Western Europe (2023).
Source: Pilots4U network.

Biorefineries

The bio-based industry within the EU is undergoing rapid development, with a notable concentration of biorefineries when compared to other regions across the continent. In the western macro-region alone, there are 1,157 facilities, constituting approximately 49% of the total 2,362 biorefineries within the EU-27, as is illustrated in Figure 83.

When categorizing bio-based industry facilities based on the source of their feedstock, those primarily utilizing raw materials from the primary sector, specifically forestry and agriculture, exhibit a notable predominance. Conversely, the proportion of feedstock sourced from marine origins is considerably lower, as can be seen in Figure 84.

Which is not surprising, since there is only a low share of biomass from marine sources (as could be seen in Figure 77, Figure 78, Figure 81). Again for Austria it differs, as already explained above and it does fit to their abundance of wood.

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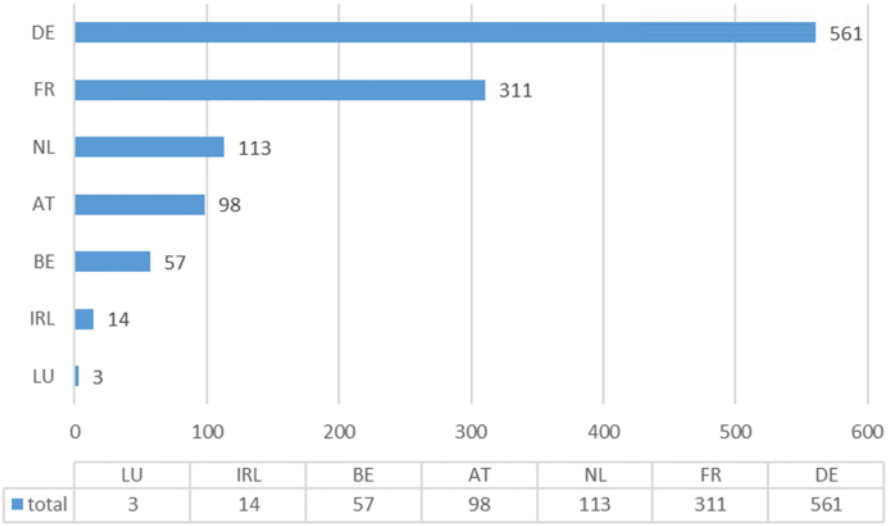
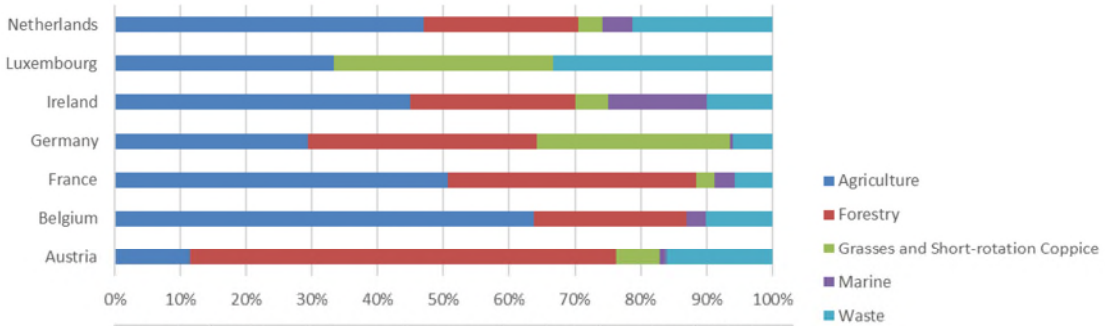


	LU	IRL	BE	AT	NL	FR	DE
total	3	14	57	98	113	311	561

Figure 83. Number of bio-based industry facilities by country in Western Europe (2020). Source: Datam JRC, European Commission.



	Austria	Belgium	France	Germany	Ireland	Luxembourg	Netherlands
Agriculture	11,43%	63,77%	50,71%	29,44%	45,00%	33,33%	46,97%
Forestry	64,76%	23,19%	37,68%	34,69%	25,00%	0,00%	23,48%
Grasses and Short-rotation Coppice	6,67%	0,00%	2,83%	29,44%	5,00%	33,33%	3,79%
Marine	0,95%	2,90%	3,12%	0,51%	15,00%	0,00%	4,55%
Waste	16,19%	10,14%	5,67%	5,92%	10,00%	33,33%	21,21%

Figure 84. Share bio-based industry facilities by feedstock origin in Western Europe (2020). Source: Datam JRC, European Commission.

Figure 85 shows the percentage of bio-based industry facilities based on the product class they generate. There is a wide variety of products obtained from biomass, but the strongest industries are the chemical and biomethane. On the other hand, it is relevant the fact, that a small amount of starch and sugar produced in the bio-based industry facilities of the western macro-region. Worth to mention, that for Austria focusing on woody biomass, their main feedstock is timber.

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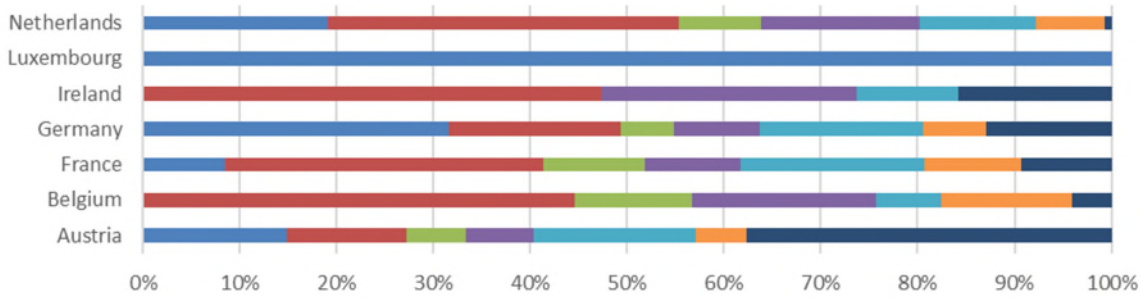

	Austria	Belgium	France	Germany	Ireland	Luxembourg	Netherlands
biomethane	14,91%	0,00%	8,50%	31,60%	0,00%	100,00%	19,15%
chemicals	12,28%	44,59%	32,86%	17,67%	47,37%	0,00%	36,17%
composites and fibres	6,14%	12,16%	10,48%	5,51%	0,00%	0,00%	8,51%
liquid biofuels	7,02%	18,92%	9,92%	8,91%	26,32%	0,00%	16,31%
pulp&paper	16,67%	6,76%	18,98%	16,86%	10,53%	0,00%	12,06%
starch&sugar	5,26%	13,51%	9,92%	6,48%	0,00%	0,00%	7,09%
timber	37,72%	4,05%	9,35%	12,97%	15,79%	0,00%	0,71%

Figure 85. Share bio-based industry facilities by product class in Western Europe (2020). Source: Datam JRC, European Commission.

6.1.2.2 Economic relevance

As illustrated within Figure 86, in the western macro-region, the bioeconomy employs approximately 4.98 million individuals across various sectors, constituting 29% of the total workforce in these sectors within the EU-27. Notably, the food, beverage, and tobacco sector (yellow sector) leads with 2.09 million employees, followed closely by the agriculture sector (green sector) with 1.72 million workers.

Based on data from previous years (as illustrated in Figure 84), the employment figures in these sectors have remained stable. These results are astonishing, as in comparison with whole Europe (approximately 17 million) the Western Region employment rate is under 30% within Bioeconomy, while this region hosts circa 43% of inhabitants, held the highest rate of patents and EU money.

Unsurprisingly, the largest countries France and Germany present most of the employment, both having a similar sectoral structure (Figure 86).

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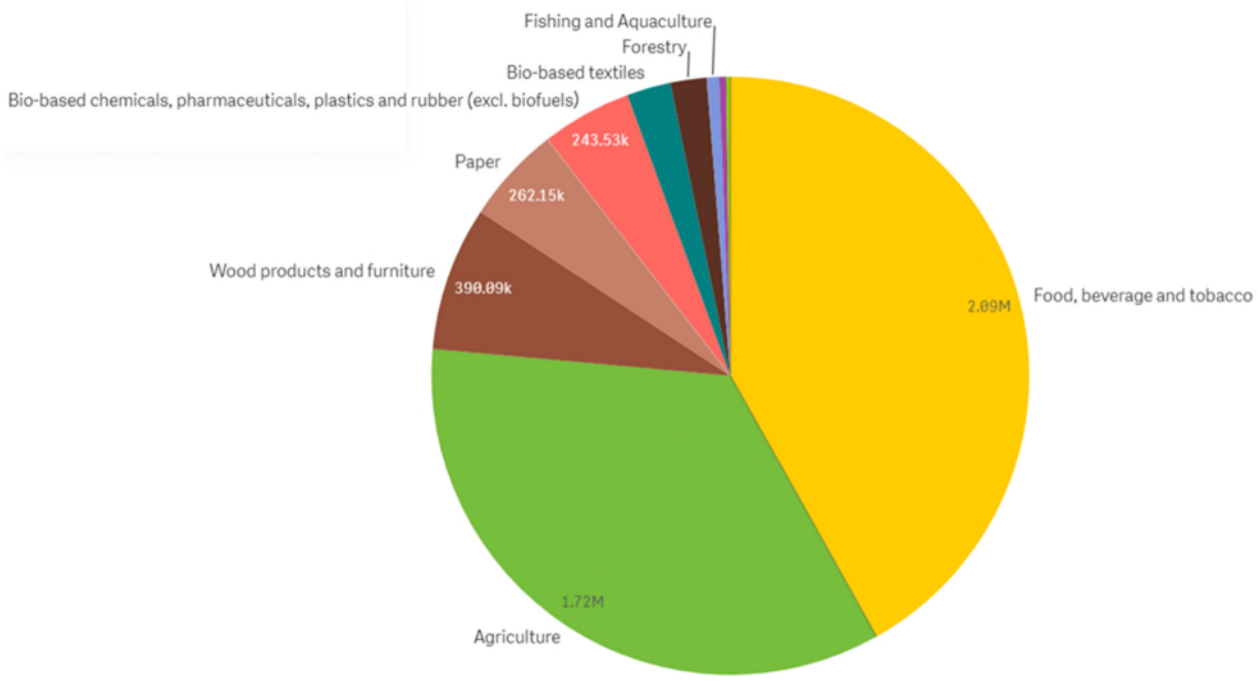

Figure 86. People employed per bioeconomy sector in Western Europe (2020). Source: Datam JRC, European Commission.

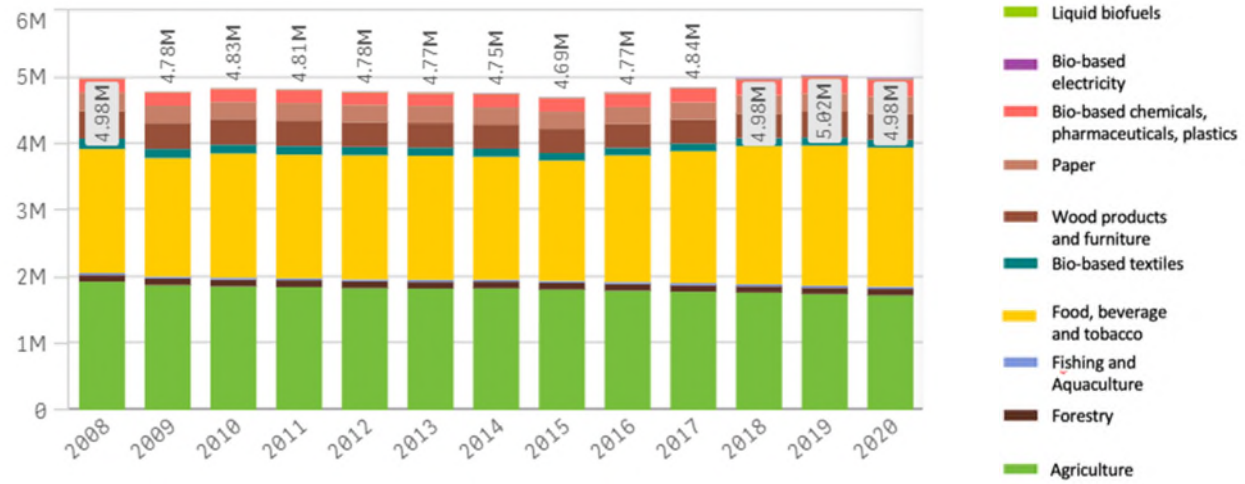

Figure 87. People employed per bioeconomy sector in Western Europe (2008-2020). Source: Datam JRC, European Commission.

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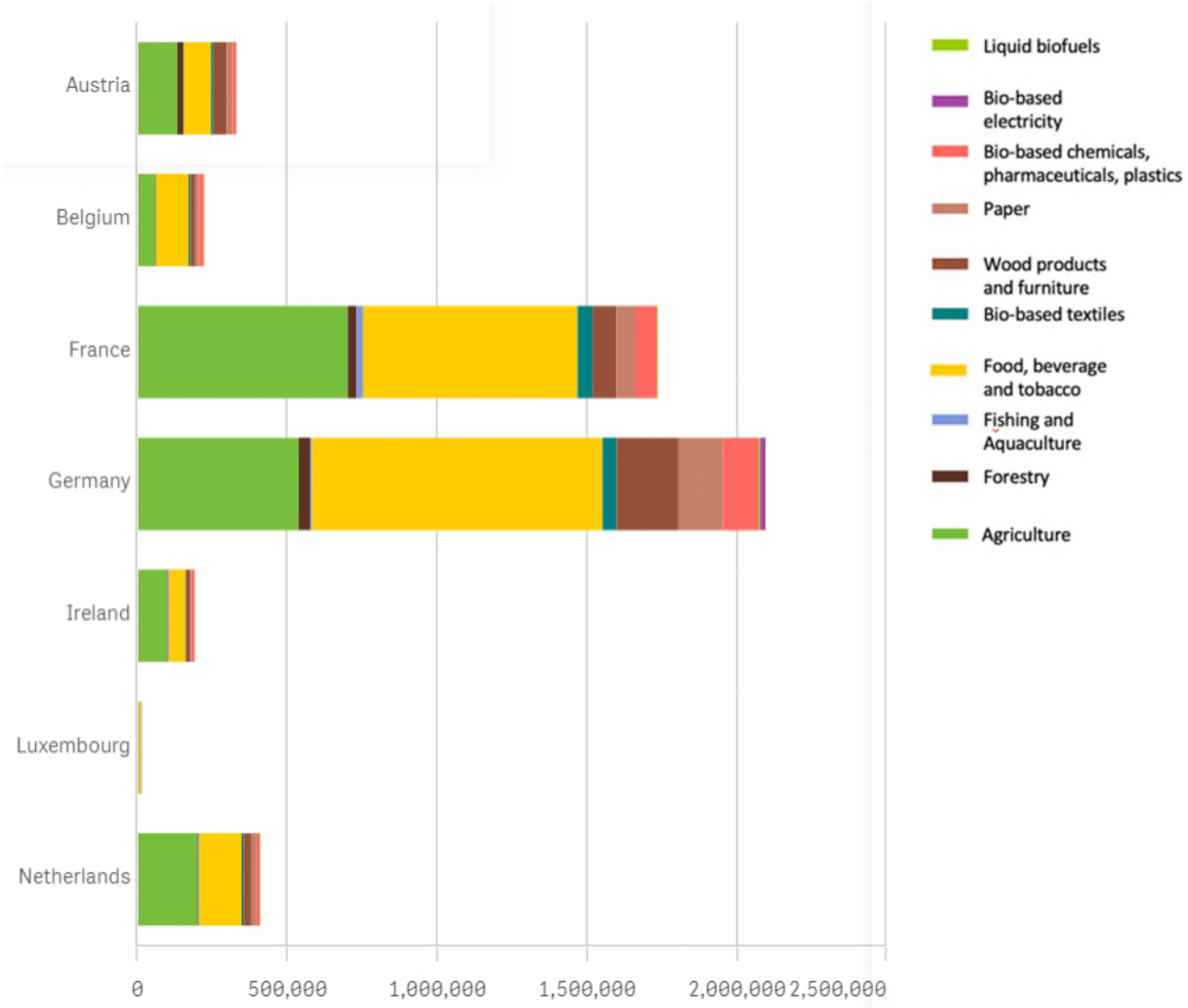

Figure 88. Number of people employed in bioeconomy sectors per country in Western Europe in 2020. Source: Datam JRC, European Commission.

The Western European Macro-region generates an added value of 320.6 million euros from its biomass production, surpassing the European average. The sector that contributes the most to this added value is food, beverage, and tobacco, followed closely by the agriculture sector. Additionally, other noteworthy sectors in this regard encompass bio-based chemicals, pharmaceuticals, plastics, and rubber (excluding biofuels). Summarized in numbers in Figure 89 and Figure 90.

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Figure 89. Value Added in Western Europe (2020).
Source: Datam JRC, European Commission.

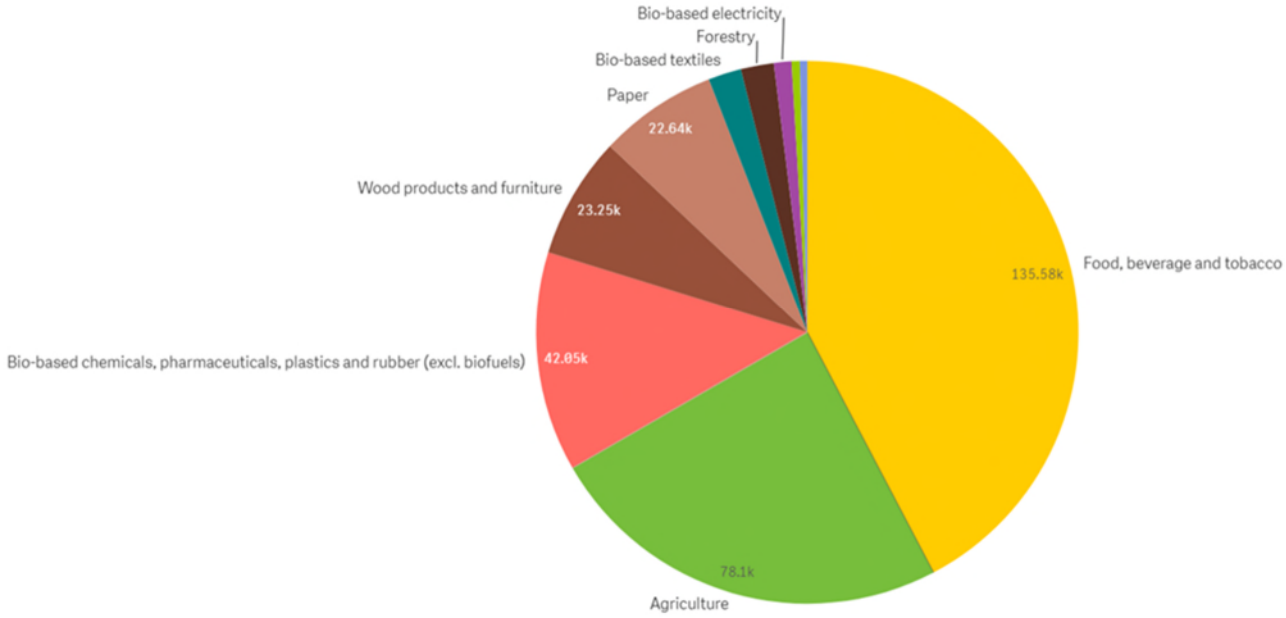

Figure 90. Value Added per bioeconomy sector in Western Europe (2020).
Source: Datam JRC, European Commission.

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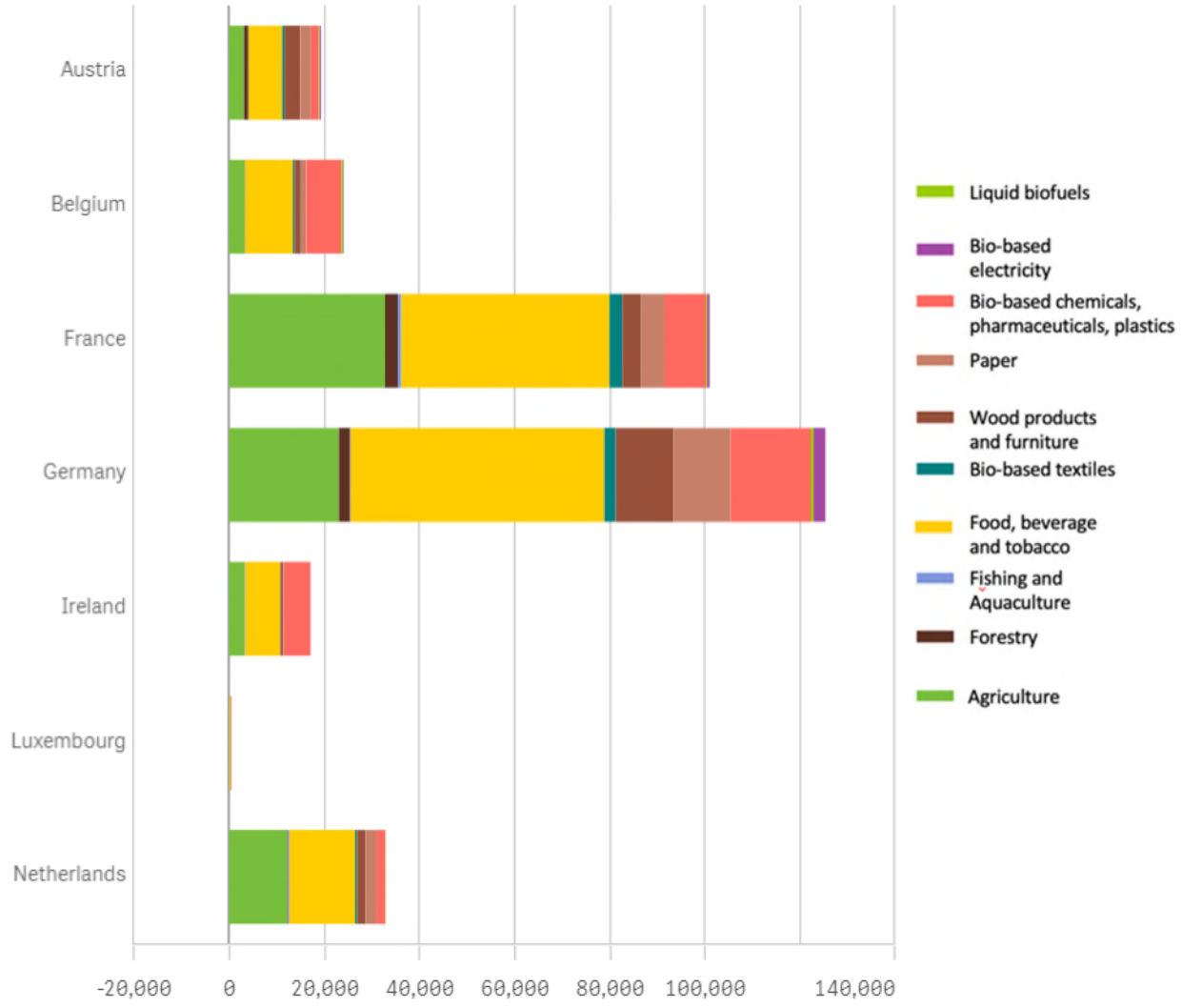

Figure 91. Value added created by bioeconomy sectors in Western Europe per country in 2020 (in million €).
Source: Datam JRC, European Commission.

Based on data from previous years (as shown in Figure 92, the value-added metrics demonstrate an upward trajectory, primarily attributable to the growth in the liquid biofuel and bio-based electricity sectors (as depicted in Figure 92). Nonetheless, it is important to note that these sectors, while on the rise, still account for a relatively modest portion of the overall value added, when compared to sectors such as food, beverage, and tobacco, as well as agriculture.

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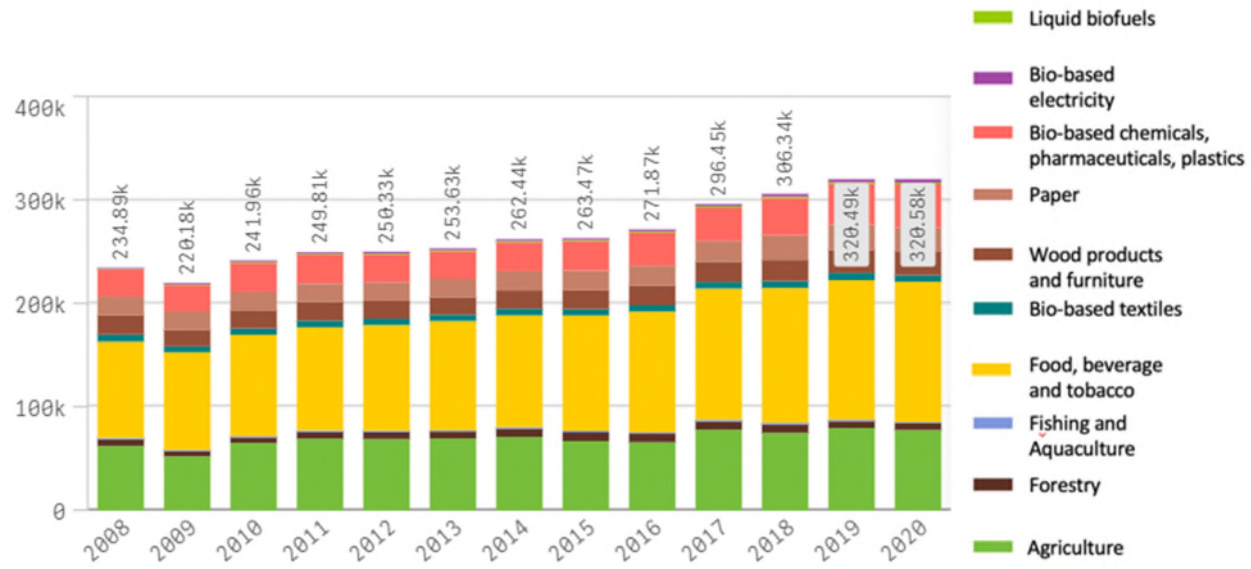

Figure 92. Value Added per bioeconomy sector in Western Europe (2008-2020). Source: Datam JRC, European Commission.

6.1.3 Actors

6.1.3.1 Academia, Research and Development

In the Western macro-region, a robust and diverse network of research and development (R&D) institutions plays an active role in advancing research and innovation in the field of bioeconomy. These institutions encompass universities, academies, public research institutes, and departmental research organizations, each contributing significantly to the progress in this vital domain.

Leading applied research, universities and research institute have defined specialities related to the regional biomass of the countries and are often related to the ministers of agriculture, energy and environment. The good position of this macro-region in the bioeconomy field is also strongly linked to its life sciences roots that powerfully fuelled the academic knowledge on fundamental research like synthetic biology and thus empowered the applied research. Due to this approach, the bioeconomy related research in the Western Region is engaging with a high technological approach.

Notably, several German institutions stand out prominently within this collaborative effort, forming a strong ecosystem dedicated to bioeconomy-focused R&D. Esteemed applied science organizations such as the Helmholtz Centre for Environmental Research (UFZ) and the Research Centre Jülich (FZJ) are noteworthy contributors. Furthermore, the Fraunhofer Gesellschaft, with divisions like Fraunhofer IGB, Fraunhofer CBP, Fraunhofer LTZ CBS, and Fraunhofer IFF, holds a central role driving the strategic bioeconomy research. Universities such as the Research Centre for Bioeconomy (University Hohenheim) and the Chair for Production and Resource Economy (Technical University Munich) actively enrich the research landscape.

Belgium also makes significant contributions to bioeconomy research, with institutions including Instituut voor Biotechnologie) actively engaged in this dynamic field. Leading universities such as Ghent University, KU Leuven, University of Antwerp, Vrije Universiteit Brussel, and Hasselt University further enhance the nation's bioeconomy endeavours.

Austria's bioeconomy research landscape is characterized by non-university research institutions, including Österreichische Forschungsförderungsgesellschaft (FFG), Institut für Industrielle Ökologie, and Österreichische Akademie der Wissenschaften (ÖAW). Initiatives like BIOS Science Austria and Christian-

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Doppler-Labore are fully dedicated to bioeconomy research, while the Bundesforschungszentrum für Wald plays a pivotal role in advancing knowledge relevant to the bioeconomy.
France boasts a diverse array of institutions with a strong focus on the bioeconomy, including INRAe (National Institute for Agricultural Research), CNRS (National Centre for Scientific Research), and CEA (Alternative Energies and Atomic Energy Commission) that diligently foster research and innovation within the bioeconomy sector.
In the Netherlands Key academic institutions like Wageningen University & Research, TU Delft, and the Energy Research Centre of the Netherlands (ECN-TNO) play pivotal roles in advancing bioeconomy research.
Luxembourg's bioeconomy research efforts are primarily led by institutions such as the Luxembourg Institute of Science and Technology (LIST) and Environmental Research and Innovation (ERIN). The University of Luxembourg also actively contributes to studies related to the bioeconomy.
Ireland's bioeconomy research is spearheaded by applied science organizations such as BIOrbic which is the national bioeconomy research centre, Teagasc (Agriculture and Food Development Authority), and the Marine Institute. Universities like UCD and Munster Technological University are integral players in this endeavour. Additionally, various technological platforms, including the Dairy Processing Technology Centre (DPTC), Irish Manufacturing Research (IMR), Food for Health Ireland (FHI), Meat Technology Ireland (MTI), and VistaMilk, substantially enhance bioeconomy research and innovation in the country.
Collectively, these institutions, despite their varying structures and areas of focus, drive bioeconomy-related R&D in the Western macro-region, making significant contributions to the advancement of sustainable and innovative solutions within this crucial field. In the Western macro-region, the bioeconomy-relevant R&D landscape encompasses a diverse array of institutions in terms of number, types, and sizes.
Showcase: France can be mentioned as a particular showcase featuring a substantial presence of R&D institutions specializing in bioeconomy-related research. While specific quantitative data regarding the precise number and dimensions of these institutions is not available, the qualitative context underscores the vibrancy of bioeconomy research within France. Furthermore, in a comparative analysis with R&D institutions across the entire European Union (EU), France's contributions to bioeconomy research emerge as highly significant. Notably, in 2018, French publications accounted for 2.8% of the global bioeconomy research output. This figure, although showing a gradual decline since 2005, underscores France's active participation in the bioeconomy research sphere. When contextualized within the broader EU framework, France's position in bioeconomy research remains noteworthy. Its 2.8% share of global publications demonstrates its competitiveness and substantive involvement in the EU's bioeconomy research landscape. Furthermore, France's commitment to international collaboration is evident, with approximately 55% of its bioeconomy research publications co-authored with researchers from other nations. This international engagement serves to amplify France's standing and influence within the global bioeconomy research community, emphasizing its dedication to advancing this pivotal field on a broader, international scale.
Within the Western macro-region, research and development initiatives in the bioeconomy domain manifest sector-specific characteristics and emphases, corroborating the observations delineated in the state of play and industry chapters. This regional scrutiny underscores how diverse countries in the Western macro-region underscore distinctive sectors and facets within the broader ambit of the bioeconomy domain.
For instance, Austria places substantial emphasis on its wood industry, with noteworthy initiatives like the Austrian Wood Initiative assuming a pivotal role in addressing climate protection and decarbonisation. Simultaneously, agriculture and forestry constitute integral constituents of Austria's bioeconomy landscape. R&D entities, including Joanneum Research Forschungsgesellschaft and the Austrian Institute of Technology, ardently engage in bioeconomy-focused research pertaining to these specific sectors. Furthermore, the Forum Holzbau convenes international wood bioeconomy forums, spotlighting themes like individual layer fabrication, sustainable packaging, and biochemicals. These sector-specific foci align

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with Austria's dedicated endeavours to advance bioeconomy endeavours, notably in the context of its well-established wood and forestry sectors.
In Belgium, the panorama of bioeconomy R&D activities mirrors precise emphases within various sectors, encompassing sustainable agriculture, bio-based materials, circular economy, renewable energy, plant biotechnology, microbial biotechnology, marine resources, forestry, and food. Distinct research institutions in Belgium specialize in these sectors, collectively enriching the comprehensive tapestry of bioeconomy research. These sector-specific priorities underscore Belgium's holistic approach to addressing multifarious facets within the bioeconomy spectrum. Contrarily, Germany channels its focus toward applied research within the bioeconomy, emblematic of a pragmatic, industry-oriented approach. This orientation is congruent with Germany's reputation for its robust commitment to innovation and technological advancement. Similarly, in Ireland, the emphasis is on applied research with an emphasis on agriculture and food production, chemicals and biotechnologies as well as bio-based materials.
France, conversely, delineates sector-specific characteristics within its bioeconomy R&D landscape. This is notably discernible in its emphasis on agriculture and food production, wherein agriculture serves as a prominent wellspring of biomass. Furthermore, research activities are prominently centred around biochemistry and industrial biotechnologies, spanning domains such as green chemistry and pharmacology. The accentuation on bio-based materials and extraction reaffirms France's sector-specific proclivities. France's strategic alliances between research stakeholders and industry counterparts encompass both fundamental and applied research, underscored by its steadfast commitment to advancing bioeconomy pursuits within these specified sectors. In the Netherlands, the research landscape is primarily focused on biomass valorisation, energy and waste reduction reflecting the country's policy priorities.
Lastly, Ireland's bioeconomy R&D efforts encompass a heterogeneous array of sectors, encompassing agriculture and food production, chemicals, biotechnologies, and bio-based materials. This multifaceted approach aligns with Ireland's comprehensive strategy for bioeconomy development, addressing diverse sectors to foster sustainability and innovation.
In summation, the bioeconomy R&D landscape in the Western macro-region delineates sector-specific attributes and focal points that resonate with the meticulous findings articulated in the state of play and industry chapters. Each constituent country within the region adapts its bioeconomy initiatives to align with its distinctive strengths and priorities, collectively contributing to the broader progression of bioeconomy endeavours.
Collectively, the Western macro-region demonstrates a rich tapestry of bioeconomy knowledge centres, research competencies, and specialized academic programmes, each contributing to the advancement and promotion of bioeconomy-related endeavours while aligning with their unique strengths and priorities. As a matter of fact, bioeconomy is a broad topic involving broad cross-specialities and creating a full encompassing bioeconomy degree would be unrealistic to have value for all applied fields. Specialization in their own country strength is then prioritized, bioeconomy is on top of each sector branch (agronomy, energy, industry, marine etc.).
Take for example Austria. Austria has taken proactive steps with the establishment of the "Initiative Bioeconomy Austria", which actively nurtures and advances bioeconomy-related initiatives. Moreover, Austria's FH Campus Vienna offers specialized academic programmes. Notable among them are "Verpackungstechnologie" (Packaging Technology) at the undergraduate level and "Packaging Technology and Sustainability" at the graduate level.
Across the border in Belgium, "Bio.be" serves as a prominent bioeconomy knowledge hub, facilitating collaboration among companies, research institutions, and stakeholders within the life sciences and biotechnology sectors. However, Belgium does not focus on one speciality and provides masters' degrees in bioengineering, with specializations available in Molecular Biotechnology, Environmental Technology, and Food Technology.

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Germany, another regional player, distinguishes itself with several universities offering specialized degree programmes in bioeconomy. Noteworthy institutions include the University of Hohenheim, Technical University Munich, University Greifswald, and University Göttingen. These institutions provide comprehensive bachelor's and master's programmes covering Bioeconomy, Forest System Management, and Forestry Bioeconomy.
Turning our attention to France, the nation promotes bioeconomy development by encouraging research institutions like INRAE to focus on this field. INRAE, for instance, has established a thematic research area dedicated to the bioeconomy, conducting interdisciplinary research endeavours and identifying eleven key challenges. Link to these segmentations, specific bioeconomy-focused degree programmes exist in different ways, combining dedicated & specialized school in bioengineering across the country and universities with regional specialities link to near-available biomass and their own research activities.
Netherlands, multiple universities and research institutions such as TU Delft and Wageningen University have dedicated centres that foster investments in the bioeconomy. Moreover, Wageningen University is planning to initiate a new MSc programme on circular bioeconomy.
Ireland, within the region, stands out for its substantial strides in bioeconomy education and research. Initiatives like BioBEC Bio-based Industries, and BiOrbic, Ireland's national bioeconomy research centre, play pivotal roles in education and the sustainable development of a circular bioeconomy. Notably, Ireland offers a Master of Science programme in Circular Bioeconomy with Bio-based Business, a collaborative effort involving institutions such as IT Tralee, UCD, and Teagasc.
The Western macro-region exhibits a degree of homogeneity in its collective commitment to research and development within the bioeconomy domain. Common characteristics shared across the region include a shared emphasis on advancing bioeconomy-related R&D, promoting interdisciplinary research approaches, and fostering international collaboration. These shared traits underscore the region's dedication to harnessing biological resources and sustainable practices for economic and environmental gain.
However, there are notable differences among countries within the Western macro-region in the context of bioeconomy R&D. These distinctions primarily revolve around sectoral priorities, degree of specialization, research funding, policy frameworks, and international partnerships.
Firstly, countries within the region exhibit varying sectoral priorities within the bioeconomy. For instance, Austria places significant emphasis on its wood industry, while Belgium focuses on sustainable agriculture and biotechnology. These sectoral disparities align with each country's unique economic structures and strengths. Secondly, research funding levels and sources differ significantly between countries. While some nations may allocate substantial public and private funding to support bioeconomy research, others may have more limited resources available for such endeavours.
Furthermore, the regulatory and policy frameworks related to the bioeconomy can vary widely between countries, influencing the direction and pace of bioeconomy R&D and implementation.
Lastly, while international collaboration is a shared characteristic across the Western macro-region, the extent and nature of these partnerships can differ. Some countries may have more extensive global collaborations, while others may primarily engage with neighbouring nations.
In conclusion, the Western macro-region demonstrates a certain level of homogeneity in its overarching commitment to bioeconomy R&D, interdisciplinary research approaches, and international collaboration. Nevertheless, significant differences exist among countries regarding sectoral priorities, specialization levels, research funding, policy frameworks, and international partnerships. These distinctions arise from each nation's distinct economic, environmental, and research landscape, highlighting the region's diversity in bioeconomy R&D pursuits.

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6.1.3.2 Industry

Across the Western macro-region, a dynamic and diverse bioeconomy landscape thrives, characterized by a multitude of companies actively participating in bioeconomy-related activities. These companies encompass a wide range of types, sizes, and sectors, collectively illustrating the region's comprehensive engagement in the bioeconomic domain.

It is notable, that the large companies taking part in the bioeconomy are non-dedicated, the majority do keep their conventional business line and are either transitioning or building a side department to enter the bioeconomy area. At the opposite, SME and start-ups are mainly dedicated to bioeconomy.

Austria, for instance, features a mix of both dedicated bioeconomy companies and non-dedicated entities. Notable participants such as "Sappi Papier Holding GmbH" and "Bioraffinerie in Utzenaich" are deeply involved in bioeconomy-related endeavours. Additionally, organizations like "Wirtschaftskammer Österreich" and "Cleantech Cluster Umwelttechnik und Energietechnologie" make meaningful contributions to the bioeconomy despite their broader interests. These companies vary in size, with small and medium-sized enterprises (SMEs) like "Ecover" coexisting alongside larger entities like the "Lenzing Group". Austria's bioeconomy sectors span recycling, plastics, wood, and biotechnology, with a notable presence in the biotech and pharmaceutical sector.

Similarly, Belgium hosts a diverse range of bioeconomy companies, including SMEs like "Ecover", "B4Plastic", and "EcoSynth", specializing in eco-friendly products and chemicals. Larger corporations such as "Solvay" and "Galactic" play pivotal roles, particularly within the chemical sector. These companies operate across various sectors, encompassing bio-based cleaning products, chemicals, energy, and eco-plastic products.

Germany's bioeconomy landscape is characterized by a multitude of dedicated biotech companies and multinational corporations actively engaged in bioeconomy-related activities. Notably, French multinationals also contribute significantly to Germany's bioeconomy ecosystem. Irish companies of varying sizes, including both major industrial players and SMEs, collectively drive the country's bioeconomic endeavours. Key industry leaders such as "Glanbia", "Nuritas" and "BioMarine Ingredients" are prominent within this sector. Luxembourg's bioeconomy efforts include companies specializing in biomass combustion, gasification, waste management, digestible processing, and the production of natural construction materials. These companies, which differ in size, demonstrate a collaborative coexistence, with smaller entities like "Sosil Concept" complementing larger counterparts with broader market reach. The Netherlands, on the other hand, hosts a diverse array of bioeconomy companies involved in sectors such as chemicals, coatings, lactic acid production, biofuels, and bio-based products. Companies of varying sizes, including major corporations like "DSM" and "AkzoNobel", as well as innovative players like "Avantium", actively contribute to the country's bioeconomic activities.

In the bioeconomy landscape of the Western macro-region, specialization within specific sectors is apparent, and the coverage of various stages of the bioeconomic value chain varies across countries.

Austria stands out for its specialization in the wood sector, with initiatives like the "Austrian Wood Initiative" and the presence of the "Bioraffinerie in Utzenaich" underscoring its strengths in this domain. Simultaneously, Austria maintains a comprehensive approach to the bioeconomy by actively engaging in primary production activities, including agriculture, forestry, and water management. In contrast, Belgium presents a well-rounded bioeconomy landscape, showcasing strengths across multiple sectors. These encompass biotechnology, biopharmaceuticals, agri-food, agriculture, renewable energy, bioenergy, chemicals, bio-based materials, and agricultural biotechnology. Belgium's diverse bioeconomic portfolio implies a broad coverage of various sectors within the bioeconomy, extending across various stages of the bioeconomic value chain.

France has cultivated significant expertise in key fields of the bioeconomy, showcasing specialization in areas such as alternative proteins, biochemistry, industrial biotechnologies (green chemistry),

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pharmacology, bio-carburants, bio-energies, and bio-sourced molecules and materials. This specialization underscores France's proficiency in specific segments of the bioeconomy value chain, spanning from research and development to production and application.
Luxembourg places strategic emphasis on certain industry sectors within its bioeconomy landscape, with a particular focus on energy, waste management, bio-based construction materials, and polymers. This strategic emphasis reflects Luxembourg's commitment to addressing specific segments of the bioeconomic value chain, with a strong emphasis on sustainability and resource management.
With expertise in agri-food, forestry, chemicals and bio-based materials segments of bioeconomy, collaborations between research institutes and industry In Ireland are in line with the country's strategic focus. In Netherlands, there is more emphasis on biomass valorisation, reducing waste and energy.
In the Western macro-region certainly there exist prominent and dedicated industry and business associations, along with influential clusters, that are deeply committed to advancing the bioeconomy. These organizations play pivotal roles in shaping the bioeconomic landscape and fostering its growth and development. There is a certain homogeneity of the cluster approach and good practices in the western region, where the support is mainly sectoral and speciality based and tend to be more regional than country wide. Nonetheless, some initiatives from clusters are set in place to gain a broader scope and wider geographical impact.
Austria, for instance, features noteworthy associations, including the "Association of the Austrian Wood Industry" and the "Association of Austrian Paper Industry", both specializing in the wood and paper sectors, respectively. Moreover, the "Österreichische Industriellenvereinigung" and the "Fachverband der Chemischen Industrie (FCIO)" are instrumental in championing the bioeconomic agenda. Austria also hosts vital organizations like the "Österreichischer Biomasse-Verband" and the "Kompost- und Biogasverband" with dedicated focus on biomass and biogas initiatives.
Belgium showcases a comprehensive array of influential bioeconomy associations and clusters, including "CATALISTI", "Flanders' Food", "The Blue Cluster", "TWEED Cluster" among others. These entities span a diverse range of sectors within the bioeconomy, facilitating collaborative efforts and driving innovation. Additionally, "ValBiom" and "GreenWin" significantly contribute to Belgium's bioeconomic landscape.
France stands out with its "Bioeconomy4Change (B4C / ex-IAR)" cluster, which is the sole competitiveness cluster entirely dedicated to the bioeconomy. This cluster assumes a central role in shaping the bioeconomic landscape in France, specializing in key segments of the sector, from research and development to production and application.
In Ireland, a number of clusters exist such as Irish Bioeconomy Foundation, which works on fostering the transformation of natural resources to competitive, high-value products and Circular BioEconomy Cluster, which promote, that is composed of diverse stakeholders working on fostering bio-based value chains and unlocking business opportunities.
In the Netherlands, clusters such as Biotech Campus and The Centre of Expertise Bio-based Economy are active within bioeconomy applied research.
Germany hosts associations such as "BIO Germany", "OVID Association", "Association of Chemical Industry (VCI)", and the "German Industry Association Biotechnology (DIB)" all actively engaged in bioeconomy-related endeavours. These associations foster innovation, collaboration, and knowledge exchange within the bioeconomic domain.
Luxembourg underscores its commitment to the bioeconomy through innovation clusters managed by Luxinnovation, including the "Luxembourg EcoInnovation Cluster", "Luxembourg Wood Cluster", and "Luxembourg Materials & Manufacturing Cluster". These clusters, alongside associations like the "Biogasvereenegung a.s.b.l." and "Neobuild", contribute significantly to Luxembourg's bioeconomic landscape, emphasizing sustainability and resource management.

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These influential industry and business associations, together with dedicated clusters, collectively serve as catalysts for innovation, research, and collaboration, thereby advancing the bioeconomy throughout the Western macro-region.
In the Western macro-region, there is a collective commitment to diversify bioeconomy sectors, including biotechnology, renewable energy, sustainable agriculture, and bio-based materials. This reflects a mutual understanding of the bioeconomy's potential to address both environmental, economic and societal challenges. Collaboration in bioeconomy research and development is widespread, with universities, research institutions, and businesses frequently partnering to advance bioeconomic innovations. This collaborative ethos is a pervasive trait within the Western macro-region. Many countries in the region receive government support and funding for bioeconomy-related initiatives. Governments acknowledge the pivotal role of the bioeconomy in driving economic growth, fostering sustainability, and generating employment opportunities. Consequently, there is a degree of alignment in policy frameworks aimed at promoting bioeconomic activities. Nevertheless, noticeable distinctions also emerge. Each country tends to exhibit specialization in specific facets of the bioeconomy. For example, Austria specializes in the wood and paper sectors, while Belgium excels in multiple sectors, including biotechnology, renewable energy, and chemicals. France, conversely, boasts notable expertise in areas such as chemicals and industrial biotechnologies.
Variations exist in the scale and scope of bioeconomy endeavours. Germany, as the largest economy in the region, boasts a more extensive and diversified bioeconomy sector compared to smaller nations like Luxembourg. The presence and influence of bioeconomy industry associations and clusters vary among countries. While some nations host dedicated and influential clusters like France's B4C cluster, others may have fewer organizations.
The bioeconomy industry landscape in the Western macro-region is well-developed and robust, reflecting significant progress in advancing bioeconomic activities. This region encompasses a diverse array of sectors actively engaged in the bioeconomy, including biotechnology, renewable energy, sustainable agriculture, and bio-based materials, among others. Collaboration in bioeconomy research and development is a common practice, fostering knowledge exchange and advancement. Many countries in the region receive substantial government support and funding for bioeconomy-related initiatives, aligning policy frameworks with economic growth, sustainability goals, and job creation.
Each country tends to specialize in specific aspects of the bioeconomy, contributing to a diverse regional landscape. For example, Austria specializes in the wood and paper sectors, while Belgium excels in multiple areas like biotechnology, renewable energy, and chemicals. The presence and influence of bioeconomy industry associations and clusters vary among countries, with some hosting dedicated and influential clusters, such as France's B4C cluster.
Germany, as the largest economy in the region, boasts a substantial and diversified bioeconomy sector, highlighting the region's capacity to drive bioeconomic activities across various domains. In summary, the Western macro-region's bioeconomy industry landscape is characterized by diversity, collaboration, government support, specialization, and the presence of industry clusters and associations. This collective commitment significantly contributes to regional economic growth, sustainability, and innovation.

6.1.3.3 Civil Society

Within the context of the bioeconomy and its policy discourse across Austria, Belgium, France, Germany, and Ireland, numerous non-governmental organizations (NGOs) are actively involved across different tiers, including the European Union (EU), macro-regional, and national dimensions. Many of the NGOs that do engage on the bioeconomy topic, are the ones active on the climate change and sustainability questions and are country focus.

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In Austria, the Forschungsinstitut für biologischen Landbau Österreich (Fibl) plays a substantial role in shaping public discourse concerning the bioeconomy, with a particular emphasis on organic farming and sustainable agriculture. Meanwhile, the Institut für Umwelt – Friede – Entwicklung Wien (IUFE) contributes to discussions encompassing environmental, peace, and developmental matters, potentially addressing bioeconomy-related subjects. Additionally, the Ökosoziales Forum likely focuses on addressing the social and environmental facets of the bioeconomy, advocating for sustainability and social responsibility. The renowned WWF Österreich is likely engaged in advocating for sustainable bioeconomy policies within Austria, given its global conservation efforts. Furthermore, the Österreichische Gesellschaft für Umwelt und Technik (ÖGUT) is likely engaged in promoting environmentally friendly technologies and may participate in discussions related to the bioeconomy.
In Belgium, Bond Beter Leefmilieu (BBL) stands as a prominent environmental NGO, actively engaging in discussions on the bioeconomy with a notable emphasis on environmental sustainability.
In France, the Association Française des Biotechnologies Végétales (AFBV), operating as an independent NGO, advocates for plant biotechnologies, which may intersect with discussions on the bioeconomy and sustainable agriculture. Additionally, B4C, as a dedicated bioeconomy cluster in France, is likely to play a substantial role in shaping bioeconomy policy and development within the country.
In Germany, a multitude of NGOs and networks actively participate in bioeconomy discussions. NABU, a German nature conservation organization, is likely to advocate for sustainable and ecologically responsible approaches to the bioeconomy. The Civil Society Platform Research Change, composed of diverse civil society and environmental organizations, research entities, and associations, strives to influence research and innovation policies in favour of a novel systemic approach, likely emphasizing sustainability in the bioeconomy. The collaboration of Denkhaus Bremen (Aktionsforum Bioökonomie) with BUND and ‘Forum Umwelt und Entwicklung’ forms part of a network concentrating on critical aspects of the bioeconomy, advocating for sustainability and inclusivity. Furthermore, various concerns raised in Germany, encapsulated in the General Bioeconomy Strategy. Concerns, such as the imperative to reevaluate the economic system, incorporate agro-ecology, and address import issues from developing countries, are likely advanced by multiple NGOs and civil society organizations.
In Ireland, several bioeconomy clusters and foundations actively promote innovation and development within the bioeconomy sector.
The main questions that are rising from the promotion of the bioeconomy are linked to the sustainability aspect and the inclusivity of all players along the value chain. Different means are employed to discuss this bioeconomic transformation within the western region. In the following the two countries Austria and German were contrasted to each other representing different ends of the spectrum.
Austria prioritizes forest restoration over wood removal, offering an environmentally-conscious alternative to traditional practices. They advocate for the concept of agri-ecology, promoting sustainability in agriculture. Additionally, Austria calls for adjustments to the Common Agricultural Policy (CAP), indicating a critical stance on existing policies. Furthermore, they underscore the importance of social-science oriented research to understand the societal consequences of bioeconomic transformation, broadening the conversation beyond economic and ecological aspects.
In contrast, Germany’s approach involves the regular publication of position papers and active participation in bioeconomy events and workshops. This commitment to sharing alternative viewpoints is evident. However, it is worth noting that Germany is described as “less integrated in policy-making”, implying that while they contribute perspectives, their influence on shaping policies may be limited compared to Austria. In the light of the sustainability aspect, there is a certain resistance on some field of the bioeconomy like biomaterials or food alternatives.
In the context of France, there is evidence of resistance, a lack of acceptance, and criticism of certain aspects of bioeconomy. The analysis highlights ongoing debates about the meaning of bioeconomy and its associated policies. These debates indicate a lack of consensus and competing models within the

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bioeconomy discourse. Additionally, there is criticism of definitions that prioritize biotechnologies or biorefineries, as these definitions initially did not prioritize environmental and sustainable development concerns.

6.1.4 Bioeconomy Policies in the Western Macro-Region

From all four macro-regions, the Western Region is the most developed macro-region in Europe in terms of developing several bioeconomy strategies and action plans. However, the status regarding bioeconomy policies in the Western Macro-region is not homogenous. The smaller countries Luxembourg or Belgium lack national policy documents, which specifically outline bioeconomy development in their countries. However, Germany, Ireland, France and Austria have made significant progress with the publication of bioeconomy policy strategies or strategic documents in the last decade. In Germany, for instance, bioeconomy strategy development started in 2010, as the German government published its first strategy, the National Research Strategy[30] (Bundesministerium für Bildung und Forschung, 2010) and, in addition, a National Policy Strategy in 2013 (Bundesministerium für Bildung und Forschung (BMBF) and Bundesministerium für Ernährung und Landwirtschaft (BMEL, 2020) . Both strategies were merged together and revised in 2020 into a comprehensive national bioeconomy strategy. Responsible for the strategy are the Federal Ministry for Education and Research (BMBF) and the Federal Ministry for Food and Agriculture (BMEL). Also in France, a dedicated policy strategy was adopted in 2017 (Fund et al., 2018) and laid down foundations for long-term bioeconomy development. Additionally, the French government published a couple of bioeconomy-relevant strategies, such as the French Strategy on Biomass in 2012, the strategic agenda for Research, Transfer, and Innovation as well as the national research strategy that incorporates multiple sectors relevant for the bioeconomy in France. With the adoption of its climate and energy strategy #mission 2030, the Austrian government has also adopted a bioeconomy strategy in 2019 (Federal Ministry for Sustainability and Tourism et al., 2019) and a complementary action plan[31] for the implementation of strategic objectives. In the Netherlands, first formal steps towards bioeconomy development were taken by companies and the civil society organizations with the Manifest Bio-based Economy in 2011 (Bio Base NWE, 2015)**,** aimed at promoting the bioeconomy in its country. In 2012, the cabinet published the Green Growth strategy that has the bioeconomy as one of different focal points. Eventually, in 2018, also the Dutch government published “the position of the bioeconomy in the Netherlands”, a strategy that establishes frameworks for bioeconomy development in the Netherlands (Ministry of Economic Affairs and Climate Policy of the Netherlands, 2018).

Whereas Germany laid down a rather broad focus on its bioeconomy, targeting multiple sectors of the German economy, Austria mainly addresses the timber industry, with wood as the most important raw material. Both strategies, therefore, differ in its specific sectoral focus. For instance, Austria wants to position itself as a technology leader for products made from pulp, fibre, saw or wood. Germany’s ambitions goes even further, highlighting that it lays the foundation to become a bioeconomy leader and to create the technology and jobs for tomorrow[32]. In Ireland, the Irish government published a national bioeconomy policy statement in 2018. Key pillars of this document were a pronounced emphasize on policy co-ordination and stakeholder engagement, research, innovation and skills as well as development of markets and competitiveness (Government of Ireland, 2023a). Specific sectoral objectives and foci on the other hand do not exist, although the strategy aims to achieve bioeconomy development in a more horizontal perspective, strengthening overall sectoral coherence. According to the Bioeconomy Implementation Group Second Progress Report, the policy statement did not identify individual sectors or targets. The below Table

[30] https://biooekonomie.de/sites/default/files/files/2016-09/nfsb_2030.pdf
[31] https://www.bmk.gv.at/themen/klima_umwelt/klimaschutz/biooekonomie/aktionsplan.html
[32] https://www.bmel.de/DE/themen/landwirtschaft/bioeokonomie-nachwachsende-rohstoffe/nationale-biooekonomiestrategie.html

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35 displays key objectives of the national bioeconomy strategies that have been developed throughout the Western Macro-region. Main objectives show numerous similarities, such as an explicit emphasize on innovation and knowledge as well as many economic, ecologic and societal goals (Government of Ireland, 2018). The below Table 35 displays key objectives of the national bioeconomy strategies that have been developed throughout the Western Macro-region. Main objectives show numerous similarities, such as an explicit emphasize on innovation and knowledge as well as many economic, ecologic and societal goals.
The distribution of ministries that are in charge for the bioeconomy strategy development is also not homogenous among the countries of the region and include ministries from a diverse field of policy domains:

- Agriculture
- Environment, Climate, Sustainability, Nature
- Education, Research, Innovation
- Economic Affairs

Table 35 Objectives/Targets of Western Region Countries with dedicated bioeconomy strategies

Country	Objectives/targets of the strategies/action plans
Austria	(1) Achieve climate goals (2) Reduce dependence on non-renewable resources (3) Promote Innovation (4) Promote economic development (5) Secure and create jobs (6) Promote sustainable social transformation
France	(1) Guarantee food security and sustainable living standards for current and future generations by conserving natural resources and the ecosystemic functions of habitats (2) To be efficient, resilient, circular and productive over the long term (3) To focus on the general public and to be rooted in local regions, contributing to the development of economic value and jobs (4) To offer innovative solutions that are effective, affordable and capable of addressing the diversity of human needs
Germany	(1) Develop bioeconomy solutions for the 2030 Agenda for Sustainable Development (2) Recognize and harness the potential of the bioeconomy within ecological boundaries (3) Enhance and apply biological knowledge (4) Establish a sustainable raw material base for the industry (5) Promote Germany as the leading location for innovation in the bioeconomy (6) Involve society in the bioeconomy and strengthen national and international collaboration
Ireland	(1) Sustainable economy and society (2) Decarbonisation of the economy (3) Jobs and Competitiveness (4) Regional Prosperity

Source: Own table.

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However, many other ministries are increasingly involved in bioeconomy policy-making (as can be seen in Table 36 below). For instance, in Germany, not only the federal ministry for education and research (BMBF) has the main responsibility for the national bioeconomy strategy, but also the federal ministry for food and agriculture (BMEL). Whereas the former one has the main responsibility in strategy making, the later one is mainly in charge for the bioeconomy implementation in Germany. With the development of the National Biomass Strategy (Bundesministeriums für Wirtschaft und Klimaschutz et al., 2022) that is prospected to be published in the coming year, also the federal ministry for economic affairs and climate action (BMWK) and the federal ministry for the environment (BMUV) will play a leading role for the strategy. So far, only a key points for a national biomass strategy has been published. Also in the other countries, bioeconomy strategy development and implementation is shared between different ministries. In France, for example, bioeconomy policy is not only shaped by education and research and the food and agriculture policy domain, but also economy and finance, territorial cohesion and the ministry for ecological and inclusive transition share responsibilities in the bioeconomy development in France. The strategy of France[33] focusses mainly on the non-food part of the bioeconomy and does not cover circular economy, as food, nutrition and circularity is already subject of other related strategies. Similar responsibilities can be observed in other countries and indicates that an increasing need of horizontal policy coordination between the different ministries is required. In some countries, such as Ireland and Germany, (partly) coordination mechanisms have been already established. In Germany, the interministrial working group (IMAG) that was established in 2013, is responsible for the information exchange (including cross-cutting themes) and coordination of the members of the group (Deutscher Bundestag, 2019), facilitating horizontal coordination between the affected ministries. In the last decade, several ministries of the German government became members of the group, including the ministries for the Environment, for development policy or for economic affairs. In addition, the German Bioeconomy Advisory Council, which consist of different bioeconomy experts and representatives, has the role to advise the federal government for the development of the bioeconomy and give regular recommendations on the policy process[34]. In the last publication, the advisor council claimed, for example, that bioeconomy policy should be horizontally more aligned between the responsible ministries (German Bioeconomy Council, 2023a). Vertically, also working groups between the federal and its state governments exist, coordinating bioeconomy activities between both territorial levels.

An interesting case is Ireland, where, among the department of Agriculture, Food and Marine, and the department of Communication, Climate Action and Environment, even the Department of the Prime Minister is responsible for the bioeconomy policy in Ireland. Similar to the German case, also a Bioeconomy Implementation Group (BIG) has been established, which is jointly chaired by the Departments of the Environment Climate and Communications (DECC) and Agriculture, Food and Marine (DAFM) (Government of Ireland, 2023a). The implementation group has the task to give recommendations for the development of the bioeconomy in Ireland and to improve coherence among all relevant sectors as it has defined by the national policy statement. In Austria on the other hand, no specific advisory council or interministrial group exist. Although also the Netherlands has not any interministrial working group that is coordinating the activities of the responsible ministries, in 2009 the interdepartmental programme Bio-based Economy (IPBBE) was launched, which aims to promote cooperation between civil society parties and actors from businesses, research and technology[35] Responsible for bioeconomy activities in the Netherlands is mainly the ministry for economic affairs that has the supervision of regulations in the area of feeds and seeds and is in charge for the guidelines for industrial research and development as well as innovation. Other ministries which have competences and jurisdictions are the ministry for the environment, the

[33] https://agriculture.gouv.fr/la-bioeconomie-nouvelle-vision-du-vivant
[34] https://www.biooekonomierat.de/biooekonomierat/auftrag-und-ziele.php
[35] https://www.nsob.nl/denktank/overzicht-van-publicaties/multi-level-strategy-key-succes).

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ministry for education, culture and science and the health ministry that is coordination decision-making in areas, such as Agro- and medical biotechnology.[36]

Table 36 Strategies and Action Plans of the Western Macro-region

Country	Bioeconomy Strategy/ Action Plan	Responsible Ministries
Austria	National Bioeconomy Strategy/ Action Plan	- Ministry for Education, Science, and Research (BMBWF) - Ministry for Sustainability and Tourism (BMNT) - Ministry for Transport, Innovation, and Technology (BMVIT)
Belgium	Only regional strategy (Flemish Bioeconomy Strategy)	Departments of ministry for R&I, Agriculture, Energy
France	National Bioeconomy Strategy Action Plan	- Ministry of Economy and Finance - Ministry of Higher Education, Scientific Research and Innovation - Ministry of Territorial Cohesion - Ministry for Ecological and Inclusive Transition
Germany	National Bioeconomy Strategy	- Federal Ministry for Education and Research (BMBF) - Federal Ministry for Food and Agriculture (BMEL)
Ireland	National Bioeconomy Policy Statement Action plan (published October 2023)	- Department of the Taoiseach (Prime Minister) - Department of Agriculture, Food & Marine - Department of Communications, Climate Action &Environment
Luxembourg	No national bioeconomy strategy No existing bioeconomy action plan	
Netherlands	The Position of the Bioeconomy in the Netherlands	- Ministry for Economic Affairs and Climate Policy

Source: Own compilation.

[36] https://biooekonomie.de/themen/laenderdossiers-weltweit/niederlande

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All policy strategies in the Western Macro-Region share the objectives of decarbonizing the economy, creating competitiveness or promoting a sustainable societal transformation and are in line with the defined objectives of the European Bioeconomy Strategy that has been published in 2018. Considering the coverage of the four topics that will be analysed (policy & governance, applied R&D and Technology Transfer, Cross-sectoral Collaboration, Financing) it is important to note, that these four topics differ in their extent that they are targeted in the different strategies. In Ireland for example, reinforced policy co-ordination and stakeholder engagement or sectoral coherence are especially mentioned as key pillar of the policy statement. Similar, in Germany policy alignment is addressed in the context of policy coherence, as the strategy claims for closer integration of policies and strategies. Contrarily, in Austria policy alignment is less communicated throughout the strategy. Only little references to the European Bioeconomy Strategy and Agenda 2030 are made. In almost every country several references to applied R&D and Technology Transfer are made in that sense that all countries promote research and innovation through increased funding in the public and the private sector or aim to further promote the cooperation of applied research organizations with companies. France can be seen as a case in point as the PIA funding programme is focusing on promoting cutting-edge technology with a total budget of EUR 52 billion.

In the remaining countries of the macro-region, the bioeconomy is rather less developed as in the aforementioned cases. In the smaller countries Belgium or Luxembourg, a strategy has not yet developed. For instance, Belgium consists of three independent regions, Flanders, Wallonia and Brussels. From these regions, only Flanders has presented a bioeconomy strategy, the so-called“Bioeconomy in Flanders” so far (The Interdepartmental Working Group for the Bioeconomy, 2013). Key objectives of the strategy are the development of solutions for major societal challenges, such as climate change, the development of a sustainable economy or required structural changes in order to achieve a transition towards a post-fossil economic system (Department of Economy, 2020). In addition, the regional government of Flanders has also implemented other measures, such as the New Industry Policy in 2011, or the Flemish Materials Program in 2012, which partly addresses bioeconomy relevant initiatives. Key focal points of the Flemish strategy are its contribution to green growth, job creation or the development of the circular economy. As defined as a long-term goal, Flanders wants to become the most competitive bioeconomy region in Europe by 2030 (Department of Economy, 2020). On the other side, the two other regions have not developed specific strategic documents on bioeconomy development. Similar to Belgium, also Luxembourg has not yet developed a national bioeconomy strategy, although some actions plans of Luxembourg relate to the bioeconomy. In 2010, for example, the government published its National Action Plan on Renewable Energy, a sectoral document that is referring to biomass as one of the top performers for electricity in the future. Also the smart specialization strategy from 2017 or the strategy on the national wood cluster mentioned bioeconomy as important (Haarich et al., 2022).

Regarding existing gaps it is important to highlight that only Austria, France and Ireland developed a bioeconomy action plan from the countries who has published already dedicated bioeconomy strategies. Whereas in Germany, no bioeconomy action plan exists, Austria already developed one and Ireland has been published its action plan during the Irish Bioeconomy Weeks[37]. Ireland’s action plan highlights the ambition to become a global leader for the bioeconomy, harnessing its natural resources and competitive advantage. The action plan is grounded on seven key pillars, addressing not only different sectors, such as agriculture, food, forestry or marine, but also circular economic deployment, research & development or claims to further improve policy integration (Bioeconomy Action Plan Consultation and Discussion Document, 2022). Additionally, the action plan highlights the ambition to increase coherent communication and outreach of the Irish bioeconomy and aims to develop a national bioeconomy strategy in the future

[37] https://www.gov.ie/en/press-release/595e3-ministers-mcconalogue-and-ryan-publish-first-national-bioeconomy-action-plan/

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(Government of Ireland Department of Environment, 2022). In addition, in its first report to the Bioeconomy Implementation Group, the Bioeconomy Forum stated that the regulatory system needs to be better understood and regulatory approaches to be better streamlined and harmonized[38]. Similarly, also Germany currently elaborates an action plan, submitting concrete measures for translating the objectives of the German bioeconomy strategy. The German Bioeconomy advisory council that has been assigned for supporting the process stated in its latest recommendations for actions (German Bioeconomy Council, 2023) that still Germany would lack overarching coherent bioeconomy policy at national level. The action plan of Austria aims to translate the objectives of the Austrian National Bioeconomy Strategy in concrete measures. Core of the action plan are, hence, 11 thematic areas, which are further subdivided into diverse field of actions: The thematic areas comprises topics, such as Science and Research, sustainable consumption, agriculture or forestry. For instance, the action plan aims to support sustainable and continuing timber provision through methods of forestry area planning. For each of these different measures of the thematic areas, different ministries are in the lead or are contributors. With its action plan, Austria covers multiple sectors of the bioeconomy and is broadening the application of the bioeconomy. The Action plan of France is slightly different to Austria's as its scope is limited to the development of non-food outlets for biomass. Bio-waste has been excluded since other sectoral policies are already dedicated to waste streams.

Regional Strategies

In addition to national bioeconomy strategies which have been adopted, several countries of the Western macro-region have published regional strategies. The Table 37 below shows the number of regional bioeconomy strategies in the Western-Macro-region with respect to the extent these strategies focus on the bioeconomy. Belgium and Germany are representative cases as they have the highest share of fully dedicated regional bioeconomy strategies (Haarich et al., 2022). In countries like Austria, Ireland and the Netherlands fully dedicated regional strategies do not exist, although strategies with minimum bioeconomy relations have been adopted. Regional strategies in Germany have been developed in six federal states have adopted bioeconomy strategies in their territorial jurisdiction with partly different objectives and focal points. In France, likewise, three main regional strategies exist (1) Grand Est (2) Hauts de France (3) Ile-de France. All of the three strategies share objectives, such as to develop efficient and sustainable production of regional resources or to intensify innovation and market access. In order to coordinating the different regional activities better, all three regions signed in 2018 a "biopact", establishing more cooperation by experimenting with new public policies, encouraging innovation and strengthening interregional collaboration. Although all three strategies share common objectives, action plans and adopted measures are adapted to each of the specific characteristics of the region. Ireland, on the hand, has not yet developed any regional strategies due to the relatively centralized government administration, although it seems likely that a strategy in the southern region of Ireland might be developed in the future (Haarich et al. 2022). Regional strategies in Germany have been developed in six federal states have adopted bioeconomy strategies in their territorial jurisdiction with partly different objectives and focal points. In France, likewise, three main regional strategies exist (1) Grand Est (2) Hauts de France (3) Ile-de France. All of the three strategies share objectives, such as to develop efficient and sustainable production of regional resources or to intensify innovation and market access. In order to coordinating the different regional activities better, all three regions signed in 2018 a "biopact", establishing more cooperation by experimenting with new public policies, encouraging innovation and strengthening interregional collaboration. Although all three strategies share common objectives, action plans and adopted measures are adapted to each of the specific characteristics of the region. Ireland, on the hand, has not yet developed any regional strategies due to the relatively centralized government administration, although it seems likely that a strategy in the southern region of Ireland might be developed in the future.

[38] https://www.gov.ie/en/publication/046ce-stakeholder-coordination-consultative-groups

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Table 37 Number of regional bioeconomy strategies in the Western Macro Region

Country	Fully dedicated	Strong focus	Minimum Content	Total number
Austria	0	1	7	8
Belgium (Flanders)	1	1	1	3
Germany	7	2	4	13
Ireland	0	0	7	7
Netherlands	1	1	4	6
France	3	13	2	13
Luxenbourg	0	0	0	0

Source: Own table based on Haarich et al. (2022).

In addition to the regional strategies that have been described, there are also aspirations to establish joint cross-border bioeconomy strategies. One example is the Trilateral strategy for the chemical industry between Netherlands, Flanders and North Rhine-Westphalia. In 2017, the ministry of economics, innovation, digitalization and Energy of NRW, the department of economy, science & innovation of the Flemish region and the Netherlands Ministry for Economic Affairs signed the strategy to become the world's engine for the transition towards a sustainable and competitive chemical industry cluster (Ministry of Economic Affairs, 2017). On a horizontal level, the strategy highlights the implementation of a trilateral High-Level Group (HLG) that is supported by an Inter-Ministrial Steering Group (IMSG) and thematic working groups for mobilizing the bioeconomy community in respect to the priority objectives (Ministry of Economic Affairs, 2017). For instance, the trilateral high-level group is designed to organize joint meetings of representatives from industry, science and governmental ministries. The IMSG, on the other side, consist of three involved ministries from the three regions and are coordinating strategy implementation and support the HLG. Another cross-border strategy that can be mentioned here, is the EU bioeconomy strategy for the Danube region, where some regions of Germany and Austria are involved. The macro-regional strategy was jointly developed by the European Commission and several countries (nine member states).

Policy Instruments

The Western Macro-region, incorporating Germany, Austria, Belgium, the Netherlands, Luxembourg and Ireland differ on the question, what the bioeconomy mean for them. Whereas some countries have a broad conception of the bioeconomy, others only are focused on specific sectors and still have not much developed their bioeconomies. As the bioeconomy is still a new paradigm in Europe, most of the policy instruments are located on supply-side measures and use national funding programmes to boost different sectors. In Germany, for instance, the federal ministry for education and research (BMBF) have established numerous finding programmes, which focus on different sectors or domains.

In the table below, national funding programmes are listed with their respective association to the responsible ministries. As the table indicates, most of the funding activities are associated to the federal ministry of education and research (BMBF) Among those funding programmes, which have a clear focus on technical innovation in the bioeconomy, the funding programme bioeconomy as social change is unique

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in the German research landscape as it funds socio-economic research in the bioeconomy with a focus on social science research. The ministry for economic affairs and climate protection has only a few funding programmes, from which Industrial Bioeconomy is the only dedicated instrument in the bioeconomy. Although the federal ministry for food and agriculture had the co-lead in the development of the national bioeconomy strategy, the ministry offers only one funding programme, which specializes in renewable raw materials and aims to develop the bioeconomy in Germany further. Important to highlight is also that Germany perceives the bioeconomy as a broad concept that incorporates all relevant sectors of the economy. That is the reason why only less funding activities are specialized on specific sectors, but have a broad scope on the innovations they are funding.

Table 38 National funding programmes in Germany

Funding Programme	**Ministry**	**Duration**
Bioeconomy as social change	BMBF	Permanent
Bioeconomy International	BMBF	
Model Region of bioeconomy for digitalization of plant-based value chains	BMBF	
New generation research for the bioeconomy	BMBF	
Strategy Process - Next generation of biotechnological production processes	BMBF	Permanent
Ideas Competition - new products for the bioeconomy	BMBF	Permanent
Future technologies for the industrial bioeconomy	BMBF	Planned
Innovation areas for the bioeconomy	BMBF	2016-2017
Industrial Bioeconomy	BMWK	Permanent
High-Tech Founder Fund IV	BMWK	
Central Innovation Programme middle class (ZIM)	BMWK	
EXIST Funding scholarship	BMWK	
Renewable Raw Materials	BMEL	Permanent

Source: Own compilation.

A different approach can be observed in Austria, where the bioeconomy is mainly focused on the food and timber sector. As highlighted in the Austrian bioeconomy strategy, Austria wants to position itself as technology leader for e.g. pulp and fibre products as well as saw and wood products. Austria has developed a national network programme, Bioeconomy Austria, which aims to develop a network of different actor groups and a unique bioeconomy cluster in Austria. Other related policy instrument that have been implemented in Austria, have their focal points on artificial technology (AI for Green) or

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Climate Change (Frontrunner, Öko-Scheck). Also in Austria, most of these policy instruments are rooted in supply-side policy tools, whereas demand-side policies seem to play no significant role in Austria.

Ireland provide policy instruments, which are located in the funding domain. National funding programmes, as the Bioeconomy demonstration fund, the Circular Venture Programme or the BioConnect Innovation Centre are at the heart of supporting innovative companies and entrepreneurs with a key focus in the bieoconomy including biotechnological innovations. France on the other side, has established different demand-side policy instruments. For instance, France signed several laws, which are not dedicated to the bioeconomy, but are related to bioeconomic development: Law n 2016-138 against Food Waste for example aims to prevent food waste. For instance, if a grocer possesses a sailing area, larger than 400 m2, he is obliged to donate his food waste. Another regulatory measure that has been implemented in France is the Energy Transition for Green Growth Act (LTCEV) from 2015, which establishes a comprehensive list of targets and measures for low-carbon economic development. Although not directly dedicated to the bioeconomy, it outlines also bioeconomic related measures. For instance, the act wants to establish renewable energy (e.g. biomass) in more homes and wants to recycle 60% of waste by 2025. Also in Belgium, demand-side policies exist. For instance, with the prohibition of the use of certain biomass feedstocks for bioenergy, the Belgium government aims to ensure that the use of energy is regulated throughout the hierarchy of biomass feedstocks.
In conclusion, it can be highlighted that in the Western Macro-Region dominate supply-side measures, such as grants for Industrial R&D and support for public research, whereas demand side polices only play a minor role in the region. The larger countries have specific bioeconomy policy instruments, while the others countries in this region cover bioeconomy in more cross-cutting measures. In general, the number of relevant policy instruments is in countries higher that have already developed national bioeconomy strategies or action plans. Furthermore, in France and Belgium also some demand-side policy instruments could be identified as described above. These policies are mainly laws and regulations of certain climate change policies, which are only related to the bioeconomy, but may play a role

6.2 Policy process and policy coordination in selected MR countries

The following subchapter deals with policy processes and types of policy coordination mechanism in selected MR countries: Germany, France, Ireland and Belgium. The question how political authorities coordinate their bioeconomy activities is highly relevant, as usually not only one ministry is in charge for bioeconomy policy, but several ministries of different domains share responsibility.

6.2.1 Characterization of horizontal coordination between different ministries/departments

As mentioned above, in almost every country of the Western macro-region, various ministries are active in the bioeconomy, such as those for Food and agriculture, Education and Research or for the Environment. Coordination mechanisms or instruments that facilitate the cooperation between these political actors have been increasingly considered as important by some countries. Germany is a case in point. As mentioned previously, the main responsibilities of the bioeconomy policy is shared between the federal ministry for education and research (BMBF) and the federal ministry for food and agriculture (BMEL). As the national bioeconomy strategy was developed, both ministries agreed, that the BMBF would lead the strategy process and that BMEL would have the lead in the implementation plan of the bioeconomy in Germany afterwards. The reason behind this division in responsibilities was the assumption that the BMBF mainly deals with researching the bioeconomy through different funding programmes, whereas the BMEL could contribute more for implementing and applying practices of the bioeconomy in different sectors (e.g. regulatory aspects). For the coordination between the involved ministries, an interministrial working group (IMAG)

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exists, that has the task to meet on a regular base and discuss specific issues of responsibility between the ministries. The national bioeconomy advisory council, which has the task in outlining specific recommendations for the government attends also the IMAG and reports recent activities inclusively open dialogue between the participants. The members of the BÖR are equally appointed by the leading ministries. Currently the Bioeconomy Advisory Council is assigned to accompany the development of a bioeconomy implementation plan in Germany and published recently a position paper with recommendations, such as promoting more dialogue and participation, stringer approaches for policy coherence and policy integration or diversified agriculture (German Bioeconomy Council, 2023b).
Among both mentioned ministries, also a number of other ministries (BMZ, AA, BMUV, BMWK) are members of the group, although their contribution remains limited and depends on issues that might be relevant for them. The question how well this interministerial working group is working remains vague, as this group is mainly acting as a platform for discussing certain aspects of the bioeconomy and not assigning other ministries with specific tasks or responsibilities. However, interviews that were conducted with different stakeholders indicated that the BMUV is increasingly committing to the group. An interesting case is the plan to develop a comprehensive Biomass Strategy (NABIS) in Germany with shared responsibilities by the federal ministries of environment (BMUV), of economic affairs (BMWK) and agriculture and food (BMEL) (BMWK, 2020). As the question how should be dealt with land use is highly controversial discussed at the political level, it is still unclear how the federal ministry for food and agriculture (BMEL) and the federal ministry for the environment (BMUV) can agree on a common approach, as genuinely the latter ministry wants to protect land from economic exploitation, whereas the former have an interest in increasing agricultural production on land. The same conflict arise with the question which areas biomass mining should be intensified for and which implications it would mean for nature protection. Another joint initiative that have been launched between the BMBF and the BMZ was “GlobE - Research for global nutrition security”, which aimed to support German-African Science-networks and facilitate new partnerships. Together both ministries invested around 45 million Euro into these collaborative project.[39]
Also in France instruments of policy coordination exist between the responsible political actors. In 2019, FranceAgriMer set up a cross-industry thematic commission (CTI) for regular meetings between the responsible government departments and further stakeholders, such as from research bodies, public operators or industry representatives. The CTI as working group is considered as an important instrument for facilitating the exchange and coordination of public policies initiatives and the wider bioeconomy development. Among its different objectives, the thematic commission is also monitoring the implementation of the national bioeconomy action plan. As part of its role, different working groups on specific themes have been established:

- Agricultural and agri-food methanization
- Biofuels
- Bio-sourced products
- Animal by-products

In order to provide sector professionals, a steering committee was also established in line with the initiation of the action plan (Barrett et al., 2021). Also in Flanders (Belgium), the key responsibilities between the ministries are clearly defined. Although every ministry has a separate agency that is implementing the respective policy, it is difficult to synchronize policies among those agencies to support a growing bioeconomy. This implies, that the development of the bioeconomy is not a problem of shared responsibilities, but the lack of a common understanding or a consensus how the bioeconomy should look

[39] https://www.bmbf.de/bmbf/de/forschung/energiewende-und-nachhaltiges-wirtschaften/biooekonomie/globe-forschung-fuer-die-globale-ernaehrungssicherung/globe-forschung-fuer-die-globale-ernaehrungssicherung_node.html

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like. As every ministry is considering the bioeconomy from its own domain, creating such a common consensus have been identified as a challenge by the interview partners. Although also Flanders has a formal coordination mechanisms (interdepartmental working group), this collaboration platform has proved to work inefficiently as it is just a forum for the policy advisers of the agencies and decisions of them are not binding. Examples for the involved agencies are the Flemish Institute for Technological Research (VITO) or the Public Waste Agency of Flanders (OVAM). Overall, in Belgium policy integration between the three different regions is very weak, as little cooperation platforms exist between them.

In Ireland, the implementation of the national policy statement is assigned to the High-Level Bioeconomy Implementation and Development Group (BIG), which is co-chaired by the Department of the Environment, Climate and Communications (DECC) and the Department of Agriculture, Food and the Marine (DAFM). It also includes associated public bodies across the primary sector (agriculture, forestry, marine). Another exemplary instrument is the National Bioeconomy Forum that has been launched in 2020 and was mandated through the national policy statement of Ireland with the task to provide expert opinion, advice or recommendations to the High-Level National Bioeconomy Implementation Group (BIG) and contribute to better alignment of bioeconomy implementation among diverse stakeholders at regional and national level.[40] The National Bioeconomy Forum consist of 33 members and is supported by the Expert advisory group who has 19 members, representing 9 Higher Education Institutes and Research Organizations in Ireland. In its first report to the Bioeconomy Implementation Group (BIG) the High-level forum claimed that the bioeconomy needs to apply to renewable energy and natural capital concepts in an integrated manner. In addition, the BIG came in its second progress report to the conclusion that more sectoral coherence needs to be achieved. The BIG also conducted an assessment of the current level of sectoral coherence in Ireland and recommended to develop a bioeconomy policy guidance document and an increased access to bioeconomy expertise across Departments and agencies for policy maker in order to encourage the embedding of bioeconomy in current and future policies (Government of Ireland, 2023b). The BIG also provided a coordination structure, bringing together related departments and agencies on a regular bases. The coordination structure aims to develop sectoral and policy coherence within relevant sectors. Although no formal coordination mechanism exist in Austria, the three involved ministries held regular inter-ministerial meetings to exchange potential needs of the Austrian bioeconomy strategy. Another coordination tool that has been established in Ireland is the North-South Ministerial Council and will consider North South Bioeconomy development under research in the agricultural area of cooperation. The North-South Ministerial Council (NSMC) was established under the Belfast/Good Friday Agreement from 1998 and makes decisions on common policies in areas, such as the Common Agricultural Policy or in research and rural development, among other fields.[41]

In conclusion it can be implied that although most of the countries located in the Western Macro-region have formal and informal coordination mechanisms established, policy coordination between different ministries remain a challenge, as they do not share a common understanding on what they want to achieve with the bioeconomy and on what vision they are agree on. As these ministries prioritize their own sectoral interests, it is challenging to find common solutions and consensus.

[40] https://www.gov.ie/en/press-release/6ed29-launch-of-the-national-bioeconomy-forum
[41] https://www.northsouthministerialcouncil.org/areas-of-co-operation/agriculture

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Table 39 Coordination instruments in the analysed countries

Country	Coordination Mechanism	Involved actors
Belgium (Flanders)	Interdepartmental Working Group for Bioeconomy	Various ministries and government agencies
France	Cross-industry thematic commission (CTI)	FranceAgriMer
Germany	Interministrial working group (IMAG), federation-state working group	BMBF, BMEL, BMUV, BMWK, BMZ, others
Ireland	Bioeconomy Implementation and Development Group (BIG)	DECC DAFM

Source: Own compilation.

It is important to note, that not only horizontal policy coordination plays a crucial role for the European Bioeconomy, but also attempts to align policies on a vertical scale across different territorial levels. This includes European exchange platforms, in which member states have the possibility to discuss essential topics with representatives of the European Level, such as the European Bioeconomy Policy Forum (EPBF) or the SCAR Bioeconomy Working Group, which especially discuss how existing policies can be aligned with other policy fields. In addition, it can be also observed that some countries, which share common interests are working together on a project level, as it has been the case with the initiative "Bioeconomy in the North", which associate Germany with other Northern Countries, such as Finland, Norway or Sweden in areas like non-feed biomass resources.[42] Another example include the Agriculture and Fisheries Council that is being held by different member states represented by the ministers of leading ministries. Germany, for example, has highlighted that in the light of limited capacities, biomass needs to be used where it proves to be most effective for the sustainable economy.[43] In Germany, also several federal states have developed their own bioeconomy strategies. In the context of the development of the action plan in Germany, the government were actively involving the federal states for shaping the action plan. Through the formal Working Group between the government and the federal states, another coordination group exist that tries to ensure policy coherence between the policies at the different territorial levels. Moreover, the national bioeconomy advisory council launched a dialogue format between December 2021 and February 2022, in which the BÖR invited representatives of the federal states (federal initiatives) to foster the cooperation between the work of the BÖR with federal states (German Bioeconomy Council, 2022).
A good example also are governmental advisory boards and inter-ministerial working groups, which have been established in several countries in the WE region to oversee the implementation, monitor, and evaluate the national bioeconomy strategies, as well as give direct input to those. Those structures involve policy stakeholders from single or multiple ministries mandated to advise on the implementation process of bioeconomy actions. In Ireland, an interministrial working group composed of the departments of Agriculture, Food, and Marine and the Environment, Climate, and Communication chairs the Bioeconomy Implementation Group, mandated by the Prime Minister to develop policy coherence within relevant sectors, stakeholder engagement, and cross-sectoral collaborations.
Another type of advisory boards is the non-governmental double helix structured stakeholder groups, which are mainly composed of academia, industry policy and public representatives. In Germany, the German

[42] https://www.ptj.de/projektfoerderung/biooekonomie/bin
[43] https://www.bmel.de/DE/themen/landwirtschaft/eu-agrarpolitik-und-foerderung/gap/agrarrat-10-2022.html

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Bioeconomy Council provides advice for the federal government on bioeconomy policy development, while the 'Bioeconomy4Change' cluster in France focuses on creating new synergies and business opportunities within bioeconomy sectors. Within Belgium, or better Flanders Region the general consensus was not to make a large advisory group for the bioeconomy policy, as surveyed by the department of Economy, Science and Innovation (EWI), when asking Flanders's Industry composed of bio based companies and federations, but to better set-up and involve a defined stakeholder group, when plans are concrete and practical (Department of Economy, Science and Innovation, 2020). For every instrument EWI involves mostly sector organizations, which are the intermediaries and because for them, it is their job to divulge this information and to ask feedback from their members, which are then consolidated and reported.

6.2.2. Role of stakeholder involvement in bioeconomy policy making

Those countries who have established significant bioeconomy development, have also involved different stakeholders in the development of their bioeconomy strategies or strategic documents. Those stakeholders have the capacity to substantially influence the policy process. With a diverse set of formats, stakeholders are able to bring in their positions and interests. For instance, in Germany, stakeholders were not only included in the development of the bioeconomy strategy, but they have also the possibility to shape the political discourse through relevant events, such as the annually Biotechnology days or expert discussion, in which the public is not included. A highlighting example is the Alternative Bioeconomy Summit, which aims to consider the bioeconomy in the light of planetary boundaries. More than 100 experts took part if the online event, including the State Secretary of the Federal Ministry of Food and Agriculture, the National Bioeconomy Advisory Council (Daniela Thrän) and several civil society organizations.[44] The State Secretary highlighted that the conference serves as platform to negotiate important issues of the future bioeconomy and that a broad debate in the society would be needed. However, it is difficult to judge to which extent these various stakeholder group had actually an impact on policy-making. In France, the launch of the "Bioeconomy Trophy" is another noteworthy initiative, aiming at facilitating the dialogue with stakeholders and citizens. Trophies are awarded in bioenergy, bio-sourced materials and plant-based chemistry and involves inter-ministerial coordination every year with presence of the four leading ministries of the French bioeconomy (Barrett et al., 2021).

Moreover, the federal ministry for education and research in Germany has a dedicated funding programme (Bioeconomy as social change) that aims to include social-science perspectives to the bioeconomy. Some projects, which specifically include also critical voices or the participation of different stakeholders groups beyond the bioeconomy community. In the context of the development of a national biomass strategy, the key points' statement of the involved ministries stated that the strategy process will be accompanied by a stakeholder consultation to include relevant actors, such as Businesses, Science, Civil Society, federal states or the German parliament. These stakeholders provide technical recommendations and will enhance the overall acceptance of the strategy. Another initiative that is worth noting are the organization of Citizens dialogues, which were carried out from the Nature Conservation Union (NABU) and the federal Nature Conservation Agency (BfN). Within this initiative four interactive workshops and an online-dialogue over a couple of weeks were organized, in which the participants could learn about theoretical backgrounds of the bioeconomy or bioeconomy future concepts. In general, the perception of civil society organizations is rather critical regarding the question, if stakeholders are appropriately involved and claim that the ministries should take more efforts in binding joint decisions of all actors. In France, also various workshops were held with the participation of stakeholders (industry representatives, technical institutes, research establishments) to draw up the national bioeconomy strategy and its action plan. Additionally, the Bioeconomy CTI have also established a regular exchange between the government and other stakeholders. Active engagement of stakeholders were also taking place in Ireland. With the process of developing the

[44] https://denkhausbremen.de/en/alternative-bioeconomy-summit/

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national bioeconomy policy statements consultations were regularly held. Furthermore, a key action during the process was laid down in the Action Plan for Rural Development, which suggested to hold a consultative seminar on the bioeconomy with explicit stakeholder engagement of development agencies or the private sector. With the launch of the bioeconomy forum, Ireland has given the mandate to liaise with stakeholders across several industries, relevant semi-state commercial companies, representative bodies and non-governmental and community groups. The bioeconomy forum consist of different representatives, such as environmental NGOs, local authorities, sectors producing biological resources or semi state commercial companies. In regular reports, the bioeconomy forum is mandated to give recommendations for the future development of the Irish bioeconomy. In its first report, the Bioeconomy Forum specified the need for policy to support co-operative interactions among multiple actors (e.g. businesses, scientific communities, social movements etc.). Stakeholder engagement is essential to address local and regional challenges and in identifying of priority product and market opportunities according to the report. Moreover, with the Irish Bioeconomy Network, which is coordinated by the Bioeconomy Implementation and Development Group, a wide range of stakeholder from leading organizations, centres, clusters or programmes are brought together, promoting engagement and raising awareness in the bioeconomy.[45] Although in Belgium also several stakeholder involvement activities are taking place (e.g. working groups, steering committees), engagement with the wider public still lacks elaboration. That is the reason, why in Flanders bioeconomy is still more unknown among the general population.

In some countries, it can be also observed that different NGOs play a crucial role in shaping policies or campaigning against bioeconomy policies. In Germany, the Bioeconomy Action Forum is an interesting example, how different NGOs build an alliance to have a common and unified position in the bioeconomy. The Forum is organized by Denkhaus Bremen and its cooperation partner BUND (Friends of the Earth). Together with other NGOs (e.g. WWF, Brot für die Welt, FIAN) they debate the future bioeconomy with respect to agriculture, forestry, bioenergy or on conflicts associated to the bioeconomy, such as land grabbing or land use conflicts. However, a structural problem of such alliances remain the limited financial resources building-up such initiatives would require. In the Netherlands, the plans of the government to implement biomass subsidies led to the creation of new environmental organizations and campaigning against the House of Representatives. At the end, the NGOs were able to discontinue the planned biomass subsidies of the government (Kuhlmann, 2022). The examples show that civil society organizations are able to leverage the government and influence the policy discourse in the public against the interest of the government.

What also became evident throughout the interviews was the fact that the interrelations of actors highly depend on the closeness of topics these actors are covering. As Nature Conservation Organization genuinely are closer to the ministry for the environment, the interrelations between these actors are deeper. Not surprisingly the federal ministry for economic affairs and climate protection share more interest with business associations than with environmental NGOs or societal movements.

6.2.3. Dealing with Goal Conflicts

At the political level, goal conflicts of the bioeconomy play an increasingly important role and are controversially discussed among political actors. In Germany, the conflict between land use and environmental protection has been a conflict point between actors, as the example of the biomass strategy showed. A proposition for this goal conflict would be to reconsider our diet habits including the way how we keep animal, according to environmental organizations in Germany. Another goal conflict that is discussed at high levels of the BMBF in Germany are the ethical considerations of the breeding technologies. The BMBF strongly supports the application of these breeding technologies, as they deliver

[45] https://www.gov.ie/ga/foilsiuchan/046ce-stakeholder-coordination-consultative-groups/#irish-bioeconomy-network

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suitable solutions for food supply globally. As at the European level genome-editing is regulated with the EU-Gene technology law, it is still unclear whether these technologies will be implemented in the European agriculture. As under this law, such plants have to be formally approved and require obligations to provide proof, it is still unlikely that breeding technologies will be used at a broad scale in Europe. In the case of Germany, also the national bioeconomy advisory council (BÖR) is assigned to launch participatory format with stakeholders, discussing development pathways and practical compromises for overcoming goal conflicts, also with respect to the sustainability objectives.[46] Further examples, which have been discussed in the countries of the Western Macro-region are the competition of feedstock and the potential to develop unsustainable value chains.

Similar to other EU member states, the transition towards a sustainable bioeconomy in Ireland unfolds with complex trade-offs, for example in relation to issues such as bio-products, market competitiveness, environmental goals, use of bio-resources, and land-use changes. According to the Irish Bioeconomy Forum report 2022, goal conflict in Ireland has been predominantly navigated through policy, frameworks and accreditation systems. Besides the precautionary principle adopted within policy frameworks (no harm to the public or the environment), the Bioeconomy Implementation and Development Group (BIDG) in Ireland (formerly called the Bioeconomy Implementation Group) plays a vital role in navigating policy coherence between the bioeconomy and other sectoral policies. A high level of coherence has already been identified between the strategic policy objectives of Project Ireland 2040 (the Irish National Development Plan) and the national bioeconomy policy statement (Kelleher, Henchion et al. (2019). The BIDG continues to work to reinforce the policy context for a sustainable and circular bioeconomy in Ireland. Another example of how potential conflicts are addressed is provided by the strategy for the agricultural and food sectors to 2030; Food Vision 2030, through a process involving significant stakeholder engagement, identifies a shared vision for the future, along with actions for embedding the agri-food sector in the circular bioeconomy. In addition, there are several standards and accreditations available nationally to alleviate goal conflicts, mainly between primary sectors and the environment such as CRE scheme for compostable waste recycling and Bord Bia's Origin Green in the agri-food sector. The latter is a national sustainability programme bringing together government, the private sector and full supply chain actors (e.g., farmers, food producers retailers) to achieve sustainability targets and community welfare while ensuring no harm to the environment.

Belgium's bioeconomy aspirations hinge on achieving sustainable economic development, environmental preservation, and societal well-being. However, a pivotal conflict arises concerning land use, particularly in balancing the demands of agriculture, urban development, and bio-based industries. Striking a harmonious equilibrium proves challenging, requiring collaborative dialogue and integrated policies to navigate conflicting interests. Policymakers play a central role in crafting strategies that optimize land use, and investments in research and innovation focus on technologies that reconcile economic growth with environmental responsibility. With adaptive governance and public awareness initiatives, Belgium endeavours to forge a resilient and responsible bioeconomy, addressing conflicts and advancing its multifaceted goals.

6.3 Applied R&D and Technology Transfer

6.3.1 Policy Instruments for Applied R&D and Tech transfer in selected MR countries

In the Western macro-region, the funding situation for Technology Readiness Levels (TRL) 4-7 in applied research and development is diverse, with a mix of national, European, and collaborative initiatives

[46] (https://www.bmel.de/DE/themen/landwirtschaft/bioeokonomie-nachwachsende-rohstoffe/ueberblick-biooekonomie.html

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contributing to the landscape. Specific policy instruments strategically target higher TRL levels, aiming to bridge the gap between research outcomes and practical applications.
National initiatives, exemplified by France's Investments for the Future Programme, allocate substantial resources to projects focused on advancing technologies to TRL 4-7. These programmes reflect a commitment to fostering innovation that is closer to market readiness. At the European level, Horizon Europe plays a pivotal role in supporting projects targeting TRL 4-7. Collaborative efforts and transnational initiatives under Horizon Europe emphasize elevating the readiness levels of technologies, fostering a unified approach to innovation across the Western macro-region.
Specific policy funding schemes that enable firms to use multi-purpose facilities, such as open-access pilot plants, are instrumental in advancing technologies through TRL 4-7. A first overview of such kind of facilities is provided through the Pilots4U Initiative. These schemes facilitate access to crucial infrastructure, supporting practical testing and validation of technologies in real-world settings. One implemented funding scheme is the German "Förderprogramm Industrielle Bioökonomie"[47] initiated by the BMWK. The programme aims to increase construction and use of demonstration plants for the industrial bioeconomy and thus the scaling up of innovative bioeconomic processes and procedures, and has as such lighthouse character for other countries and regions.
Activities like matchmaking, exhibitions, and accelerator programmes are relevant at TRL 4-7, providing platforms for knowledge exchange and collaboration. These initiatives foster connections between research institutions, industry players, and potential investors. While there are indications that such activities work well, the effectiveness can vary based on sector-specific dynamics and the level of engagement from key stakeholders.

6.3.2 Structures and Challenges for Applied R&D and Tech transfer in selected MR countries

In the dynamic landscape of the Western macro-region, several pivotal actors and collaborative initiatives take centre stage in driving applied research and development, as well as facilitating technology transfer. These entities play a vital role in bridging the gap between academic research and practical application, fostering innovation across various sectors. In Germany, innovation hubs and clusters like the Fraunhofer Society or the German Research Center for Artificial Intelligence (DFKI) in the field of digitalization serve as dynamic catalysts for applied R&D. These entities create collaborative ecosystems, uniting researchers, businesses, and government bodies to push the boundaries of technological advancements. The Netherlands showcases strong innovation hubs such as Brainport Eindhoven and Food Valley, specializing in high-tech systems and agri-food innovations, respectively. These hubs function as collaborative environments that stimulate the transfer of technology from research institutions to industry applications. France leverages public-private partnerships (PPPs) within the framework of the Investments for the Future Program (PIA). Initiatives like the Institutes for Energy Transition (ITEs) exemplify collaborative efforts between public institutions and private enterprises, accelerating the development and transfer of innovative technologies. In Belgium, the Belgian Science Policy Office (Belspo) fosters collaboration between the public and private sectors, evident in initiatives like the Space Pole. Such partnerships drive applied R&D, particularly in space-related fields, facilitating the transfer of cutting-edge technologies. Luxembourg has embraced the establishment of Technology Transfer Offices (TTOs) associated with research institutions and universities. These offices actively engage in technology transfer initiatives, acting as intermediaries between researchers and industry partners to bring innovations to practical fruition. Ireland's Enterprise Ireland plays a pivotal role in the innovation ecosystem by supporting collaboration between academia and industry. Through funding and expertise, Enterprise Ireland facilitates applied R&D projects and technology transfer, driving innovation across sectors. Transnational networks and initiatives, such as InterTradeIreland, facilitate cross-

[47] https://www.bmwk.de/Redaktion/DE/Dossier/industrielle-biooekonomie.html

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border collaboration between Ireland and Northern Ireland. These initiatives promote knowledge exchange, technology transfer, and collaborative R&D projects, particularly in sectors like bioeconomy. Austria's innovation agency, Austria Wirtschaftsservice (aws), contributes significantly to applied R&D and technology transfer. Collaborating with businesses and research institutions, aws provides funding and support to drive innovation across diverse sectors.

Collectively, these actors and initiatives form a vibrant tapestry of collaboration within the Western macro-region. Their efforts not only advance applied R&D but also actively contribute to the seamless transfer of technology from research environments to real-world applications, fostering innovation and economic growth.However, the adequacy of structures and infrastructures for fostering innovations in the bioeconomy is a mixed scenario. While there exist notable innovation hubs, research centres, and technology transfer offices, certain gaps and challenges persist.
The existing structures demonstrate strengths, such as cutting-edge research facilities and collaborative initiatives. However, some key elements may be missing, including adequate state-of-the art pilot plants and a broader engagement of small and medium-sized enterprises (SMEs) to effectively scale up and implement bioeconomy innovations. The integration of SMEs is crucial for the practical application and commercialization of bio-based technologies.
Efficiency concerns arise in the awareness and preparedness of entities like tech transfer offices and firms regarding the potential of the bioeconomy. There may be instances, where these entities are not sufficiently aware of the opportunities within the bioeconomy, or their workforce may lack specialized training. Additionally, challenges in securing financing at certain stages of innovation development hinder the smooth progression of bioeconomy projects.
Major challenges in applied research and technology transfer within the bioeconomy in the Western macro-region encompass the need for improved coordination and awareness among stakeholders. This includes enhancing collaboration between research institutions and industry, ensuring SMEs are active participants in the innovation ecosystem, and addressing gaps in training and financial support for those involved in the bioeconomy value chain. Overcoming these challenges requires a holistic approach that fosters a conducive environment for innovation, encourages collaboration, and addresses the specific needs of bioeconomy initiatives.

6.4 Cross-sectoral Collaboration

Given the intricate and interdisciplinary nature of the bioeconomy, national policies and action plans in the Western region sector have identified policy coordination and cross-sectoral collaboration as critical pillars for realising the bioeconomy's potential through:

- Encouraging the alignment of bioeconomy development across various national strategies
- Investing in cutting-edge research and innovation
- Initiating and fostering collaborations with multi-stakeholders at the national, regional, and international levels

Given that the bioeconomy policy is often driven by ministries of agriculture, forestry, rural development, or economics in multiple countries across the WE region, interministrial and cross-sectoral collaborations is crucial for attaining the full potential of sustainable bioeconomy.

6.4.1 General overview of cross-sectoral collaboration

In recent years, a discernible trend has emerged towards increased recognition of the benefits of cross-sectoral collaboration within the Western macro-region. Stakeholders from various industries acknowledge the potential for innovation, enhanced problem-solving, and collective impact through collaborative efforts,

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particularly in addressing complex challenges requiring expertise from multiple sectors. Governments and industry players actively promote collaborative frameworks, emphasizing the need to break down silos for more effective problem-solving. Initiatives encouraging dialogue and partnerships between traditionally distinct sectors, such as technology, healthcare, and environmental sustainability, are on the rise.
Despite positive trends, challenges persist. Regulatory differences and diverse legal frameworks among Western European countries can impede seamless collaboration. Additionally, competitive dynamics within specific sectors may create hesitancy among companies to engage in open collaboration, though there is a growing realization that sharing information can lead to mutual benefits. Comparatively, the Western macro-region's trends in cross-sectoral collaboration align with global patterns, as many countries recognize the value of breaking down traditional barriers for innovation and sustainable development. Initiatives and programmes at the European Union level further support cross-sectoral collaboration, contributing to a broader culture of cooperation. Recent important changes include the emergence of bottom-up activities where stakeholders organize themselves to support cross-sectoral collaboration. These grassroots efforts showcase a proactive approach from the ground level, indicating a growing awareness and commitment to overcoming barriers through collective action.
Challenges persist at the sectoral, country-specific, and regional levels. For instance, in Germany, there's hesitancy among companies within competitive industries to engage openly in collaborative innovation. Regulatory differences between Belgium and Luxembourg pose hurdles, while regional disparities in infrastructure development impact collaborative endeavours in Ireland. Resource constraints, both financial and human, pose significant barriers to collaboration. In the Netherlands, insufficient funding for collaborative initiatives and a shortage of skilled professionals in specific fields may impede joint projects.
In recent years, a noteworthy development in the Western macro-region has been the emergence of bottom-up activities where stakeholders have proactively organized themselves to support cross-sectoral collaboration. These grassroots initiatives showcase a ground-level commitment to overcoming barriers and fostering collaborative efforts.
For instance, in Germany, industry-led consortia have been established to promote cross-sectoral collaboration in areas such as sustainable manufacturing practices and the circular economy. These consortia bring together representatives from diverse sectors, including manufacturing, environmental sciences, and technology, to jointly address shared challenges and explore innovative solutions. Similarly, in Belgium, stakeholders from various industries have formed networks focusing on bio-based technologies and sustainable resource management. These initiatives aim to leverage the collective expertise of participants, spanning agriculture, biotechnology, and environmental sciences, to drive advancements in the bioeconomy. In Ireland, bottom-up activities have been observed in the establishment of industry-led forums addressing themes like renewable energy integration and waste reduction. Stakeholders, including businesses, research institutions, and governmental bodies, collaborate within these forums to promote sustainable practices and shared learning.
In the context of the Western macro-region, two primary production/raw material resources that play a pivotal role in bio-based material flows are forestry and agriculture.
Forestry stands out as a crucial sector due to its significant contribution to the production of raw bio-based materials, including wood, timber, and various forest products. In countries like Germany, where approximately one-third of the land is covered by forests, Austria, with about 47% forest coverage, and France, boasting diverse forest ecosystems, forestry is a key player in providing renewable resources. The sustained management and utilization of these forest resources contribute substantially to the region's bio-based material flows.
Agriculture, another fundamental primary production sector, plays a vital role in providing raw bio-based materials for diverse applications such as food, bioenergy, and industrial processes. Countries within the Western macro-region, notably France, Germany, and the Netherlands, have well-developed agricultural sectors. France, one of Europe's largest agricultural producers, is known for its diverse cultivation,

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including wine and dairy production. Germany, with a robust agricultural sector contributing to cereals, sugar beets, and livestock farming, and the Netherlands, a major global exporter of agricultural products, collectively form the backbone of bio-based material flows in the region. These primary production sectors, forestry and agriculture, were selected for their substantial and sustained contributions to the production of raw bio-based materials, making them integral components of the Western macro-region's bioeconomy.

6.4.2 Policies supporting Cross-sectoral Collaboration in selected MR countries

In the Western macro-region, a range of policies has been implemented to stimulate cross-sectoral collaboration. These policies, often country-specific, share a common aim of fostering an environment where diverse stakeholders can work collectively to address challenges and drive innovation. In Ireland, cross-sectoral collaboration is being encouraged through multiple instruments including policy and funding schemes. For instance, the food vision 2030 of Ireland entails 'cross-sector collaboration and investment, nationally and internationally, should be pursued for the development of circular and climate-neutral'. Across the WE region, Several funds and public-private partnerships are also to support collaborations between industry and research such as SFI programme for industry and BioConnect in Ireland and SME Innovation Scheme for Top Sectors (MIT) in the Netherlands. A variety of policy instruments, funding initiatives, and support measures have been deployed to bolster cross-sectoral collaboration. These efforts aim to create an environment conducive to effective collaboration between stakeholders from diverse sectors, promoting innovation and addressing common challenges. One prevalent approach is the implementation of comprehensive policy frameworks, such as Germany's High-Tech Strategy. By encouraging collaboration among research institutions, businesses, and governmental bodies, Germany seeks to harness a wide spectrum of expertise and perspectives. This approach reflects a commitment to breaking down silos and leveraging the strengths of different sectors for comprehensive solutions.
In the Netherlands, the Top Sectors approach exemplifies policies targeting challenges within the value chain. This strategy, focusing on key sectors like horticulture, water, and high-tech systems, is designed to optimize collaboration along the entire value chain. By identifying and addressing bottlenecks, the Dutch government aims to create a more seamless flow of resources and information between sectors, enhancing overall collaboration. Meanwhile, in Belgium, policies emphasize collaboration in specific sectors, with a notable focus on renewable energy. The National Energy and Climate Plan outlines strategies to strengthen collaboration between the energy, transportation, and industrial sectors, driving the transition towards sustainable energy sources. These policies highlight a concerted effort to channel cross-sectoral collaboration toward addressing pressing challenges and advancing strategic goals in the Western macro-region. Austria, guided by the Research, Technology, and Innovation (FTI) Strategy, utilizes funding programmes like the COMET Competence Centers and K-Project schemes to support research collaborations between academia and industry. The Climate and Energy Fund provides financial incentives for projects promoting sustainability and innovation across sectors.

6.4.3 Mapping cross-sectoral collaborative structures

The bioeconomy is complex and entails inter-disciplinary knowledge. In the WE region, multi-stakeholder collaborations are fostered through a wide range of platforms both within and beyond ministries, such as advisory boards, and working groups. These platforms entail the establishment of links and connections between various stakeholders across sectors to support and accelerate the development of the bioeconomy and promote the deployment of bio-based innovations.
Clusters have provided some good examples of cooperation and collaboration, particularly bringing sectoral groups together. Multiple clusters in the WE region focus on translating collaborative R&D into products, processes, and services, such as the public-private partnership cluster 'CIRCULÉIRE' and the circular bioeconomy cluster in Ireland and the competitive clusters in France. An example of collaboration between

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research and industry is the Farm Zero C project, which is developing the world's first climate-neutral dairy farm located in Ireland. It is a collaboration between Carbery, BiOrbic and others to create a climate-neutral, economically-viable dairy farm. Clusters also play a key role in supporting innovation, business opportunities, and the growth of SMEs and mid-sized companies. The Innovation Salzburg cluster in Austria supports the growth of companies by linking them to financing opportunities. The cluster industrial bioeconomy (CLIB) in Germany fosters dialogue and cooperation between industry, science, and civil society. The clusters also play a key role in supporting innovation, business opportunities, and the growth of SMEs and mid-sized companies, knowledge exchange, high-level experts and peer-to-peer learning opportunities, dialogue between industry, academia, and civil society, technology transfer; and raising awareness about the growing bioeconomy.

These frameworks help to reduce the 'time to market' while also facilitating the growth of technology and companies. For example, in Ireland, Accelerate Green is a good example of collaboration between stakeholders, including environmental, community, and commercial partners, to facilitate peer-to-peer learning and support the scaling up of sustainability-driven businesses. The Green Chemistry Campus in the Netherlands is among the business accelerators for bio-based innovations. Networking groups and activities also exist in multiple countries to bring together different bioeconomy sectors, such as the Model Region for Sustainable Bioeconomy Networking and the Bioeconomy Cluster in Germany, which works on food, chemistry, and energy. ChemBooster in France provides a unique service by pooling skills and technological platforms to accelerate projects within the theme of sustainable green chemistry.

Efforts in the WE region to support collaborations are not limited to those developed nationally; regional and cross-border collaboration mechanisms have been on the rise over the past years. The Circular Bioeconomy Cluster, the first regional bioeconomy cluster in Ireland is one of the examples. The cluster aims at promoting the circular bioeconomy in the South-West region by bringing various stakeholders, such as industry, enterprises, government, and research centres, together to accelerate business opportunities and the deployment of technology across sectors. Another example is the Platform for Accelerating the Circular Economy (PACE), in which the Dutch government works alongside 40 members representing government, business, and international organisations to drive circular economy goals. In Austria, the Circular Economy Forum is an independent multi-stakeholder platform that acts as a development and dialogue platform for companies. In Belgium, the macro-regional Vanguard Initiative brings together regions with significant industrial capacities and highly emphasises collaboration, knowledge sharing, and collaborative initiatives to foster innovation and competitiveness.

Efforts in the WE region to support collaborations are not limited to those developed nationally; regional and cross-border collaboration mechanisms have been on the rise over the past years. Cross-boundary collaboration platforms in the WE countries mainly encompass partners from Belgium, the Netherlands, and Germany. For example, the BIG Initiative of clusters and networks in the trilateral area's Belgium region of Flanders, The Netherlands, and the German state of North Rhine-Westphalia' supports the transition of the chemical industry towards climate neutrality and circularity with the aim of becoming the global leader of bio-based innovation. BIG-Cluster has defined important topics to focus on. These are the flagship topics "aromatics and fine chemicals from woody biomass", "chemicals from CO and CO2", and "alternative fuels from various feedstocks" and the cross-cutting topics "bioeconomy education", "closing the loop", and "digitalization". However, current project activities appear to be limited.[48]

The Trilateral Strategy for the Chemical Sector is a cross-border collaboration between the Netherlands, Flanders (Belgium), and North Rhine Westphalia (Germany) to promote the competitiveness and economic growth of the chemical sector through collaboration. These cross-boundary clusters in the three countries aim to transform this mega-industrial cluster into a world leader in bio-based innovation, promote cross-border collaboration, and commercialise bio-based technology and products. BIG-Cluster has defined

[48] The projects listed https://www.bigc-initiative.eu/ haven been finished in 2021 or 2022.

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important topics to focus on. These are the flagship topics “aromatics and fine chemicals from woody biomass”, “chemicals from CO and CO2”, and “alternative fuels from various feedstocks” and the cross-cutting topics “bioeconomy education”, “closing the loop”, and “digitalization”.
Transitioning to a sustainable bioeconomy necessitates collaborative efforts and the involvement of multiple stakeholders, among others. The WE region’s efforts demonstrate a commitment to bioeconomy development at the national, regional, and cross-boundary levels, as seen by the variety of cooperation platforms available in the macro-region. Although no single approach can ensure an effective transition to a sustainable bioeconomy, promoting participatory governance structures such as inter-ministerial working groups can foster the inclusion of multiple sectors, allowing for the adjustment of sectoral goal conflicts and resource competition. Other initiatives will include investing in capacity and skills development, tracking progress, fostering engagement with diverse stakeholders, and increasing collaboration at the national, regional, and EU levels.

6.5 Financing

6.5.1 Policy Instruments for Financing in selected MR countries

In the Western Macro-region, the volume and type of financing rounds is the highest in the reported area, well developed, with full range of funding rounds with the more mature growth financing deals predominant. Special case is Belgium where most of the EU-funding programmes are located and the country might appear as one with the biggest number of investors. The proportion of grants is smaller compared with the other macro-regions. There are no significant disparities across the countries with the most developed markets as the ecosystems are well-established, stable and predictable, with distinguished intermediaries and advisories competing for companies and thus providing diverse range of services, including paid. The bioeconomy companies have more opportunities but also face more competition on the big national markets and for access to biomass for their products, but also face bigger competition, especially at early stage, for funding. The number of more mature stage deals can also be explained by the bigger number of local and international investors in the region, while the trust in the economic policies is comparatively higher than in the rest of Europe. The concentration of renowned universities and knowledge hubs also plays a role with the range of tech-transfer offices, accelerators, incubators, as well as branches of EU-wide organisations and programmes.
The Western macro-region, comprising Austria, Belgium, Germany, France, Netherlands, and Ireland, presents a rich array of funding mechanisms tailored to provide direct support to Small and Medium-sized Enterprises (SMEs). Each constituent country within this macro-region has devised distinctive policies and programmes aimed at bolstering SMEs. Below is a comprehensive overview of this landscape, along with specific insights into the allocation of budgets for bioeconomy support networks. Austria, for instance, features two prominent instances of budget allocation for bioeconomy support networks. The “Bioeconomy Austria” network, facilitated by financial backing from Waldfond Österreich, convenes stakeholders from the realms of politics, business, civil society, and academia to champion bioeconomy initiatives. Furthermore, the “Think. Wood Austrian Wood Initiative” concentrates on knowledge dissemination and networking for the New European Bauhaus, underpinned by financial support. Germany channels its budgetary resources into bioeconomy support networks through two pivotal policy instruments. “New generation research for the bioeconomy” places its emphasis on SMEs, fostering research, development, and innovation endeavours spanning the domains of natural sciences, information technology, and engineering. Meanwhile, the “Central Innovation Program for the middle class (ZIM)” finances individual projects and Research and Development (R&D) collaborative efforts within innovation networks, serving as a critical driving force in bioeconomy advancement. France’s “Plan Climat” aligns with the concept of bioeconomy support networks. It extends support to start-ups in the green technology sector and extends a

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"Green loan" programme to facilitate their growth and development, with a particular focus on environmentally friendly technologies. Moreover, there are currently 14 incubators and 7 accelerators supporting early-stage projects in bioeconomy fields, including biotechnologies, food, and energy transition in France. Ireland exemplifies budget allocation for bioeconomy support networks through "the Climate Action Plan 2023", which apportions funds to bolster innovation and sustainable farming, thereby contributing to the overall expansion of the bioeconomy and sustainable initiatives within the nation. These initiatives bear testament to the unwavering dedication of the Western macro-region in nurturing the growth of the bioeconomy through the support of collaborative networks and projects. The allocation of budgets for these networks assumes a pivotal role in driving innovation, sustainability, and economic progress across the region.

Budget allocations, essential for providing direct support to small and medium-sized enterprises (SMEs), serve as the cornerstones of innovation and economic growth across the Western macro-region. Within this dynamic region, a variety of policy instruments have been thoughtfully crafted with specific budget allocations, each with the common aim of empowering SMEs and propelling their respective countries forward. Germany, at the forefront of SME support, demonstrates a comprehensive commitment to fostering innovation and progress. A striking initiative, the "Model Region of Bioeconomy for Digitalization of Plant-Based Value Chains" is dedicated to advancing digitalization within plant-based value chains, thus fuelling research and innovation opportunities for SMEs. This initiative encompasses individual projects, junior groups, and collaborative endeavours, all contributing to the digital transformation of plant-based industries. In addition, the "Central Innovation Program for the Middle Class (ZIM)" efficiently channels budgetary resources to support individual projects, R&D cooperation projects, and innovation networks, promoting collaboration and innovation throughout the SME sector. Austria echoes this dedication through its "AI for Green" initiative, which allocates budgets for research-intensive technology developments in artificial intelligence (AI) and AI technologies geared toward addressing climate change. France, equally committed to SME support, has established policy instruments like the "Plan Protéines Végétales", which designates funds to support investments in agriculture and technical equipment for the cultivation, drying, and harvesting of vegetable proteins. In Belgium, "Brustart" and "Bruseed" are standout policy instruments, channelling budget allocations to stimulate entrepreneurship and innovation. Luxembourg, a contributor to SME support through "InvestEU" exemplifies its commitment to fostering economic growth and innovation within the SME sector. Ireland introduces the "Bioeconomy Demonstration Fund", which not only supports the production and application of bio-based materials but also emphasizes the significance of bio-based chemicals, materials, food and feed ingredients, and soil nutrients. Turning to the Netherlands, we find a nation playing a significant role in SME support. The "SDE+ Incentive Scheme" offers subsidies to companies and organizations across various sectors, including industry, mobility, electricity, agriculture, and the built environment. This scheme actively encourages the adoption of sustainable practices and technologies, with a specific focus on renewable energy and environmental sustainability. Collectively, these policy instruments underscore the unwavering commitment of these nations to empower SMEs and drive innovation, economic growth, and sustainability within their respective regions. In the Western macro-region, a variety of strategies and policy instruments have been devised to facilitate go-to-market activities, encompassing investment forums, commercialization efforts, marketing, and communication strategies. These collective efforts reflect the region's shared commitment to innovation and sustainability. Let's delve into the landscape to understand how each country contributes to these objectives:

- Germany, while not boasting an extensive array of policy instruments explicitly designed for go-to-market activities, demonstrates its dedication to sustainable and circular economic practices through initiatives like "Circular Biomanufacturing"

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- Austria, Belgium, Luxembourg, and the Netherlands, in their pursuit of economic growth and innovation, have yet to pinpoint specific policy instruments tailored for go-to-market support, but they share these common objectives.
- France takes a proactive stance by implementing the "Anti-waste law for a circular economy (AGEC)", allocating funds to stimulate the development of new markets. Additionally, the "Plan Climat" extends specialized support to emerging renewable energy providers, providing financial and insurance backing to nurture their growth.
- Ireland distinguishes itself with the "Bioeconomy Demonstration Fund", a strategic initiative aimed at offering practical examples of bio-based innovation and solutions to policymakers, public and private investors, and local communities. This fund plays an active role in supporting the development and commercialization of bioeconomy-related projects.

6.5.2 Company financing

The following part shows the finding of an in depth analysis done about data from the beginning of 2021 until 13 April 2023. All these findings are based on reported data in Dealroom.

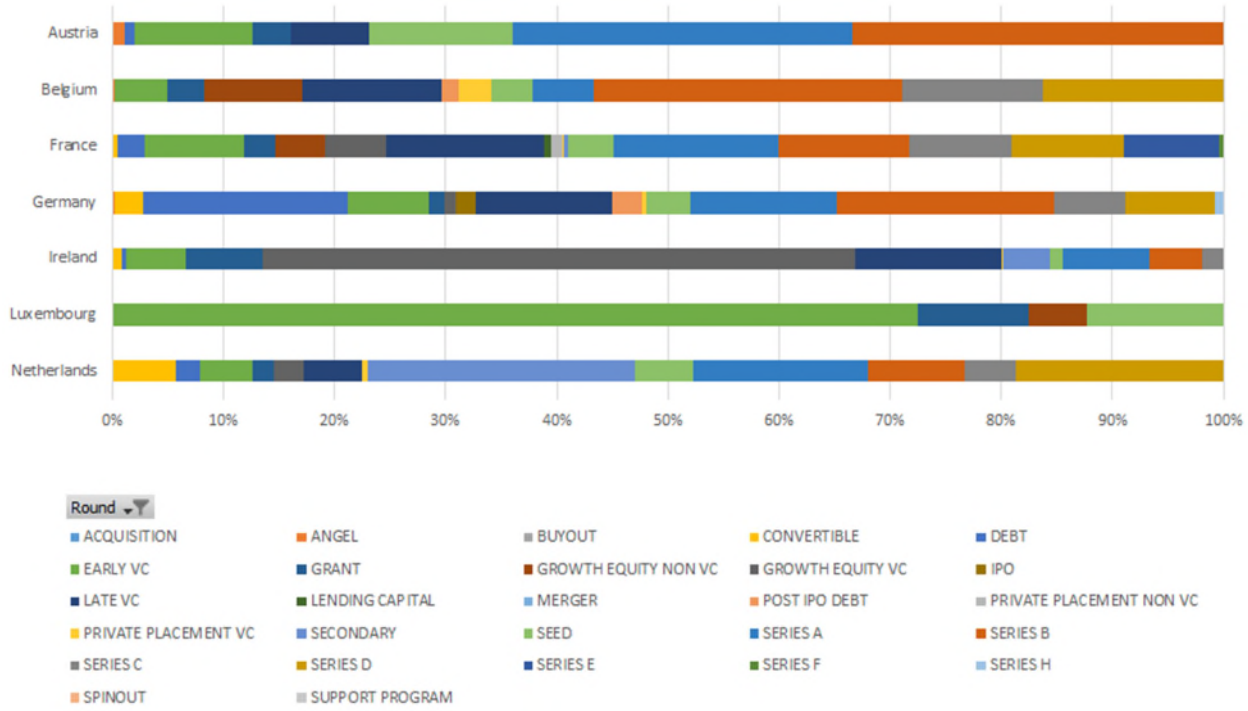

Figure 93. Type of reported financing rounds in Western macro-region.
Source: dealroom.co (2023).

The companies in the Western macro-region receive predominantly private funding from investors located both inside and outside their countries. The investors from this region fund companies globally with private investors from France, Germany, Belgium and the Netherlands, accounting for 92.47% of the investors located in the region. All countries except Austria are represented in the top 20 investors in Europe by

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number of deal participation with 2325 funding rounds in total. This means that in Germany, Ireland, Netherlands the average amount for a single deal is higher than in Austria, Belgium, France.
There is similarity in the proportions in the investment amount related to the number of investment rounds (Figure 94) for early-stage companies (TRL 1-6) in all countries in the Western Macro-region, the investment amounts for Austria, Belgium and France smaller for relatively big number of financing rounds. One can only speculate at this stage for the reasons, as there are complex reasons like legislative framework, national and regional policies, EU policies transposition (national adaptation), size of market, number of local investors, geographic factors, access to market, even size of average remuneration for highly qualified employees, and so on. This is the subject of analysis in T2.4.

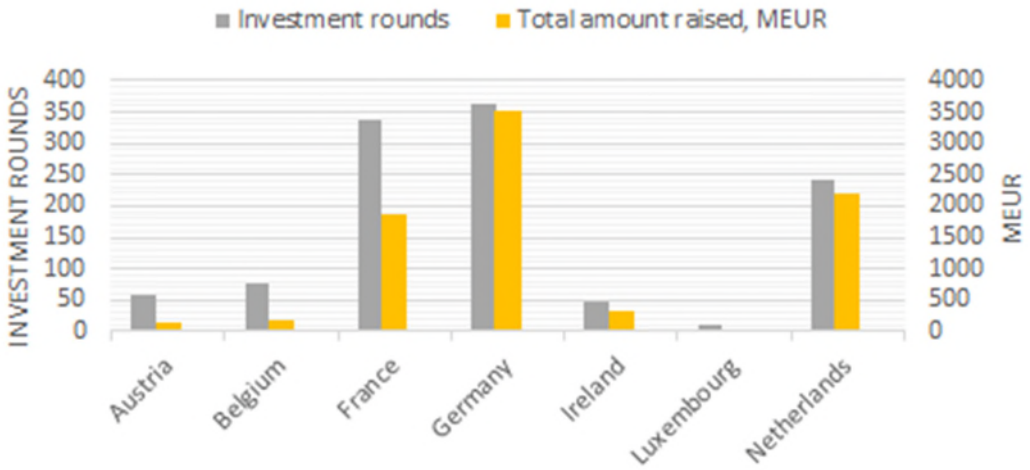

Figure 94. Early stage funding rounds and amounts in Western MR.
Source: dealroom.co (2023).

The total amount raised per country for all investment deals is presented in Figure 95. The region is characterised by big number of investment rounds for all company development stages, with the two biggest deals at the top 5 for the entire Europe in the reported period taken place in Germany.

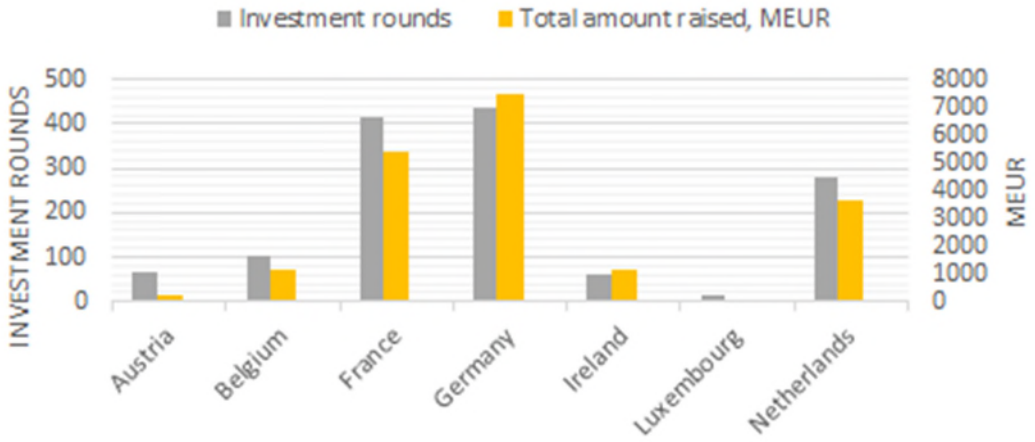

Figure 95. Total reported amount raised by country in Western macro-region.
Source: dealroom.co (2023).

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6.5.3 Impact of Policies for Financing in selected MR countries

Within the Western macro-region, various funding initiatives are in place, managed by entities such as Austria Wirtschaftsservice (AWS) and Bpifrance, aiming to support SMEs. The effectiveness of these programmes relies on their adaptability to the diverse needs and dynamics of different industries, ensuring that they meet the specific challenges faced by businesses.

Flanders, with a strategic vision to position itself as one of the preeminent bioeconomic regions in Europe by 2030, has implemented robust measures to actualize this goal. The regional government, recognizing the manifold benefits inherent in the bioeconomy, including heightened resource efficiency and job creation, has allocated substantial support through an array of grants and subsidies. Complementing this financial support, Flanders maintains an R&D-friendly tax system, enabling companies to recuperate portions of their investments. With a noteworthy commitment to research and development, constituting 2.89% of Flanders' GDP, the region stands as a pivotal hub for innovation, poised to foster sustainable economic growth.

In tandem, Ireland exhibits a comprehensive framework supporting the development of the circular and bioeconomies. Diverse and well-coordinated research and innovation funds are available, facilitated through various channels including European Union programmes and different governmental bodies such as the Department of Agriculture, Food, and the Marine, the Department of Communication, Climate Action & Environment, and the Department of Business, Enterprise and Innovation. Agencies such as Enterprise Ireland, the Environmental Protection Agency, Science Foundation Ireland, and the Irish Research Council play integral roles in channelling financial support. Noteworthy initiatives include Enterprise Ireland's backing for bioeconomy innovation and piloting facilities, exemplified by the establishment of a facility in Lisheen, Co. Tipperary.

Ireland's commitment to academic research and competitive enterprises is evident through Science Foundation Ireland, with its support for initiatives like the Beacon Bioeconomy Research Centre (now BiOrbic). Additionally, the InterTradeIreland Impact funding programme fosters cross-border collaboration between SMEs in the Republic of Ireland and Northern Ireland, further enriching the bioeconomy landscape.

Meanwhile, Germany stands as a stalwart supporter of bioeconomy projects, offering financial backing through grants, loans, and tax incentives. Renowned programmes such as Bioeconomy International and Bioeconomy Innovation Programmes serve as catalysts for the development and commercialization of bio-based innovations. The substantial financial commitment by the Federal Ministry of Education and Research (BMBF) and the Federal Ministry of Food and Agriculture (BMEL), amounting to 3.6 million euros from 2020 to 2024, underscores Germany's dedication to advancing bioeconomy-relevant projects and measures. Furthermore, Germany leverages funding programmes and initiatives provided by the European Union, reinforcing collaboration, innovation, and market deployment across European countries.

SMEs in the macro-region, including those in the Netherlands, have access to grants and subsidies as part of support mechanisms. In Ireland, support for SMEs is provided through entities like Enterprise Ireland, tailoring assistance to the needs of Irish businesses. The success of these programmes depends on their ability to address the specific challenges faced by businesses in the Irish context.

Beyond the regional context, it is crucial to evaluate the awareness and accessibility of these programmes. SMEs may not always be fully cognizant of the available programmes, necessitating efforts to enhance awareness through outreach and educational campaigns. Moreover, obstacles to accessing these funds, whether due to complex eligibility criteria or intricate application processes, need to be addressed. Simplifying procedures and providing assistance can alleviate these challenges, ensuring that a broader range of SMEs can access the support they need. Adequacy of funding amounts is another critical consideration.

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6.6 SWOT Analysis of the Western Macro-Region

Table 40 SWOT Analysis of the Western region

Strengths - Strong technical expertise/knowledge and capabilities available for efficient biomass utilization - Innovative approaches uprising for CO2, alternative proteins - Comprehensive Framework: Policy framework encourages sustainable biomass use, bio-based innovations and industry support. - Effective Coordination: governance structure facilitates policy implementation through intersectoral and interministrial working groups - Stakeholder Engagement: Collaboration with stakeholders helps align policies with industry needs.	**Weakness** - Infrastructure gaps: Some industries lack necessary infrastructure for biomass use. - Incentives: Government incentives promote bioeconomy investment, but only at regional level and not cross-country. Low mobility of funding. - Limited land resources: Western region faces land scarcity for woody biomass production (except of Austria).
Opportunities - Room for improvement in horizontal coordination within bioeconomy policy and other policy fields, for mobilizing regions - Innovation Potential: very strong R&D capabilities can drive biomass conversion technology development. - International Collaboration: Collaborating with other countries fosters knowledge exchange. - Highly skilled workforce needed - Knowledge Sharing: Facilitating technology transfer accelerates biomass technology adoption. - Diversification: Collaboration between sectors can lead to new bio-based products and value chains.	**Threats** - Budget Constraints: Economic challenges may limit government funding for bioeconomy initiatives. - Investment Risks: Uncertainties can deter private investors. - Global Competition: Western region competes with other nations in the global bioeconomy market (new food with Singapore). - Market Volatility: Biomass price fluctuations can affect industry competitiveness. - Though regulatory process (on European level) (GMO, Novel Food, Pesticides)

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6.7 Conclusions for the Western Macro-Region

1. The Western macro-region plays a pivotal role in the EU's bioeconomy landscape: With the exception of Austria, it is specialized in agriculture, with delivering input of food, feed, energy, and biomaterials.
2. With almost half of EU biorefineries, the Western macro-region excels in the industrial deployment of the bioeconomy, especially in chemical and biomethane production.
3. Robust research and development institutions across countries actively contribute to bioeconomy-related research, fostering innovation.
4. A dynamic landscape thrives with diverse companies, where large corporations transition into bioeconomy, and SMEs/start-ups are dedicated to bioeconomic activities.
5. Germany, Ireland, France, and Austria stand out for their leadership in bioeconomy strategy development, demonstrating a commitment to long-term sustainability and innovation. However, strategies, policy development is not uniform across countries, revealing disparities, especially in Luxembourg and Belgium there are less strategic approaches.
6. Each country tailors its bioeconomy initiatives to its distinctive strengths, showcasing Austria's focus on wood-based bioeconomy, Belgium's emphasis on sustainable agriculture, and Ireland's commitment to circular bioeconomy education.
7. Challenges persist in achieving seamless collaboration and policy coherence, emphasizing the complexities of aligning interests and priorities.
8. Stakeholder involvement, including industry associations, NGOs, and collaborative platforms, emerges as a critical element in shaping bioeconomy policies.
9. Ongoing debates and criticism, underscore a lack of consensus in the bioeconomy discourse. Among others, there are concerns about sustainability, governance of biomaterials and novel food products
10. Diverse funding sources for applied research and development, coupled with technology transfer initiatives, underscore the region's commitment to advancing bioeconomy technologies. However, policy instruments supporting commercialization and demand-side policies are fragmented
11. Challenges, including awareness, accessibility, and funding adequacy, necessitate a holistic approach with recommendations for enhancing outreach and simplifying application processes for broader SME access to funding support.
12. There is a significant range of activities of policy actors, clusters as well as firms to enhance cross-sectoral collaboration, which is nevertheless an ongoing challenge in this macro-region as well

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7 Comparison of Macro-Regions

In this deliverable, the bioeconomy state of play and activities were mapped in four EU macro-regions Western, Southern, Central and Eastern European and Baltic Sea macro-region. The 4 macro-regions have specific profiles which can be distinguished from each other. However, within each single macro-region, there exist also significant differences between the countries, so the macro-regions are not homogeneous on a country level.

Each macro-region comprises 6 to 8 of the 27 EU member states (table)[49] and covers approximately one fourth of the EU land area. However, the macro-regions differ from each other in their population density, with the Western MR being the most densely populated macro-region (44% of EU population). The Baltic Sea macro-region is the most sparsely populated one (6% of EU population), having a large land area available for a relatively low number of inhabitants. The Southern and CEE macro-region are close to the EU average regarding area and population.

Table 41 Assignment of EU member states to ShapingBio macro-regions

MR	No of EU countries	Countries	Area in million sq. km (Share of EU-27)	Inhabitants in million (Share of EU-27)
Western	7	AT, BE; GER, FR, IRE, LUX, NED	1.21 (29%)	195 (44%)
Southern	6	ESP, PT, MT, GRE, CYP	1.03 (25%)	129 (28%)
Baltic	6	DK, EE, FI, LV, LT, SWE	1.00 (25%)	28 (6%)
CEE	8	BG, CRO, CZ, HUN, POL, RO, SL, SK	0.88 (21%)	100 (22%)

Source: Own compilation.

The Baltic Sea MR also differs from the other three macro-regions with respect to the predominant source of biomass from primary production: While in the Western, Southern and CEE macro-regions, 76 to 85% of biomass is provided by agriculture, in the BSR only 41% is agricultural biomass and 59% comes from forestry. Therefore, forestry, wood products, furniture, construction, paper and fuelwood are economically very important in the BSR bioeconomy, especially in Finland and Sweden (45.8% of total GDP of BSR countries[50]). The CEE macro-region differs from the Southern and Western MR in the extent of converting their resource of agricultural biomass to value added products domestically: it is lower in the CEE macro-region.

[49] There are slight deviations in the assignment of member states to the CEE and BSR macro-regions in ShapingBio, compared to other existing assignments: The ShapingBio CEE macro-region differs from the BIOEAST initiative in the way that the CEE MR does not include the Baltic States Estonia, Latvia and Lithuania. In ShapingBio, these Baltic States are assigned to the ShapingBio Baltic Sea macro-region. The ShapingBio Baltic Sea macro-region differs from the Baltic Sea Region in that it does not include Russia (as it is a non-EU member state), and Germany is assigned to the Western macro-region in ShapingBio.

[50] https://datam.jrc.ec.europa.eu/datam/mashup/BIOECONOMICS/index.html

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7.1 Policy

7.1.1 Strategies and Governance

Bioeconomy is a broad concept which does not only cover many industrial sectors. It also requires transformative change from a linear fossil- to a circular bio-based economy and has close interlinkages with other policy fields. This makes development and implementation of holistic, coherent bioeconomy policy challenging, requires complex coordination efforts (typical for "wicked problems") and close collaboration between many actors. Although bioeconomy has been a policy priority on the EU level for more than a decade, this is not the case in all EU member states. The mapping yielded a broad spectrum of approaches that EU member states pursued towards a national bioeconomy policy:

a) Dedicated bioeconomy strategy: with/without action plan, time scale early to late adopters (e.g. Germany, Italy, Finland, Portugal), but in some cases not updated (e.g. the Netherlands, France).
b) No dedicated strategy, but dedicated policy initiatives and action plan or roadmap (e.g. Estonia)
c) Bioeconomy addressed within other strategies (e.g. Hungary)
d) Bioeconomy aspects addressed within other strategies, scattered (e.g. many CEE countries, Greece, Malta)

Which approach is chosen in a given member state seems to be country-specific. At least, no clear pattern per macro-region can be observed. However, the Western MR is the macro-region with the highest number of countries which chose approaches a) or b), and in the CEE MR, most countries can be assigned to approach d). They can be characterized by the absence of coherent dedicated bioeconomy policy frameworks which go beyond traditional sectors. However, there are activities ongoing to develop bioeconomy strategies in these countries.
Within each macro-region, the EU member states have reached different stages of bioeconomy policy development. Based on the qualitative and quantitative information collected in the mapping, the relative stage within a macro-region is tentatively indicated in Table 42.

Table 42 Achieved relative stage of bioeconomy policy development within a macro-region

Macro-Region	**Leading**	**Progressing**
Western	Germany France Netherlands Ireland Austria	Belgium Luxembourg
Southern	Italy Spain Portugal	Greece Malta Cyprus
Baltic Sea	Finland Sweden Denmark	Estonia Latvia Lithuania

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Central and Eastern Europe	Hungary Poland	Slovakia Slovenia Romania Bulgaria Croatia Czech Republic

Source: Own compilation.

Different stages of progression bear the opportunity of mutual learning, within and between macro-regions. A specific feature of the Baltic Sea MR and the CEE MR is that they each have a strong tradition of intra-regional cooperation at the macro-level: the EU strategy for Baltic Sea region and the BioEast Initiative, respectively, provide unique platforms for cooperation and coordination between the member states in both macro-regions.

In the mapping, the existence of formal or informal platforms for regular exchange between the involved policy actors (e.g. networks, inter-ministerial working groups) was taken as an indicator for bioeconomy policy coordination in the respective country. Such platforms were found in only so-me of the EU countries. They can therefore be considered as good practice towards overcoming complex coordination challenges in the bioeconomy. However, deeper analyses would be required to find out to which extent these platforms do not only serve information exchange between the involved bodies, but also lead to coordinated, joint and binding decisions and actions and integrated systemic approaches.

A challenge for policy-making in the bioeconomy are potential goal conflicts, e.g. land-use conflicts between food and feed, industrial and energy use, and environmental protection, biodiversity and habitat conservation, and how to fairly distribute benefits and burdens between certain actors along value chains, or between societal groups in general. As the bioeconomy implies a transformation of whole sectors, the integration of traditional labour force in new emerging, bioeconomy sectors is an additional emerging challenge. While these goal conflicts are in principle known and present in the European bioeconomy, the mapping showed that macro-regions differ to which extent these goal conflicts are in the centre of bioeconomy discussion and discourse. For instance, in the Western and Baltic Sea macro-region land use conflicts and socio-ecological implications are prominent topics in the discourse, while especially in the CEE MR – and to some extent in the Southern MR - more the enablers and barriers to the bioeconomy transition (e.g. structural change, general engagement in the bioeconomy) and economic implications are discussed.

Many socio-economic contributions to the debate of the bioeconomy transition direction have pointed out that different visions of bioeconomy exist. Therefore, stakeholders and political bodies do not necessarily have the same vision of a desirable bioeconomy and thus set different priorities which goals to achieve, which issues to address in which way. This poses a challenge to find balanced solutions to goal conflicts. In principle in all countries which developed dedicated bioeconomy strategies, efforts were made to involve stakeholders in the strategy development and to broaden the range of stakeholder beyond actors from science and industry. The stakeholders had to opportunity to comment drafts. However, most bioeconomy strategies do not address solutions to goal conflicts in detail and focus mainly on the different benefits the bioeconomy offers. Moreover, techno-centric and economic-growth-oriented visions appear to be predominant in the strategies in these countries. While in some countries, formal platforms for the inclusion of actors exist (e.g. cross-sector thematic commission (CTI) in France, Bioeconomy implementation group in Ireland, Circular Flanders in Belgium), some other countries remain very vague regarding proactive stakeholder engagement.

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7.1.2 Policy instruments

The existence or non-existence of a dedicated bioeconomy strategy is only an indicator or proxy for bioeconomy policy development in the countries. The practical implementation of policy and support measures may play a larger role than the existence of a formal strategy. However, implementation is more difficult to map as only a few countries have published an action or implementation plan (Ireland, Austria, France) or are in the process of developing one (Germany). Therefore, bioeconomy mapping in ShapingBio aimed to identify relevant policy instruments.

Only few countries (DE, AT, IE, ES), all from either the Western or Southern MR, have two or more policy instruments specifically dedicated to bioeconomy, and few countries (e.g. IT, FI, PT) have only one bioeconomy-specific policy instrument. So, in the majority of MS no dedicated bioeconomy policy instruments seem to exist. Rather, almost all MS have policy instruments in place such as programmes to foster specific sectors (e.g. agri-food) or open programmes (e.g. for R&D, regional development) that in principle can also support bioeconomy activities. However, it could not be identified in this mapping exercise which share of these instruments is actually devoted to bioeconomy.

More generally for dedicated and related instruments, although bioeconomy policy is evolving in the MS, there is a low dynamic regarding new policy instruments. Almost all dedicated bioeconomy policy instruments are public support for research or grants for industrial R&D. Only few instruments could be identified that support activities on higher TRL levels (in Germany and Ireland), or that address also network activities (e.g. in AT, DE, IT, IE). No national equity funding instruments exist on the member states level which are comparable to the Circular Bioeconomy Funds on EU level. Moreover, hardly any dedicated demand-side instruments (e.g. public procurement, enabling regulation, support of private demand) are in place for the bioeconomy, the only exceptions being Ireland.

Countries which follow approaches a) or b) with respect to bioeconomy strategy (see above), also seem to be more active in implementation. However, the measures implemented in these countries do not yet cover fully the high ambitions and goals that the bioeconomy strategies claim. Therefore, implementation of the bioeconomy strategies by appropriate policy mixes is an ongoing issues in many of the Member States that have such a strategy.

In conclusion, the bioeconomy policy landscape in EU member states is to some extent diverse, but still in evolution. For more advanced countries the questions arise how strategies are practically implemented and how to improve in horizontal coordination within bioeconomy policy and other policy fields, and how to mobilize regions. In other countries, across all MR, which are in the process of catching up in developing a coherent bioeconomy policy, the question arises what and how they can learn from more advanced countries. This will be subject of the analysis in the forthcoming workpackage 2 of ShapingBio.

7.2 R&D, tech transfer, bioeconomy innovation, scale up

The transition to a bio-based circular bioeconomy requires knowledge-intensive innovations. Therefore, R&D, technology transfer and scale-up of innovative processes and products to industrial scale can be considered a prerequisite for the industrial deployment of bioeconomy.

The mapping in this deliverable together with the results of the EU-mapping in Deliverable 1.2 of ShapingBio revealed significant differences between the four macro-regions regarding indicators for their ability to innovate and scale-up (Table 43).

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Table 43 Innovation indicators: Shares of the macro-regions

MR	HE cluster 6 funding*	CBE funding*	Patents*	Open pilot plants
Western	54%	49%	75%	57%
CEE	6%	6%	3%	6%
Southern	29%	33%	16%	17%
Baltic Sea	11%	12%	15%	20%
EU 27	**100%**	**100%**	**111%**	**100%**

Source: Results of this Deliverable combined with results from Deliverable 1.2 (indicated with *).

The Western MR takes a leading role. It has a robust, well-developed infrastructure of universities, research centres and industries, and active associations for bioeconomy research. There is a strong support towards high-tech university spinoffs. The R&D in the Western MR covers the entire bioeconomy. It seizes CO2 utilization and alternative proteins as emerging opportunities. R&D capabilities are strong in all MR countries. It leads both in acquiring EU funding, operating open pilot plants for scale-up and patenting activities. Moreover, EU funding is to a significant extent also complemented by national funding of R&D&I activities, coupled with technology transfer initiatives.

The CEE MR is currently positioned at the other side of the spectrum: all in all, the innovation performance is below the EU average, due to a specialization in low-tech traditional sectors, limited R&D capabilities and a lack of R&D infrastructures, such as open pilot plants, and a brain drain of skilled professionals due to low attractiveness of domestic careers. However, total expenditure on R&D is increasing, albeit from a low level, and a foresight exercise conducted in this macro-region has identified issues and challenges and a specific plan for the improvement of the situation is already in place. Although the macro-region is rich in biomass as a feedstock for bioeconomy, the prerequisites seem to be lacking to valorize this resource domestically.

With respect to the innovation indicators, the performance of the Southern macro-region is in the range that can be expected from their population share in the EU. The MR is relatively strong in acquiring EU funding and thus compensates a relative lack of national funding for bioeconomy R&D. Knowledge generation and technology development is supported by universities and research centres. Several clusters and technological platforms facilitate collaboration and knowledge exchange. Most of the technology transfer is taking place in technological poles and depends on accelerator or incubator programmes. There is a divide within the MR: the innovation capacity is mainly determined by Italy and Spain, whereas Greece, Portugal, Malta, and Cyprus are weaker with respect to infrastructure for development and scale-up of technologies in the bio-based industrial sector. The relatively low share of patents and open pilot plants in the MR could indicate a relative lack of integration of academic and industrial activities. Therefore, the strengths in academic R&D are not yet transferred fully to exploitation in industry.

The Baltic Sea MR is relatively strong in innovation per capita: its shares of EU HE cluster 6 funding, CBE funding and patents are twice as high as one would expect from the share of inhabitants (6%). The BSR has a solid infrastructure of universities, research centres and industries, and active associations for bioeconomy research. There is a strong support towards high-tech university spinoffs. The R&D in the BSR covers the entire bioeconomy. There is also a divide within the MR: The Baltic States show a lower level of R&D and technology transfer than the Scandinavian countries. Yet, each of the BSR countries specializes in different

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areas of bioeconomy: health sector and food based on proteins (Denmark), biotech (Lithuania), circular economy and cleantech (Finland), bioenergy and innovative bio-based sectors predominantly based on wood (Sweden).
The mapping of applied R&D and technology transfer activities showed that more in-depth analyses of the alignment of academic R&D with industry priorities and demand, the support of innovative SMEs and the scale-up of bioeconomy R&D to industrial deployment would gain important insights to improve the EU bioeconomy ecosystem.

7.3 Industrial deployment and cross-sectoral collaboration

Bioeconomy is expected to contribute significantly to mitigating climate change, increase resource efficiency, transition to a circular economy, regional development, employment and wealth. These impacts can only be achieved if knowledge and technologies are transferred to and exploited by industry.
The mapping showed significant differences between the four macro-regions regarding economic performance in bioeconomy.

Table 44 Economic performance in bioeconomy per macro-region in shares

Macro-region	**Biorefineries**[51]	**Bioeconomy value added**	**Bioeconomy employment**
Western	49%	49%	29%
CEE	11%	14%	39%
Southern	16%	28%	26%
BSR	24%	10%	6%
EU 27	100%	100%	100%

Source: JRC data, see chapters 2-5 above.

The Western MR is of high economic significance in the EU bioeconomy: Half of all EU biorefineries are located in this MR. The MR is characterized by a dynamic industrial landscape with dedicated companies, SMEs and start-ups, as well as large corporations having bioeconomy as part of their portfolio, supported by industrial associations. The MR also has a well-developed cluster structure which, among others, foster cross-sectoral collaboration. Industry and clusters are active in all relevant sectors of the bioeconomy. In line with the well-developed industrial landscape, also half of the EU value added in bioeconomy is generated in the Western MR. The bioeconomy employment share is remarkably low. This is an indication that industry has a focus on knowledge-intensive and feedstock-valorizing activities rather than on labour-intensive activities with low value added. Stakeholders such as industry associations, NGOs, and collaborative platforms, are involved in shaping bioeconomy policies.
The contribution of the Southern MR to the EU bioeconomy in terms of value added and employment is consistent with its share of the EU population. The southern macro-region employs policies, financing, R&D programmes, public-private platforms, tax incentives, and European programmes to promote inter-sectoral collaboration in bioeconomy projects. However, the share of open pilot plants and biorefineries is

[51] Biorefineries comprise a wide range of plants, from innovative, recently built biorefineries in which the newest principles of circular economy are applied, to very traditional, decades-old plants obtaining products from biomass (e.g. some timber, paper, or starch plants).

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comparably low. This may be an indication that a significant part of value added and employment is due to primary production in agriculture, and that opportunities could lie in higher domestic valorization of agricultural or marine biomass.
Although the CEE countries have a high amount and quality of agricultural biomass, they lack smart, value-adding, and sustainable value-chains to valorize this resource domestically. Agriculture is of high importance, especially in Romania and Poland, but in general is characterized by a low level of productivity and a high number of employees. Opportunities for change lie in the still untapped potential of valorizing agricultural residues and by-products in production, processing and consumption, the increase of biorefinery capacities, changing traditional practices and mindsets, and raising the awareness of opportunities for circular technological solutions and business models, both in industry and policy.
The BSR bioeconomy is dominated by the forest industry and the products created by the forest as raw materials. Other important sectors are agriculture and food, biotechnology, and bioenergy (from forestry) industries as well as the blue bioeconomy as an emerging field. It also features a solid chemical industry (from forestry). The BSR has a well-developed cluster structure: most industrial sectors have their own cluster representation. The majority relate to biotechnology, energy, food, paper and pulp, and waste. Finland also has many water expertise clusters, ecosystems, and networks. In the Baltic Sea MR, the share of bioeconomy employment is in line with the low share of EU inhabitants. However, the high share of biorefineries and added value is remarkable: The value added per person employed in the bioeconomy sectors in the Baltic Sea MR is almost double the value of the EU-27 average. But it mainly comes from the Scandinavian countries which differ significantly in their structure from the Baltic States, as the former host the majority of biorefineries. The Scandinavian countries (DK, FI, SE) also show strong cross-sectoral collaboration especially related to wood, agriculture, food, and fisheries sectors. Therefore, the bioeconomy sectors in Denmark, Finland and Sweden generate relatively more value added than the bioeconomy sectors in Estonia, Latvia, and Lithuania. In the latter, the added value was generated mainly by the traditional sectors. Most of the raw materials are exported and higher-level processed products are imported. They are lacking smart, value-adding, and sustainable value-chains, and there is a lower level of cross-sectoral collaboration. In the Scandinavian countries, by contrast, the novel bioeconomy sectors generate a significant part of the total added value: most of the biomass supply comes from the forestry sector (woody and lignocellulosic biomass) and is turned into products mainly timber, biomethane, pulp and paper, bio-based chemicals and liquid biofuels.
In all MR, the lack of a qualified workforce contributes to a slower industrial exploitation of bioeconomy knowledge and technologies, but for different reasons. In the Western MR, other sectors and industries are more attractive to talents than bioeconomy sectors, CEE countries and Baltic States suffer from brain drain of qualified workers who prefer to work abroad, in the Baltic Sea Region the imminent retirement of the aging workforce is a challenge, and in the Southern MR, the mobility of qualified personnel from academia to industry is not high enough.

7.4 Financing of industrial R&D&I activities and investment

In many EU member states, publicly funded R&D grants for industry are available. In most cases, these are general R&D grants, not specifically dedicated for bioeconomy. The situation is comparable for equity financing: in each MR, some MS have equity financing instruments available, which also address a broad set of sectors and technologies, not specifically bioeconomy. The Western MR tends to have a higher amount to financing possibilities and support for companies. By contrast, for the Southern, Baltic Sea and CEE macro-regions, the different EU funding sources for bioeconomy are identified as highly important opportunities.
The analysis of private financing rounds presents no clear picture regarding funding sources across the EU. In all countries with a significant number of funding rounds, a large variety of funding sources emerges.

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Moreover, rather in all countries the financing situation in earlier TRL stages and overall is in rather similar relation to each other, meaning countries with high amounts raised in early stage funding rounds are the same that perform best in total reported amounts across all development stages.
In the countries of the Western MR, the financing situation appears rather homogenous in relation to the population of the countries. Moreover, there is also high similarity in the proportions in the investment amount related to the number of investment rounds between the countries. Hence, in average the amount raised per investment is rather equal. And in almost all countries of the Western MR, Series B funding plays a higher role measured in percent of total amount raised compared to the other macro-regions.
The Baltic Sea MR also achieves a high total amount and a large number of investments and clearly outpaces the Southern MR, although it has to be kept in mind that especially in Denmark and partly Estonia this is mostly due to a very few large deals. Moreover, in the Baltic Sea MR public grants are a notable part of the financing rounds in both modest and developed innovation systems in Denmark, Finland, Lithuania and Sweden.
In the CEE MR the financing situation appears most difficult for all sources including public and national private financing as well as foreign direct investment. All countries in this MR show a limited number of investment rounds and amount raised, with the exception of single financing rounds, e.g. in the Czech Republic.
Despite some differences in the amount of funding opportunities, companies face similar challenges across the EU: In principle, there is a range of funding options. However, especially for SMEs there are challenges regarding awareness, accessibility, and funding adequacy as well administrative hurdles. In ShapingBio in deliverable D1.1 a set of hurdles for SME financing have already been identified, but more in-depth analysis is needed to develop differentiated recommendations.

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Annex: Country Fiches

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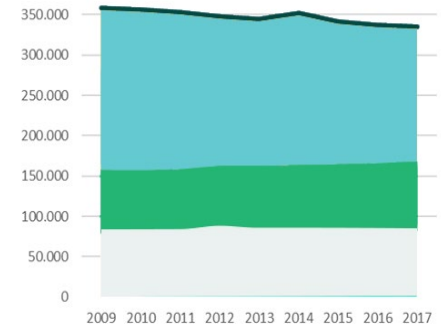
Bioeconomy country file

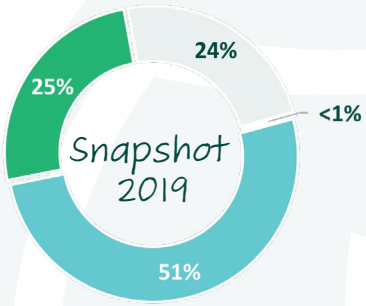
Austria

Austria sets the goal to become one of the technology leaders for wood, pulp and fiber products. Hence, the bioeconomy in Austria is based on its advanced wood industry that plays an important role for the National Bioeconomy Strategy and related policy instruments and collaborative structures. Under the framework of its national strategy, the «Bioeconomy Austria» is the most important initiative of its bioeconomy development as it serves as a platform for the network of important actors and as a future bioeconomy lighthouse cluster in Austria.

Bioeconomy: persons employed by sector

Evolution 2008-2019

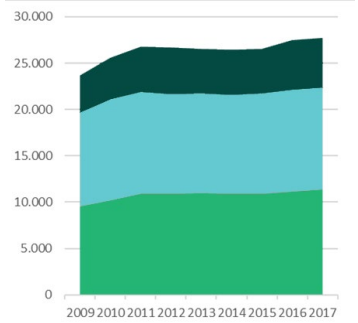


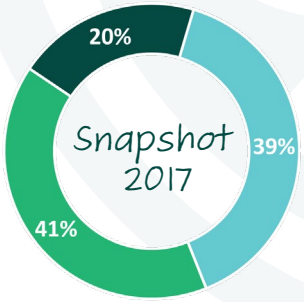


Total
Primary production
Bio-based products
Food and beverage
Bio-based energy/fuel

Biomass consumption by source

Evolution 2009-2017





Materials
Energy
Food (including inputs)

Publication date
2019

Responsible authorities

Ministry for Sustainability and Tourism (BMNT), Ministry for Transport, Innovation, and Technology (BMVIT), Ministry for Education, Science, and Research (BMBWF)

Austria
National Bioeconomy Strategy

Austria published its first bioeconomy strategy in 2019 and was initiated as an interdepartmental project between BMNT, BMVIT and BMBWF under the framework #Mission2030. The Strategy focuses on three layers: (1) increase of efficiency at all levels of the value chain (2) exploitation of renewable raw material sources through residues, by-products or wastes (3) Highlighting opportunities, which arise in replacing fossil fuels.
As part of the strategy, Austria also published an implementation plan, which addresses different action fields with concrete measures in different areas (e.g. agriculture, bioenergy)

Dominant sectors
Wood Industry
Biotechnology
Recycling Industry

Other related strategies
- Circular Economy Strategy Austria
- FTI-Strategy 2030
- Energy, Research, and Innovation Strategy
- Bioeconomy Implementation Plan

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Bioeconomy country file

Austria

Policy instruments

Bioeconomy Austria

Aims to develop a bioeconomy cluster in Austria with 10 partner organization and serves as network for over 200 organizations acting in the Austrian Bioeconomy.

AI for Green

Public funding program is focused on Artificial Intelligence and Environmental protection and includes measures for climate protection and conservation of biodiversity

Ökoscheck

Enables SMEs and non-profit-organizations to improve their climate-neutral and sustainable economic acting (CO2- Reduction, secure supply for renewable energies)

Green Frontrunner

Focus on societal challenges such as food security, climate protection or conservation of biological diversity.

Forest Fonds

With the forest Fonds, the Austrian government invests 350 million Euro into ten measures, which target the whole supply chain of Forestry, Timber, and Pulp. The measures include forest restoration, climate-fit forests or usage of raw materials.

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Bioeconomy in Austria
Collaborative structures

Ecoplus – Platform for Green Transformation and Bioeconomy

Aims to develop Niederösterreich as European Showcase for the bioeconomy, green transformation and circular economy (information turntable and networking). transition of the chemical industry towards climate neutrality and circularity.

Business Upper Austria

Standard agency specialized on wood value chains. Aims to develop solutions for mitigating resources and energy shortage. with medium-sized businesses.

Pro:Holz Tirol

Aims to strengthen the cooperation between companies for product development and is fostering networking of different research institutes. Serves as information provider for consumers and public decision-makers.

BioBase

Innovation platform for bioeconomy and circular economy that is information turntable for Economy, Science, Public Administration and Politics.

Wood Cluster Steiermark

Advising cluster partners and supporting companies from the forestry and wood sector towards success. Serves as agency for networking of companies, research institutes and decision-makers.

Showcase

Bioeconomy Austria

Bioeconomy Austria aims to foster cross-sectoral collaboration in the bioeconomy. Over 200 organizations are already part of the network (Members include Industries, Research and Development, interest groups)

The initiative is a lighthouse project of the National Bioeconomy Strategy in Austria and is funded under the Wood fonds. 10 Partner organizations are developing a national bioeconomy cluster until 2024. Throughout the project, different topic-wise regional hubs will be developed in Niederösterreich, Oberösterreich, Salzburg, Tirol and Steiermark. Each of these regional hubs are networking and adopting topics in a way that it addresses macro-regional and national dimension.

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Bioeconomy country file

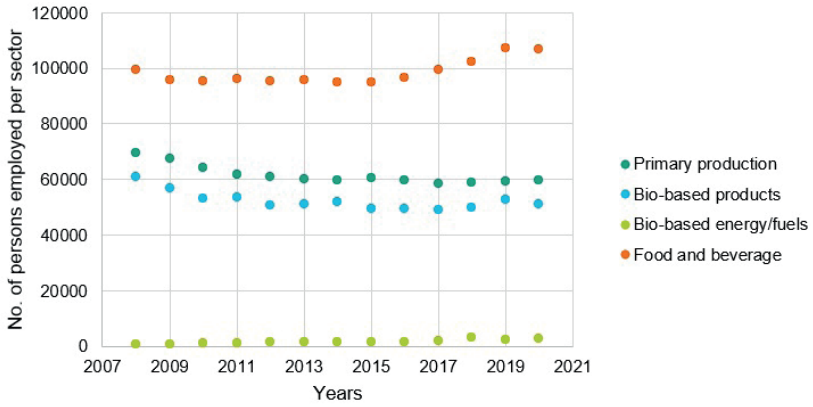
Belgium

Belgium has made significant progress in developing its bioeconomy. Using its agriculture sector and research capabilities, the country actively expands its focus on sustainable use of biomass, including agriculture, forestry, and waste streams. The Belgian bioeconomy stands out for its emphasis on research, innovation, collaboration between academics and business, and the use of renewable resources for long-term economic growth.

The primary goals of this bioeconomy are to encourage the development of bio-based industries, improve resource efficiency, and facilitate the transition to a low-carbon economy. A regional (subnational) bioeconomy strategy exists in Belgium (Flanders). Flanders, as well as Wallonia and the Brussels regions, benefit from various policy instruments and collaborative structures at a regional level.

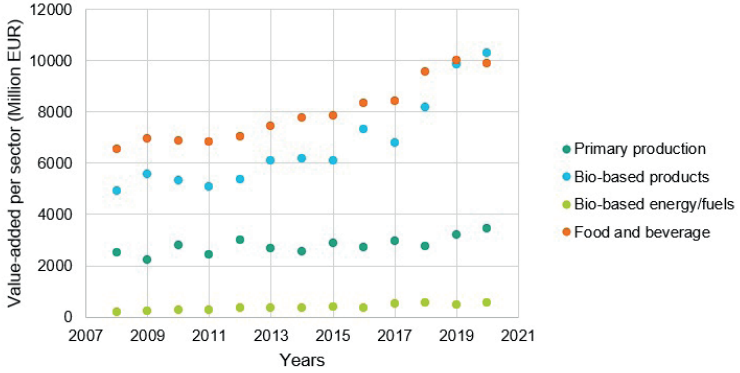
Number of persons employed per sector in Belgium

Evolution 2020-2028



Value-added per sector in Million euros in Belgium

Evolution 2008 - 2020



Policy instruments

Prohibition of the use of certain biomass feedstocks for bioenergy

Some EU countries like Belgium, Finland, and the Netherlands have prohibited the use of certain biomass feedstocks for bioenergy. Belgium and Hungary aim to ensure that the use for energy is the last step in the use hierarchy of biomass feedstocks. This is being referred to as the 'cascading principle' and is derived from EU's Waste Framework Directive (Directive, 2008/98/EC) in which it is referred to as the 'waste hierarchy'.

Tax regulation mechanism for biofuel producers from rapeseed oil

The Decree provides for the support of biofuels production through an excise duty exemption. The fuel from rapeseed oil produced by a physical or legal person that directly sells its production to the end consumer without intermediary can be exempted from excise duty. The exemption equals the excise rate of the fuel the rapeseed oil replaces. The following conditions apply:

Rapeseed oil shall be used as a biofuel

The natural or legal person producing the rapeseed oil shall sell it to the end consumer without intermediary

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Bioeconomy country file

Belgium - Flanders

Duration

2020 - 2023

Responsible authorities

Flemish Governement (Non applicable for Blegium, Wallonia and the Brussels Capital Region)

Belgium

Flanders' Bioeconomy

The plan emphasizes research, innovation and cooperation between industry and agriculture.

The plan contains three strands: research, innovation and stimulating closer cooperation between industry and agriculture. It is precisely in innovative collaborations between these sectors that there is still much potential for new sustainable activities. The strategy aims to strengthen the position of Flanders as a leading region in bio-based innovation, research, and production. It emphasizes the sustainable utilization of biomass resources, the development of biorefineries, the creation of new bio-based value chains, and the promotion of research and innovation in the bioeconomy.

Other related strategies

Bioeconomy in Flanders

Bio-economy: van ambitie tot actie

Showcase

Bio Subsidy Program for Bio-based Applications Pilot Testing

VLAIO, the Flemish Agency for Innovation & Entrepreneurship, provided subsidies to support SME's in the industry, primary agriculture, and aquaculture sectors for piloting bio-based applications. The subsidy covered 35% to 45% of approved project costs, ranging from €20,000 to €100,000.

Eligible businesses needed legal registration and operational activities in the Flemish Region. Both private companies and non-profit organizations were eligible. Size classification followed the European definition of SME, which considered specific criteria related to employment, turnover, and balance sheet values (small: <50 employees or <€10 million turnover/balance sheet total; medium: <250 employees or <€50 million turnover/€43 million balance sheet total).

Supported projects aimed to pilot and demonstrate bio-based applications with sufficient maturity but lacking immediate commercial potential. Projects focused solely on registration or certification costs of already developed products, as well as those too advanced in industrialization or commercialization, were not eligible. The duration of approved projects was capped at one year, with a possibility of extension up to two years, subject to justification. The subsidy was calculated as a percentage of the approved project budget, with 45% for small enterprises and 35% for medium-sized enterprises. The subsidy granted was limited to €8,000,000 cumulatively in the current calendar year.

The subsidies provided by regional governments, including this program, have been exempted from vennootschapsbelasting (corporate tax) since January 1, 2007.

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Bioeconomy country file

Belgium - Flanders

Policy instruments

Generic R&D instruments

Companies and research institutes can apply for subsides to conduct R&D. Subsidy percentages vary according to the maturity of the project.

Superhead cluster policy

It is a network support structure for different sectors to create R&D consortia and is linked with an earmarked R&D budget.

Flanders Future Tech Fund

Non-bankable projects risk not to find funding at conventional institutes. So, pilot installations do not find funding and are not built. The Flanders Future Tech Fund was created to bridge this gap. The FFTF funds pilots to industrialize these solutions. The business model of the plant has to private, and the income is generated not by sales, but by IP and licensing of the developed solutions.

Moonshot policy

The moonshot programme wants to develop new technological solutions to enable Flemish industry to become carbon neutral by 2050. So long-term risk research is needed.

B2BE facilitator

The B2BE facilitator brings entrepreneurs from agriculture, horticulture, marine and food industry together with industrial partners around GREEN INNOVATIONS in the carbon neutral economy.

Bioeconomy in Flanders

Collaborative structures

CATALISTI (Flanders innovation cluster for the Chemical Sector)

Actively contribute to sustainable and competitive chemical & plastics industries, as well as related sectors in Flanders, by working on new value chains, improved innovation power, clustering knowledge, and a sustainable economy

The Blue Cluster (Flanders' innovation cluster for the marine sector)

The Blue Cluster gathers public and private partners to create transformative innovation projects for the marine sector. This includes the cultivation and transformation of algae for innovative applications, and the upgrading of fisheries waste streams and organic streams from marine sources.

Flanders' Food (Flanders innovation cluster for the agro-industrial Sector)

A central point of contact for businesses, social profit organizations, knowledge institutes and authorities in the strategic domain of the agri-food industry within the Flemish innovation system.

SIM (Strategic Initiative Materials)

SIM is a non-profit organization looking to strengthen the competitive position of the materials industry in Flanders. Service of companies, knowledge and research institutions interested in innovative materials technology for applications in the field of energy & light, durable & sustainable structural materials and nanomaterials. The recyclability and sustainability in general of these material developments are a prerequisite.

FLUX 50 (Flanders innovation cluster for the energy Sector)

Flux50 is the membership organization that helps Flanders gain international recognition as a Smart Energy Region. Flux50 facilitates cross-sector collaboration between energy, IT and building companies to enhance the competitiveness of the Flemish smart energy industry in the transition towards low-carbon systems.

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Bioeconomy country file

Belgium - Wallonia

Policy instruments

Generic R&D instruments

The Walloon region offers funding to companies as well as universities and research institutions interested in developing R&D projects. Companies incorporated in the Walloon Region are eligible for an advance of up to 70% of their investment expenses for projects involving applied research or technological advancement (Article 17, Décret du 3 juillet 2008). Universities and research institutes can benefit from calls for tenders published by the Department of Energy and Sustainable Building (DG04) and by the Department of Economy, Employment and Research (DG06) of the Public Service of Wallonia

Superhead cluster policy

The investment costs eligible for financial assistance must be at least € 25,000 (Article 7 3 Arrêté du 2 décembre 2004).
The subsidy is computed by comparing the expenses of traditional energy production plants with the same capacity to the additional costs borne by companies.
The amount of the subsidy varies depending on the company:
Maximum 50% of investment costs can be funded for small and medium-sized businesses. Furthermore, the total amount of the subsidy over four years cannot exceed € 1.5 million (Art.9 2 Arrêté du 2 décembre 2004). Maximum support for large companies is 20% of investment costs.
If the enterprise is in a development zone, the total amount can be increased by 5% or 10% depending on the province (Art.9 2 and 4 Arrêté du 2 décembre 2004).
In the case of hydropower, the subsidy is based on a maximum investment amount of € 5,000 per kW for installations with capacities greater than 100 kWp, and a maximum investment value of € 9,000 per kW for installations with capacities less than 100 kWp.

Brussels

Policy instruments

Brustart (financing of young innovative companies)

Companies of less than five years can receive support of up to EUR 250,000 in the form of a loan or participation in capital for the implementation of their business plan. Brustart is an evergreen fund with EUR 10.5 million equity provided by finance.brussels and the region. Overall, EUR 2.460 million have been invested in 17 projects in 2017 under Brustart, and EUR 2.242 million have been invested in 17 projects in 2018 under Brustart and Bruseed.

Bruseed (financing of innovative companies in pre-commercialisation phase)

Innovative SMEs of less than five years can receive support of up to EUR 250,000 in the form of a loan or 37 participations in capital with a view to put their innovative products on the market (launching stage). Bruseed is managed by Brustart and the funding is provided by the region and by the ERDF for a total of EUR 6.1 million (2018-2023).

Bioeconomy in Wallonia

Collaborative structures

Coq Vert

The «Coq vert» initiative is aimed at recycling biomass materials from non-food resources (by-products, residual products, waste etc.) and puts second-generation bio-refineries right at the heart of the long-term development of these sectors in Wallonia. Opportunities with the potential to lead to research and innovation projects as well as investment or even training projects are assessed. A medium-term strategy is also under development to encourage the growth of bio-refineries in Wallonia

TWEED Cluster

The mission of the TWEED Cluster is to promote investment, innovation, development and value in sustainable energy production and exploitation, by mobilizing and acting as a facilitator between industry, knowledge institutes and governments, in this sector, around projects

Wagralim

Wagralim puts you in contact with industrialists, service and equipment companies, institutional and academic partners, and research and training centres in Belgium and abroad.

Plastiwin

Plastiwin brings innovative projects to the fore, supports the market introduction and enhances the value of the plastics industry. They create a dynamic exchange between their members to allow more technology and skills transfer, facilitate access to contractors by increasing the visibility of the value chain and by communicating about Wallonia's technological potential. Public awareness of the innovative, sustainable and circular nature of the plastics industry is raised.

GreenWin (Coq vert partner)

Boosting and fostering investments in the bioeconomy. GreenWin has firmly given itself the mission to «engineer encounters that open up the innovative paths of the future»: It is an accelerator of innovative and collaborative industrial projects. It gathers different protagonists from the worlds of economics and academia to bring about and implement the technological innovations able to generate regional economic development.

ValBiom (Coq vert partner)

As part of its public mission, Valbiom acts as a territorial facilitator of the transition towards a biobased economy. For personalised accompaniment, Valbiom also offers support and consultancy services.

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Bioeconomy country file

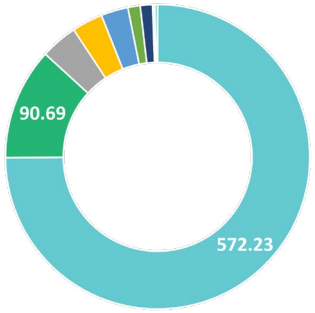
Bulgaria

Bulgaria's bioeconomy features a landscape where agriculture and forestry covers a substantial portion of the land available for biomass production (57%). The agricultural sector plays a prominent role in domestic biomass production, contributing significantly to the country's bioeconomy. Despite this, Bulgaria's R&D intensity in the bioeconomy sector remains relatively low at 0.8%.Bulgaria's bioeconomy relies primarily on its agricultural sector and woodlands for biomass production. However, with limited R&D investment in the bioeconomy, the country faces a challenge in further development and valorization.

Bulgaria's objectives for the bioeconomy include mainly support for biomass production, digitalization and knowledge transfer for bioeconomy, and promotion of sustainable practices in a broader sense, including the bioeconomy sector. Increasing R&D investment to stimulate innovation and technological advancements in biomass utilization is less pronounced. The main document is the Strategy and Action Plan for the transition to a circular economy of the Republic of Bulgaria for the period 2022-2027

Bioeconomy: persons employed by sector

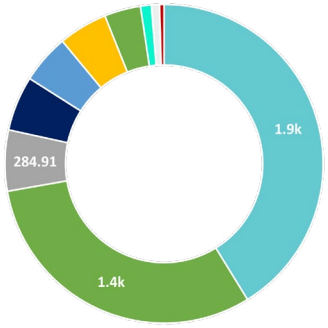
2020



- Agriculture
- Bio-based textiles
- Forestry
- Bio-based chem/ pharma/plastics
- Liquid biofuels
- Food, beverage
- Wood products and furniture
- Paper
- Fishing and aquaculture
- Bio-electricity

Value added by sector (million €)

2020



- Agriculture
- Bio-based textiles
- Forestry
- Bio-based chem/ pharma/plastics
- Liquid biofuels
- Food, beverage
- Wood products and furniture
- Paper
- Fishing and aquaculture
- Bio-electricity

Publication date

2022

Responsible authorities

Ministry of Environment and Water

Bulgaria

Strategy and Action Plan for the transition to a circular economy 2022-2027

Dominant sectors

Agriculture

Food, Feed and Beverages

Waste and water management

The strategy sets out 3 objectives: a green and competitive economy; less waste and more resources; an economy that benefits consumers. Specific measures are planned, with implementation focusing on correcting imbalances and overcoming obstacles to achieving the objectives.

Measures from 2024-2027 encompass funding for resource-efficient technologies, support for SMEs in eco-design, the establishment of re-use centers, and vocational training for vulnerable groups in repair-related activities.

Permanent measures throughout the Action Plan period include private sector involvement in waste recycling, waste prevention, new waste technologies, controls on unregulated waste disposal, support for renovation companies at re-use centers, and advanced waste separation and treatment technologies. R&D activities are mentioned but less integrated.

Other related strategies

- Draft Integrated Energy and Climate Plan of the Republic of Bulgaria (2018)
- National Development Strategy 2030 (2020)
- Innovation Strategy for Smart Specialization (2022)

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Bioeconomy country file

Bulgaria

Policy instruments

Strategic Plan for Development of Agriculture and Rural Areas 2023-2027

Encompasses almost all sectors of bioproduction and agriculture while the means for R&D remain less supported.

National Action Plan for Bioproduction

Supports organic bioproduction, utilization of biomass by-products, employment

Aquacultures and fishery Program

Addresses support to fishery, aquacultures and processing; blue economy and environment protection, R&D, energy and resource effectiveness and circular economy; digital technologies and quality.

Rural Areas Development Plan

Addresses support to rural areas, like measures to increase employment, digitalization, improvement of human resources, including bioeconomy sectors.

Fund of funds

Fund Manager of Financial Instruments in Bulgaria (FMFIB) operates as a Fund of Funds (FoF); it allocates targeted public funds from European Union programmes and national co-financing, using special financing schemes (financial instruments), including for bioeconomy sectors.

Bioeconomy in Bulgaria

Collaborative structures

AgroHub

Development of the agri- and food sector , potential for access to technological solutions and services supporting digitalisation, support to farmers and companies for process automation, resource efficiency, smart production.

BESCO – The Bulgarian Entrepreneurial Association

Acts as a bridge between startups, private and institutional investors, the govt. and other stakeholders in the innovation industry. Ist role is to upgrade the current Bulgarian legislation and propose contemporary market-driven policies based on innovation and progressive thinking, access to talent, access to capital.

Tech Tour

Community platform that connects tech entrepreneurs with investors, experts, coaches, and regions to realize their bold ambition and build successful partnerships, Event management, market information, community building, stakeholder involvement

Export Hub Bulgaria

Market entry support, events, knowledge transfer & market information, access to programmes for export potential development for Bulgarian SMEs, Knowledge transfer, supporting SMEs to access international markets

Agrarian University – Plovdiv

National centre of agricultural science and education in Bulgaria; TTO, research, sectorial development support, scientific support to policy making

Showcase

Mission Green Bulgaria

MOVE.BG initiated Green Restart Coalition that brought together over 50 of Bulgaria's leading experts in the fields of innovation economy, energy transition, bioeconomy and biomass, smart cities, nature-based solutions and sustainable finance, motivated by the desire to turn Bulgaria into one of the green and innovative leaders in Europe

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Bioeconomy country file

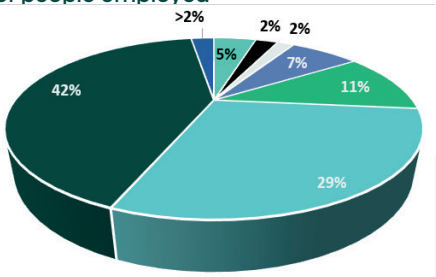
Croatia

Croatia's bioeconomy has a significant part on the national economy holding great potential for development and demonstrating notable advancement in recent years. Leveraging its agricultural prowess and research expertise, the bioeconomy in Croatia proactively expands its horizons toward sustainable biomass utilization encompassing agriculture, forestry, and waste management. The Croatian bioeconomy is supported by commitment to research, innovation, fostering collaboration between academia and industry, and harnessing renewable resources to drive lasting economic prosperity.

At its core, the Croatian bioeconomy emphasis is on bio-based sectors optimizing resource efficiency, and facilitating the shift towards a low-carbon economic model. Noteworthy is the presence of regional (subnational) strategies that further bolster the bioeconomic landscape in Croatia. The key document strategizing the development of Croatian bioeconomy now is the National Development Strategy of the Republic of Croatia until 2030, while a dedicated bioeconomy strategy and action plan are under development.

Employment by sector in Croatia (2020)

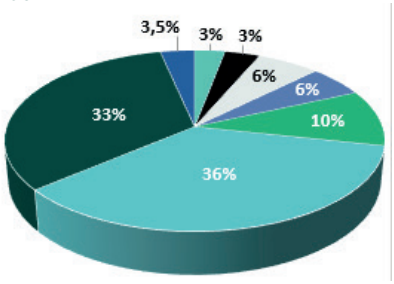
Number of people employed



- Agriculture (84.6k)
- Food, beverage and Tobacco (59.7k)
- Wood product and furniture (22.37k)
- Forestry (14.3k)
- Bio-based chemicals, pharmaceuticals, plastics and rubber (3.57k)
- Paper (4.73k)
- Bio-based textiles (9k)
- Fishing and aquaculture (4.88k)

Value added by sector in Croatia (2020)

Million euros



- Agriculture (1.22k)
- Food, beverage and Tobacco (1.32k)
- Wood product and furniture (375.18)
- Forestry (208.1)
- Bio-based chemicals, pharmaceuticals, plastics and rubber (230.83)
- Paper (129.17)
- Bio-based textiles (111.48)
- Fishing and aquaculture (126)

Source: https://datam.jrc.ec.europa.eu/datam/mashup/BIOECONOMICS/index.html

Duration

Until 2030

Responsible authorities

Ministry of Regional Development and European Funds

Croatia has a national strategy for bioeconomy. Its objectives are to increase the productivity of agriculture and aquaculture and their resistance to climate change in an environmentally acceptable and sustainable way; to contribute to climate neutrality, to reduce the use of pesticides and increase organic production in accordance with the new EU directions within the framework of the Green Deal, the Field-to-fork Strategy and the EU Biodiversity Strategy, to strengthen competitiveness and innovation in agriculture and aquaculture and to revive rural areas.

Croatia

National Development Strategy of the Republic of Croatia until 2030

Dominant sectors

Agriculture
Forestry
Fishing and aquaculture
Textiles
Bioenergy & Biofuels
Food, Feed & Beverages

Other related strategies

- Croatian Smart Specialisation Strategy S3 (2016– 2020).
- Dedicated Bioeconomy Strategy at national level under development (as of April 2022).

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Bioeconomy country file

Croatia

Policy instruments

Rural Development Programme of the Republic of Croatia for the Period 2014-2020

It is a document defining 16 measures aimed at increasing the competitiveness of Croatian agriculture, forestry and processing industry, as well as improving the living and working conditions in rural areas.

Operational Programme for Maritime Affairs and Fisheries of the Republic of Croatia for the programming period 2014-2020

Programme objectives: to promote a competitive, environmentally and economically sustainable and socially responsible fisheries and aquaculture sector, balanced and inclusive territorial development of fisheries and aquaculture areas and to foster the development and implementation of the Integrated Maritime Policy of the European Union.

Croatian Agency for SMEs, Innovations and Investments (HAMAG-BICRO)

HAMAG-BICRO issues guarantees for bank credits approved by credit institutions and other legal entities approving loans to SMEs and makes direct financial contributions to SMEs in the form of grants.

Bioeconomy in Croatia
Collaborative structures

Croatian Science Foundation

This organization has regular open calls for project financing, that include research projects on the national level. More than 500 projects were funded, of which around 50 projects are related to bio-based and bioeconomy-related sectors.

Croatian Bank for Reconstruction and Development (HBOR)

Through its specialized programmes HBOR provides support to start-ups, exporting companies, new production and companies from different sectors of economy such as industry, tourism, environmental protection and energy efficiency, agriculture....

Croatian Chamber of Commerce

Croatia's largest business network linking key economic sectors through county chambers, associations, and international offices. They provide services and contribute to enhancing entrepreneurship and competitiveness with a focus on sustainable, socially responsible growth. CCC is involved in the drafting of the Bioeconomy Strategy until 2035 involving members from the sectors of Agriculture and Industry and Sustainable Development.

EIT Climate KIC Hub in Croatia

A consortium of 8 organisations that aims to promote and establish a sustainable and responsible economy, working on innovative solutions, operating and building systemic changes including all sectors and levels of society. .

BIOCentre

One of the first research infrastructures in Croatia. It provides Business assistance and advisory services for biotech companies, laboratory space, conference rooms and fully equipped offices are available for rent; technology transfer via Central laboratory, a range of process development services; courses in business development and product development. It builds a network between individuals, companies and institutions in biotech and financial sectors

CIRTT – Centre for Research, Development and Technology Transfer at the University of Zagreb

Assists research groups at the university in securing financial support for research and development. Connects research groups with partners from the business sector and helps establish collaboration in the development of technology and commercialization of intellectual property created at the university.

Showcase

BioBRIDGES

Addressing key challenges in improving the marketability of bio-based products (BBPs) by fostering close cooperation and partnerships among bio-based industries, brand owners and consumers' representatives. BioBRIDGES aims to bridge the gap between scientific research and societal needs, promoting a more inclusive and participatory approach to biodiversity conservation and sustainable development.

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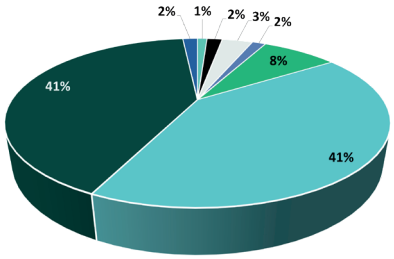
Bioeconomy country file

Cyprus

Cyprus does not have a national bioeconomy strategy either. However, there are some national strategies that can be addressed to the bioeconomy development, such as the National Action plan for the strengthening of circular economy 2021-2027 (2021). The national plan of Cyprus for Energy and Climate (2020) does not directly address bioeconomy but reflects on biomass and biogas use for electricity production as a sustainable energy means.

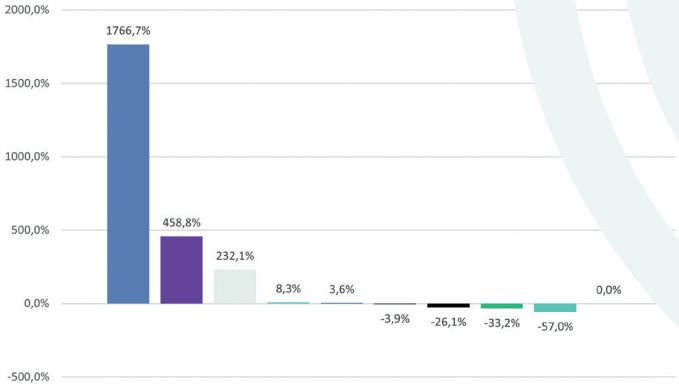
Employment by sector in Cyprus (2020)

Number of people employed



- Agriculture (14.09k)
- Food, beverage and Tobacco (14.09k)
- Wood products and furniture (2.77k)
- Forestry (500)
- Bio-based chemicals, pharmaceuticals, plastics and rubber (1.14k)
- Paper (574)
- Bio-based textiles (356)
- Fishing and aquaculture (550)

Value added growth between 2008 and 2020 in Cyprus



- Agriculture (-3.9%)
- Food, beverage and Tobacco (8.3%)
- Wood products and furniture (-33.2%)
- Forestry (1766.6%)
- Bio-based chemicals, pharmaceuticals, plastics and rubber (232.1%)
- Paper (-26.1%)
- Bio-based textiles (-57%)
- Fishing and aquaculture (3.6%)
- Liquid Biofuels (0%)
- Bio-based electricity (458.8%)

Duration

2021 - 2027

Responsible authorities

The Ministry of Energy, Commerce and Industry, Rural Development and Environment, and the Deputy Minister of Research, Innovation and Digital Policy

Cyprus

Cyprus Action Plan for the transition to a circular economy

The "Cyprus Action Plan for the transition to a circular economy 2021-2027" is based on four pillars: Cultural change for a circular economy, Providing incentives for investments in a circular economy, Development of circular economy infrastructures and Municipal Waste Management
The plan aims at transitioning to a circular economy, claiming that there will be opportunities for the transformation of companies and industries. Moreover, it also claims that the transformation will allow an increase in competitiveness, resilience, and sustainability at the local and international level.

Dominant sectors

Waste and water management
Bioenergy Infrastructures

Other related strategies

- Multiannual national strategic plan for aquaculture 2014-2020
- Bioeconomy multiannual national strategic plans for the promotion of sustainable aquaculture with development targets until 2020.

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Bioeconomy country file

Cyprus

Policy instruments

Cyprus Plastic Bag Levy

The Cyprus Plastic Bag Levy was introduced on 1st July 2018 by the Department of Environment of the ministry of Agriculture, Rural Development and Environment. According with the European Directive, Cyprus has been defined that consumers need to pay a levy of a minimum of 0,05 cents plus 19% of VAT for each lightweight plastic carrier bag they use.

Cohesion Policy Programme 'Thalia' 2021-2027

Programme "THALIA 2021-2027" constitutes a multi-annual, multi-fund development Programme , the utilisation of the resources allocated to Cyprus through the Cohesion Policy Funds, for the period 2021-2027. The total budget of the Programme amounts to €1.81 billion, of which €968 million comes from the EU Cohesion Policy Funds, while the remaining €842 million is the national contribution.
Aims to create a robust and competitive economy through smart, digital and green investments, under conditions of full employment and social cohesion.

Cyprus Energy Regulatory Authority (CERA)- Law 4902/2022

Promotion and Encouragement of the Use of Renewable Energy Sources. It consists in 7 pillars:

1)Assessment of obstacles and potential for development of Ecs; 2)Removal of unjustified regulatory & administrative barriers; 3)DSO duties around cooperation with ECs and facilitation of energy sharing; 4)Fair,proportionate,and transparent registration & licensing procedures;5)incentives connected to network tariffs based on a CBA; 6)Tools to access information; 7)Tools to access finance

Bioeconomy in Cyprus
Collaborative structures

BioSPRINT project (CBE-JU)

The BioSPRINT project aims to valorize hemicelluloses, that can be extracted, fractionated and converted for use in a range of applications. The project pursues a zero-waste approach, applying an integrated biorefinery concept that maximizes conversion of lignocellulosic biomass feedstock and its by-products, side streams and residual streams into higher added-value products.

VALUEMAG (CBE-JU)

VALUEMAG aims to provide ground-breaking solutions for microalgae production and harvesting as well as scaling up biomass transformation systems in order to provide new technologies for aquatic/marine biomass integrated bio-refineries.

Prolific project (CBE-JU)

The Prolific project will apply a range of processing technologies to agro-industrial residues of legumes, fungi and coffee in order to recover significant amounts of proteins/peptides, fibers and other value-added compounds.

UNLOCK (CBE-JU)

The UNLOCK project aims to position waste from meat production chains. An example is the utilization of feathers as a source of keratin to be used as fertilizer in agriculture. It will find applications in products such as forest and seed trays, nonwoven geotextiles, hydroponic foams and mulch films. .

Showcase
WASP TOOL - DEVELOPMENT AND EMONSTRATION OF A WASTE PREVENTION SUPPORT TOOL FOR LOCAL AUTHORITIES

The main objective of the project was to help Local Authorities to select and implement the best Waste Prevention Strategy, for the specific local circumstances of Greece and Cyprus. the project developed and implemented three Waste Prevention Strategies, one for each of the pilot areas participating in the project (two in Crete and the third in Cyprus). Four priority waste prevention actions took place in each area, two of which were common for all the three areas (i.e. food waste prevention and home composting). In addition, the LIFE team implemented extensive communication, dissemination and training activities, raising the awareness of more than one million people in the two countries on municipal waste prevention. A networking platform was also developed for waste management stakeholders, in which local authorities, educators and partners from relevant projects could exchange knowledge and experiences on waste prevention

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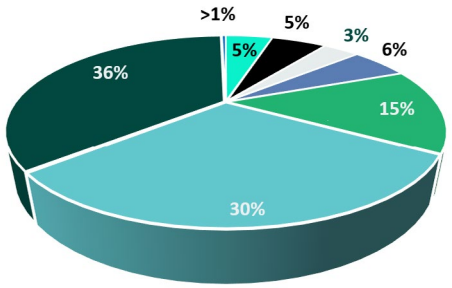
Bioeconomy country file

Czech Republic

The Czech Republic, together with other Central and Eastern European countries (the BIOEAST macro-region), has not yet sufficiently exploited the potential offered by the bioeconomy. As bioeconomy is still a relatively unknown concept for the public administration in the Czech Republic; no project dealing with this topic has been supported by national resources and there is only a small group of organizations in the Czech Republic involved in international projects focused on bioeconomy. The largest bioeconomy-related generators of turnover in the Czech Republic are the production of food, beverages and tobacco, agriculture and the production of wooden products, furniture and organic food. Together they account for approximately 80% of the total turnover. Bioeconomy is considered an early-stage industry which needs innovation to support its implementation.

Employment by sector in Czech Republic (2020)

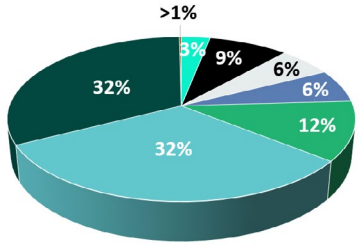
Number of people employed



- Agriculture (64.1k)
- Food, beverage and Tobacco (18,6k)
- Wood products and furniture (12.9k)
- Forestry (6.2k)
- Bio-based chemicals, pharmaceuticals, plastics and rubber (5.6k)
- Paper (4.5k)
- Bio-based textiles (3.5k)
- Fishing and aquaculture (0.2k)

Value added by sector in Czech Republic (2020)

Million euros



- Agriculture (3.5k)
- Food, beverage and Tobacco (3.44k)
- Wood products and furniture (1.26k)
- Forestry (703)
- Bio-based chemicals, pharmaceuticals, plastics and rubber (630)
- Paper (936)
- Bio-based textiles (338)
- Fishing and aquaculture (23.5)

Publication date

2019 – 2024

Responsible authorities

Ministry of Agriculture

Czech Republic

Concept of bioeconomy in the Czech Republic from the perspective of the Ministry of Agriculture for the years 2019-2024

In the Czech Republic the bioeconomy is perceived by the Ministry of Agriculture as a tool for ensuring sustainable management of natural resources, sustainable agriculture, forestry, water management and aquaculture, sustainable food and feed production and strengthening the role of primary producers and their integration into the bioeconomic value chain as well as forestry involving the entire value chain of the downstream industries.

Dominant sectors

Agriculture
Forestry
Food, Feed and Beverages
Research, development and innovation

Other related strategies

- Strategic Framework Czech Republic 2030
- Strategy of the Ministry of Agriculture with a view to 2030
- National Energy and Climate Plan of the Czech Republic
- Strategic framework of the circular economy of the Czech Republic 2040
- Research and Innovation Strategy for Smart Specialisation

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Bioeconomy country file

Czech Republic

Policy instruments

Applied research program of the Ministry of Agriculture for the period 2017–2025

The programme is aimed at supporting applied research projects in the fields of agriculture, food, water management and forestry, with expected results of high innovation potential, leading to the strengthening of stability, volume and quality of production, applicable in new products, technologies and production procedures.. 156 million CZK have been prepared for the programme.

Operational Program Technologies and Applications for Competitiveness

OP TAC is a flagship programme for supporting Czech entrepreneurs in the 2021–2027 programming period. A total of EUR 3.2 billion, equivalent to approximately CZK 81.5 billion, has been prepared for this operational programme from the European Regional Development Fund (ERDF).

The Country for the Future 2020–2027

The Country for the Future research, development and innovation programme is aimed at supporting innovative business and is one of the first essential tools for the implementation of the Innovation Strategy of the Czech Republic 2019–2030.

Bioeconomy in Czech Republic
Collaborative structures

BIOEAST HUB CZ

BIOEAST HUB CZ presents BE opportunities, supports more efficient use of biological resources, sustainable development of the EU, encourages the involvement to the international cooperation programmes, promotes BE in national strategies and grant programmes connects the national (mirror, shadow) thematic working groups (TWG)

National Cluster Association

Supports national stakeholders with relevant information

Association of research organizations

Supports the engagement and involvement of SMEs and large entrepreneurs, provides methodology for SMEs on how to use the potential of bioeconomy innovation

Czech Academy of Agricultural Sciences

Contributing to the design and development of the bioeconomy strategy, Advisory body

Technology Centre Prague

Supports national stakeholders with relevant information (mainly about EU grants, missions and research programmes)

Bioeconomy platform of the Czech Republic

Knowledge hubs transfering and fostering the national bioeconomy and its competitiveness

Czech Biofuels Technology Platform

support national stakeholders with relevant information

Showcase

BIOEAST Initiative

BIOEAST is a strategic initiative that aims to support the development of the bioeconomy sector in Central and Eastern European (CEE) countries, including Slovakia. It focuses on creating sustainable and resource-efficient solutions that contribute to economic growth, job creation, and environmental protection.

BIOEAST provides a platform for collaboration and knowledge exchange among stakeholders from government, academia, industry, and civil society. Through this initiative, Slovakia can benefit from sharing best practices, adopting innovative technologies, and accessing funding opportunities.

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Bioeconomy country file

Denmark

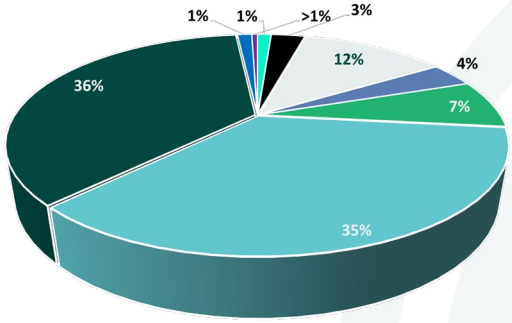
Denmark has a strong position when it comes to being first mover to market with new technologies and solutions within bioeconomy. Denmark is a pioneer in bio-based life science, fermentation, ingredients, high-value products, use of side streams, and high-efficiency use of biomass and biogas for energy production.

The key objective of the national bioeconomy policy is to unlock the full potential of biomass resources primary from agriculture, forestry and fisheries so that nutrients are recirculated, and new growth and export opportunities are created.

Denmark does not have a dedicated bioeconomy strategy yet, but the National Bioeconomy Panel (NBP) has been the advisory body to provide recommendations for the government regarding the country's bioeconomy development. Governance relevant to the Danish bioeconomy is made up of a mix of public and private regulation, voluntary and mandatory schemes, and national and subnational legislation.

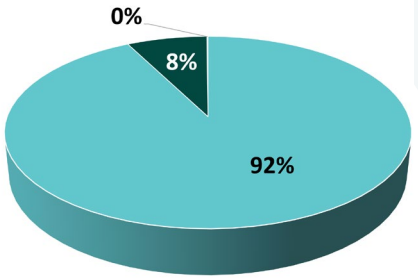
Employment by sector in Denmark (2020)

Number of people employed



- Agriculture (60k)
- Food, beverage and Tobacco (58.83k)
- Wood products and furniture (11.91k)
- Forestry (6k)
- Bio-based chemicals, pharmaceuticals, plastics and rubber (19.92k)
- Paper (4.7k)
- Bio-based textiles (1.91k)
- Fishing and aquaculture (2k)
- Bio based electricity (793.12)

Biomass production, million tonnes of dry matter



- Agriculture (24.89)
- Marine (2.01)
- Forest (0.021)

Publication date

September 2022

Responsible authorities

Ministry of Food, Agriculture and Fisheries

Denmark Bioeconomy Strategy

National Bioeconomy Panel (NBP)

New recommendations (Sept. 2022) from the NBP on how Denmark can increase the production of bioresources include:

- A national bioeconomy strategy is being drawn up, which will set the direction for the further development of the bioeconomy in Denmark.
- Financial incentives are introduced that promote the utilization of the full potential of bioresources.
- Large investments are being made in the expansion and upscaling of biorefining and cascade utilization.
- Refining of biofibers into materials and chemicals is developed and scaled up.
- Biorefining, biogas, pyrolysis and CCUS are developed as industrial symbioses.
- Areas with maize and grain crops are converted to biorefining crops with low environmental and climate impact.
- On areas that are not converted to biorefining crops, the Danish straw resource is optimized.
- Consideration of nature and biodiversity is prioritized by taking out production areas which are set aside for purely nature and biodiversity purposes.

Dominant sectors

Agriculture and Forestry

Fisheries & Aquaculture

Food, Feed, and Beverages

Other related strategies

- The Government's Strategy for Life Science (2021 - 2023).
- The Government's Strategy for Power-to-X (2021)
- The Government's Strategy for Circular Economy (2018)
- The Government's Action Plan for Circular Economy (2018)

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Bioeconomy country file

Denmark

Policy instruments

GUDP – Green Development and Demonstration Program

Invests in sustainability and growth in collaboration between industry and research

EUDP – Energy Technology Development and Demonstration Program

Funds work by enterprises and universities on the demonstration of new energy technologies

MUDP – the Environmental Technology Development and Demonstration Program

Support the development and application of new environmental and resource-efficient solutions addressing prioritized environmental challenges

Innovation Fund Denmark

Different funding programs, the largest being "Grand Solutions" have thematic calls, e.g., bioresources and energy

Independent Research Fund Denmark

Open calls within the area of basic research within technology and production sciences

Green Tax Reform (2030)

The reform introduces a new CO2 tax from 2030 with a rate of DKK 750 per tonne of CO2 emitted for companies outside the EU ETS and DKK 375 per tonne of CO2 emitted in 2030 for companies within the EU ETS.

Bioeconomy in Denmark

Collaborative structures

A trade association for everybody with an interest in biogas

A trade association for everybody with an interest in biogas

Kalundborg Symbiosis

The city's biggest industrial companies work together across sectors to share excess energy, water, and materials, so less goes to waste

Food & Bio Solution Denmark

Denmark's national cluster organization for the Danish food and bioresource industry. A unifying platform for innovation and growth – for Danish and international companies and knowledge institutions, appointed by the Danish government

GreenLAB

Is a green and circular energy park, a technology enabler, and a national research facility. Are specialize in accelerating research and technology to scale, and the concept transforms the way green energy is produced, converted, stored, and applied.

Biosolutions Zealand

To create an optimal framework and infrastructure for the development, testing, and upscaling of biotechnological products and solutions in Zealand.

Alliance for biosolutions

An initiative from the Danish Chamber of Commerce to turbocharge the great export and climate potential of biosolutions.

Showcase

Denmark's first grass protein factory is now in operation

BioRefine is Danish company that has devolved a method for extracting protein from grass. In short, this means that you can harvest grass from fields in Denmark and transform it into a protein that can be digested and absorbed by monogastric animals. Grass protein can to a certain extent replace the imported soy protein that is normally being used for animal nutrition in Danish stables. This could contribute to making livestock production in Denmark far more sustainable. The protein is produced by centrifuging grass juice, extracting the protein from the juice, drying it and finally turning it into a powder.

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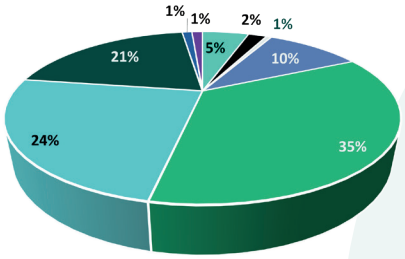
Bioeconomy country file

Estonia

Estonia is one of the high-tech hubs in North-eastern Europe and has an active national biotechnology association. It also features a solid chemical industry. There is a strong support towards high-tech university spinoffs and start-ups and the country has a network of technology parks and incubators. The main objectives of the Estonian bioeconomy are the greater added value from the circular bioeconomy, the sustainable use of resources and preservation of biodiversity, and the support of research and development, innovation, and technology. Estonia does not have a national bioeconomy strategy. However, in 2023, the authorities published a roadmap on circular bioeconomy, which serves as the main policy document for the national bioeconomy development.

Employment by sector in Estonia (2020)

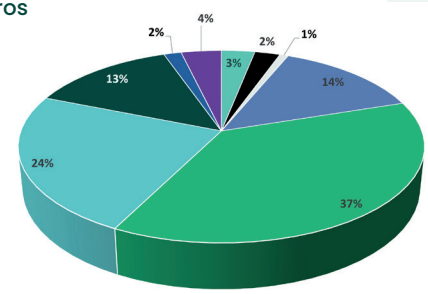
Number of people employed



- Agriculture (12.36k)
- Food, beverage and Tobacco (14.7k)
- Wood products and furniture (21.47k)
- Forestry (6.21k)
- Bio-based chemicals, pharmaceuticals, plastics and rubber (351.63)
- Paper (1.23k)
- Bio-based textiles (3.,12k)
- Fishing and aquaculture (660)
- Bio based electricity (716.27)

Value added by sector in Estonia (2020)

Million euros



- Agriculture (264.4)
- Food, beverage and Tobacco (459.4)
- Wood products and furniture (731.45)
- Forestry (267.1)
- Bio-based chemicals, pharmaceuticals, plastics and rubber (15.44)
- Paper (45.84)
- Bio-based textiles (60.69)
- Fishing and aquaculture (31.6)
- Bio based electricity (72.87)

Duration

2023 - 2035

Responsible authorities

Estonian Ministry of Regional Affairs and Agriculture

Estonia

Circular Bioeconomy Roadmap

The circular bioeconomy roadmap defines the broad fields of activities for the development of the circular bioeconomy in Estonia and the activities necessary for its development in the short term (2023–2027) and in the long term (until 2035). The document aims to form the basis for the development of regional circular bioeconomy roadmaps based on local bio-resources, the needs and opportunities of communities and municipalities.

Dominant sectors

Agriculture
Forestry
Food, Feed and Beverage

Other related strategies

- Agriculture and Fisheries Strategy 2030
- Estonia 2035
- Smart Specialisation Strategy

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Bioeconomy country file

Estonia

Policy instruments

ResTA

The ResTA program supports business-oriented R&D in the valorisation of wood, food, and subsoil resources. The total budget of ResTA is 10 821 810 €.

Baltic Innovation Fund 2 (BIF 2)

BIF2 is a EUR 156m Fund-of-Funds initiative launched by the EIF in co-operation with the Baltic national promotional institutions – KredEx (Estonia), Altum (Latvia) and Invega (Lithuania).

RITA

RITA funds socio-economical applied research based on the needs of the state. It supports strategic R&D activities - implementation of socio-economical interdisciplinary applied research as well as knowledge-based policy formulation.

NUTIKAS

The funding supports companies in commissioning necessary applied research or product development projects from universities or research institutions. The maximum funding per project is 2 million euros, whereas the minimum amount is 20 000 euros.

Circular economy program

The program supports a range of activities in the field of circular economy and waste. The program is open to local authorities, companies, non-profit organisations, foundations, legal persons governed by public law, and self-employed people.

Forestry program

It supports a range of forestry activities that aims to implement the long-term development objectives of forestry. Local authorities, companies, non-profit organisations, foundations, legal persons governed by public law, and self-employed persons can apply

Fisheries program

It supports a range of fisheries activities. it aims to achieve a balance between conservation and exploitation of fish stocks. Municipalities, companies, environmental protection bodies, non-Wprofit organisations, foundations, apartment associations, legal persons governed by public law, and self-employed persons can apply

Bioeconomy in Estonia

Collaborative structures

The Centre of bioeconomy, Estonian University of Life Sciences

The center focuses on interdisciplinary collaboration initiatives within the university and with other research institutions, companies, and organizations. It also initiates and coordinates interdisciplinary research and development of new innovative technologies, seeks funding, organises seminars, public discussions and other scientific events.

Competence Centre for Knowledge-Based Health Goods and Natural Products

The main goal of the project is to consolidate and mobilise sectorial know-how as well as other resources and raise the sectorial competitiveness via international networking, research, and development based on both academic excellence and business innovation. It also aims at supporting the cooperation of research institutes, the public sector, and enterprises.

Fisheries Information Centre

The center coordinates the cooperation between the fisheries and the aquaculture sector, fishermen's organisations, and researchers as well as to coordinate relevant studies and pilot projects.

Association of Estonian Food Industry

The association represents the interests of Estonian food industry in the development of national economic policy and interacts with authorities, producers, trade, and other interested parties by co-operating in all the links of the food chain.

Entrepreneurship education program Edu ja Tegu

The aim of the program is to develop young people's entrepreneurial competencies in line with the labour market needs. The programme gathers various stakeholders, including Education and Youth Board, ministries, Junior Achievement Estonia, Estonian universities, and county development centers

Estonian Research Council

The council funds research and innovation in Estonia, coordinates funds for bioeconomy (NUTIKAS, RITA, ResTa), and supports international research cooperation.

Centre of Competence for Wood Processing and Furniture Manufacturing

The center is a network linking the public sector, private industry, and educational and research institutions, providing knowledge, skills, and best practices in materials and technologies to advance production, management, and product development in wood processing and furniture manufacturing

Showcase

SWEETWOODS flagship biorefinery in Imavere, Estonia

SWEETWOODS Imavere biorefinery is a unique and groundbreaking demo plant that is using Sweetwater's Sunburst pre-processing technology to fractionate biomass into biocomponents faster and more efficiently than any other technology on the market. The demo plant demonstrates on an industrial scale, how novel pre-treatment technology in combination with innovative enzymatic solutions will convert more than 90% of the woody biomass into high-quality lignin and wood sugars. https://sweetwoods.eu

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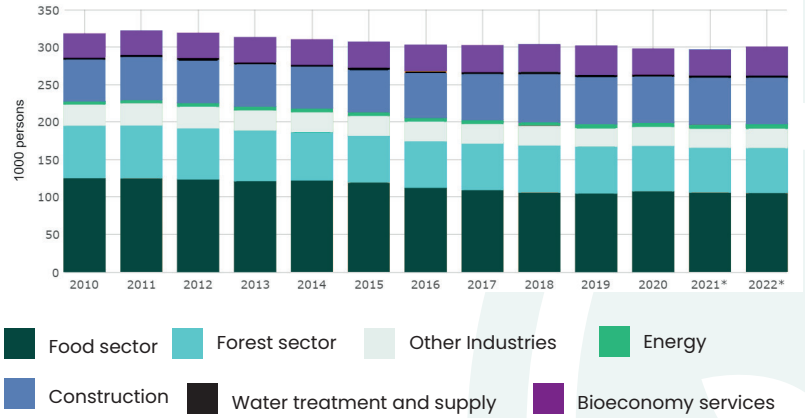
Bioeconomy country file

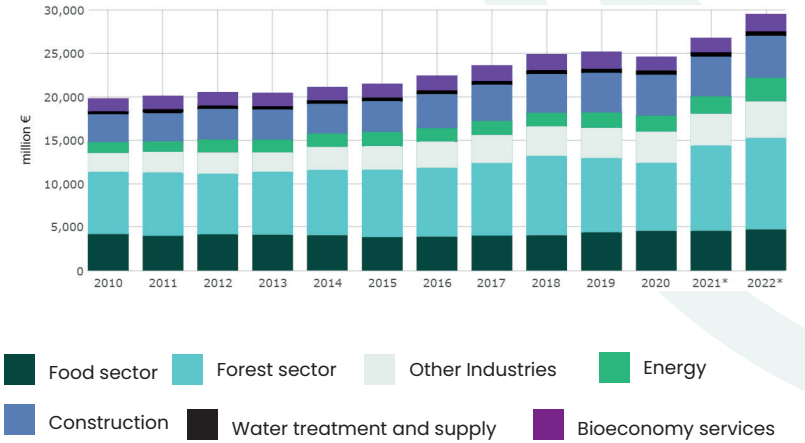
Finland

Finland is a pioneer in the bioeconomy, circular economy and cleantech. It has plenty of natural resources, large-scale biorefinery, high level of expertise and industrial strengths. Finland has a national dedicated bioeconomy strategy, which includes an exhaustive action plan for developing the bioeconomy's value added. The objective of the Finish bioeconomy strategy is to generate new economic growth and new jobs from an increase in the bioeconomy business and from high added value products and services while securing the operating conditions for the nature's ecosystems.

Employment by sector in Finland (2010 - 2021)



Value added by sector in Finland (2010 - 2021)



Publication date

2022 - 2035

Responsible authorities

Strategy development: Ministry of Economic Affairs and employment

Implementation: Steering group

Finland

The Finnish Bioeconomy Strategy Sustainably towards Higher value added

A key aim of Finland's bioeconomy is to increase the value added of the bioeconomy as a whole or to create competitive and innovative bioeconomy solutions to global problems. It is strongly R&D related.
The Bioeconomy Strategy has connections with several other Government strategies and policy programmes that outline, for example, the use of national forest resources, safeguarding biodiversity, climate and energy policy and industrial policy. The Bioeconomy Strategy's operating environment is also affected by a number of international commitments, such as the UN 2030 Agenda for Sustainable Development and the implementation of the Paris Agreement.

Dominant sectors

Forestry
Wood and furniture
Food, Feed and Beverages

Other related strategies

- North Ostrobothnia Bioeconomy Development Strategy
- Bioeconomy Development Strategy for Oulu Region in 2015–2020
- North Karelian Smart Forest Bioeconomy Strategy
- Roadmap Towards Oil-Free and Low-Carbon North Karelia by 2040

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Bioeconomy country file

Finland

Policy instruments

Food from Finland

The program focuses on the development and growth of the Finnish food industry and on the promotion of exports with branded products and services offering high added value. It helps Finnish food-industry companies in gaining access to the rapidly changing international food markets by utilizing new innovation and business know-how and research that supports the sector's competitiveness.

BioFuture2025

BioFuture2025 supports the creation of a new knowledge base and promotes major scientific breakthroughs through new ways of doing science. The program seeks out the best ideas, identifies new opportunities and supports research exploring new avenues for significant advances in the bioeconomy field.

Finnish Flagship Programme

The Research Council of Finland's Flagship Programme is an instrument that supports high-quality research and increases the economic and societal impact emerging from the research. The Finnish Flagships represent an effective mix of close cooperation with business and society, adaptability, and a strong commitment from host organisations.

FinnCERES – Competence Centre for the Materials Bioeconomy

The FinnCERES Flagship focuses on future solutions of the bioeconomy and materials research. Researchers in the Flagship aim to develop, for instance, novel lignocellulose-based materials towards industrial production for international markets.

ForestValue2

The aim of ForestValue is to comprise the joint implementation of transnational calls for proposals for research, development, and innovation in the forest-based sector with a clear financial commitment from the participating national (or regional) research programmes and the EU.

Bioeconomy in Finland
Collaborative stuctures

Bio-Economy for Change (B4C) - IAR

B4C is a Competitiveness Cluster focused on bio-based products and biorefinery. IAR brings together more than 200 stakeholders from Research, Higher Education, Industry and Agriculture, around a common goal: the optimal valorization of biomass.

CLIC Innovation

CLIC Innovation is an open innovation cluster with the mission of facilitating creation of breakthrough solutions in bioeconomy, circular economy, and energy systems

Bioenergia

The Bioenergy Association represents the interests of the bioenergy sector in Finland. The association has over 300 member organisations. It represents the entire bioenergy sector from land ownership to forest and energy companies, and technology and research in the field.

FinnCERES Materials Cluster

FinnCERES is a competence centre aiming to uncover answers to the most fundamental questions about lignocellulose disassembly and re-assembly and to create new, cost-competitive, bio-based materials that are expected to address resource sufficiency and climate change. The Flagship operates in close collaboration with industry and other stakeholders to create economic and societal impact.

Finnish Forest Association

The association supports the promotion of forest interests, brings forth topical possibilities forest can have in developing the society, strengthens the sustainable and responsible use of forests using communications and anticipates the effect changes at home and abroad can have on Finnish forest sector.

GreenHub

GreenHub is an open innovation ecosystem in the field of the forest-based bioeconomy, constitutes an example of successful regional collaboration. GreenHub is a network of multidisciplinary experts, making its expertise available to companies in the creation and development of new business activities.

The Central Union of Agricultural Producers and Forest Owners (MTK)

MTK is a trade organisation and interest group representing farmers, forest owners and rural entrepreneurs.

MTK has over 400,000 members in local agricultural producers' organisations and regional forest management associations. All of the occupations and businesses of their members are based on renewable natural resources and their utilisation in a sustainable and economical way.

Showcase
The Wood Building Programme

The Wood Building Programme (2016–2023) is a joint government undertaking coordinated by the Ministry of the Environment aimed at increasing the use of wood in urban development, public buildings as well as large constructions such as bridges and halls. The programme also aims to diversify and expand different applications for wood while creating as much value added as possible.

- https://ym.fi/en/wood-building
- https://www.luke.fi/en/statistics/indicators/bioeconomy-innumbers

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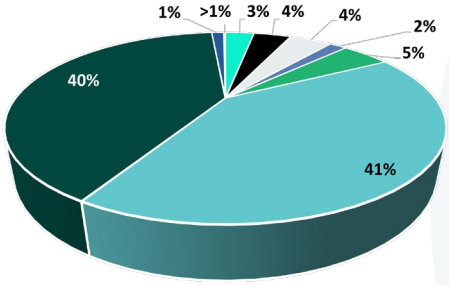
Bioeconomy country file

France

A National Bioeconomy Strategy has been in place since 2017. This strategy aims to foster the sustainable and circular use of renewable resources across various sectors. It provides a framework to promote innovation, investment and collaboration in bioeconomy. Its action plan was implemented from 2018 to 2020.

Employment by sector in France (2020)

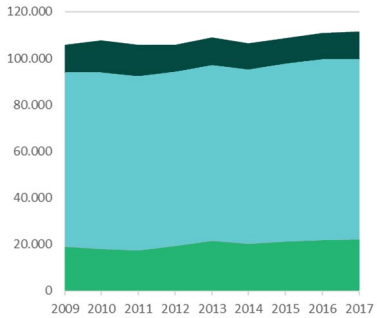
Number of people empoyed



- Agriculture (700k)
- Food, beverage and Tobacco (715.93k)
- Wood products and furniture (80.15k)
- Forestry (29k)
- Bio-based chemicals, pharmaceuticals, plastics and rubber (72.56k)
- Paper (63.71k)
- Bio-based textiles (49.83k)
- Fishing and aquaculture (21k)
- Liquid and biofuels (2.65k)

Biomass consumption by source

Evolution 2009-2017



- Materials
- Energy
- (Food including inputs)

Publication date

2018 - 2020

France

A Bioeconomy Strategy for France

Dominant sectors

- Agriculture and Forestry
- Biobased sectors
- Fisheries and Aquaculture
- Bioenergy and biofuels

Responsible authorities

Ministry of Agriculture and Food Sovereignty

In 2019, FranceAgriMer set up a cross-industry thematic commission (CTI) on the bioeconomy to maintain regular dialogue between the government, research bodies, public operators and representatives of the bioeconomy industries.
Moreover, 18 regions have published strategies related to the bioeconomy and 3 regions (Grand Est, Hauts de France and Ile-de-France) have a fully dedicated bioeconomy strategy.

Other related strategies

- National plant protein strategy (2020)
- National strategy for sustainable and healthy food (2021)
- Agroecological project for France (2016)
- National biomass mobilisation strategy and regional biomass plans (2016)
- Circular economy roadmap (FREC - 2019)
- National biodiversity strategy (2023)
- National forest and wood programme (PNFB-2016-2026)
- National strategy for the sea and coast (2017)
- National strategy to accelerate the transition to a circular economy (2021)

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Bioeconomy country file

France

Policy instruments

PIA (Plan d'investissement d'avenir / Future Investment Programme) - France2030

It is part of "France 2030" , an unprecedented plan for innovation and industry. 10 objectives based on 3 challenges: better production, better living and a better understanding of our world. Open calls for proposals are launched by ADEME or Bpifrance targeting bioeconomy development objectives. An example: 420M€ earmarked for "Biobased products and industrial biotechnologies» call for proposals from January 2022 until January 2024.

CIR (Crédit Impôt Recherche)

A specific tax credit to encourage companies to engage in (R&D) activities. Collaborations with both French and European players are eligible for this deduction, making it easier to finance certain projects or services.

Circular Economy Action Plan (PAEC)

3 axes, including "Developing the circular economy in high-potential sectors", that includes the agri-food sector.
Circular economy applied to the agri-food sector consists of promoting complementarities between farms, companies and local authorities in limited geographical areas, with positive impacts.
Actions of the plan: develop and raise awareness of short food circuits, in a logic of environmental quality; fight against food waste from production to consumption; create value with bio-waste and by-products.

Regional Biomass Schemes (included in the National Strategy for Biomass Mobilisation) - ADEME

A scheme with regional implementation promoting the development of projects on valorizing biomass into energy: heating networks, wood-fired boilers, anaerobic digestion and biogas use to reduce the share of fossil fuels and work collectively on the energy and ecological transition.

Law 2015-991 on the New Territorial Organisation of the Republic (NOTRe)

The Law NOTRe assigns new competences to the French regions. They are required to adopt a waste prevention and management plan, which must include a Circular Economy Action Plan and have a focus on bio-waste.

Law n°2016-138 against food waste

Preventing food waste by targeting "at the source"; Use unsold food through donation or transformationprocessing; Valorization of food wastes into animal feed; Use of food waste as compost for agriculture or for energy purposes, through anaerobic digestion.

Bioeconomy in France

Collaborative structures

Alliance CHEMBOOSTER IMPROVE _ ITERG – SAS PIVERT

This alliance, named ChemBooster, will provide a unique service to customers by pooling the skills and technological platforms of the two organisations on the theme of a more sustainable Green Chemistry.

Axelera

Axelera innovation cluster includes players in industry, chemistry and training in the fields of chemistry and the environment.

Toulouse White Biotechnology (TWB)

TWB is an administrative body supported by French National Institute of Agronomy (INRAE). It facilitates the interface between companies and academics, offering R&D projects from laboratory research to pilot scale (biocatalysis, synthetic biology, process engineering), in the field of biomaterials, chemicals and biofuels. with an association agreement National Institute of Applied Sciences (INSA-Toulouse) and Scientific Research National Center (CNRS)

Bioeconomy4Change

Network dedicated to bioeconomy of more than 500 members, from upstream agriculture to the marketing of finished products.

Valorial

An agri-food innovation cluster bringing together 400 manufacturers, research centres and higher education establishments around the theme of smarter food.

Protéines France

French consortium of companies with the ambition of federating and catalysing the development of plant proteins and new resources.

Protéines France aims to accelerate the development of the plant proteins and new resources sector and to make France a world leader in this field.

Vitagora

Agri-food innovation cluster with a dynamic innovation ecosystem of industry and research professionals: network of 660 members from farm to fork.

Strategic objectives: tasty, healthy and sustainable food product and service offer, driven by the demands of today's consumers, ever more concerned with the impact of food on their wellbeing and the environment.

Showcase

"Ferments of the Future" Grand Challenge

Public and private partners have joined forces to overcome the scientific and technological hurdles that slow down innovation in fields related to fermentation.

The goal of the Grand Challenge is to better understand the mechanisms involved in food fermentation in order to shape them, if necessary, to fit better with health requirements and climate change constraints, or to adapt to consumer expectations. It also aims to encourage the development of new fermented foods, based in particular on cereals, pulses, fruits and vegetables. These new products will help shift diets toward plant-based foods, making them more sustainable.

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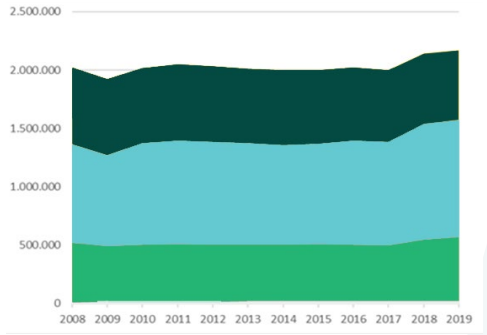
Bioeconomy country file

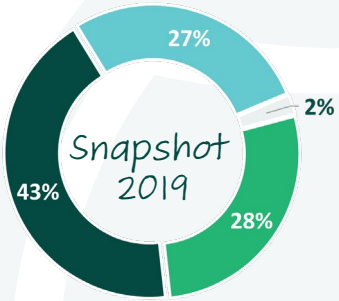
Germany

Germany has established itself as one of the leaders promoting bioeconomy policy in the European Union. In addition to its current bioeconomy strategy, Germany has founded an independent expert committee (Germany bioeconomy council) in 2009, which advises the federal government on bioeconomy policy in Germany.Germany's bioeconomy strategy is highly dedicated to bioeconomy and has numerous relations to other strategies, such as the Future Research and Innovation Strategy or the sustainable development strategy.

Bioeconomy: persons employed by sector

Evolution 2009-2017

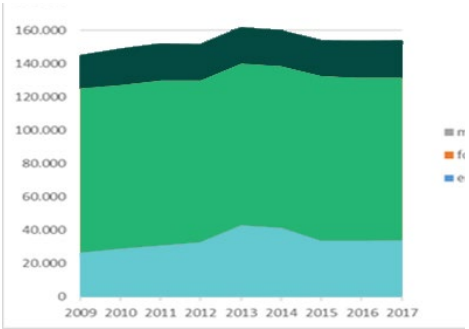


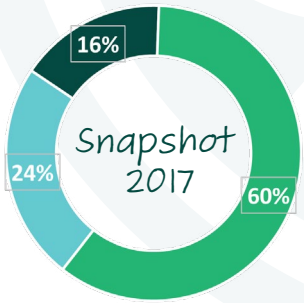


Primary production
Food and beverage
Bio-based products
Bio-based energy/fuel

Biomass consumption by source

Evolution 2009-2017





Materials
Food (including inputs)
Energy

Publication date
2020

Germany
National Bioeconomy Strategy

Responsible authorities
- Federal Ministry for Education and Research (BMBF)
- Federal Ministry for Food and Agriculture (BMEL)

The National Bioeconomy Strategy of Germany has the goal to combine economy and ecology to ensure that resources a more sustainable used.

Therefore, the strategy describes specific policy actions to improve framework conditions of the bioeconomy in Germany. An additional cross cutting area links different policy fields such as industrial policy, energy, primary sector policies (agriculture, forestry, fishery) or climate and environmental policy together

Dominant sectors
Agriculture
Forestry
Bio-based sectors
Food systems

Other related strategies
- National Policy Strategy on Bioeconomy (2014)
- National Research Strategy Bioeconomy 2030 (2018)
- Research for a bio-based eonomy (2017)
- National Biomass Strategy (upcoming)

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Bioeconomy country file

Germany

Policy instruments

Industrial Bioeconomy

Usage of demonstration plants for industrial bioeconomy.

Ideas Contest - New Products for the bioeconomy

Identification and development of bio-based products, processes and services.

KMU-Innovativ: Bioeconomy

Fostering innovation potential in bioeconomic research and SMEs.

Bioeconomy and societal change

Focus on societal challenges such as food security, climate protection or conservation of biological diversity.

Bioeconomy international

Strengthening international cooperation within bioeconomy sectors.

Bioeconomy in Germany

Collaborative structures

BIG-Cluster

Initiative of clusters and networks in the trilateral area Flanders-Netherlands-NRW. Supports the bio-based approach of the transition of the chemical industry towards climate neutrality and circularity.

Central Innovation Program for medium-sized companies

SMEs and research institutions are partnered with medium-sized businesses.

Clusters4Future

Contributes to knowledge and technology transfer through different clusters

Bioeconomy Cluster industrial bioeconomy dialogue platform

Think Tank fostering dialogue and cooperation between industry, science and civil society.

Model Region for sustainable Bioeconomy

Networking of different bioeconomy-close sectors such as food, chemistry and energy in North-Rhine Westphalia, Germany. Establishment of innovation labs.

Showcase

Bioeconomy Cluster e.V.

The Bioeconomy Cluster e.V. aims to develop the region Mitteldeutschland as a role model for global bioeconomy innovations and activities. Within the cluster, research institutes and educational institutions work together on the development of the whole region. Through networking activities between strong German sectors such as forestry, chemical, plastic or bioenergy, the cluster generates positive impacts on the smart usage of biomass in the region.

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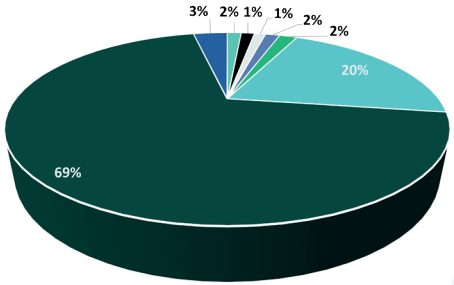
Bioeconomy country file

Greece

Greece does not have a specific National strategy on the Bioeconomy yet, although the Greek government assigns a high priority to resource efficiency as well as energy-efficient and low carbon investments. There are significant opportunities in Greece for the development of a resourceful industry in the sector of renewable resources and in valorization of waste that are currently untapped due to an overall lack of governance. The main governmental body implementing Bio-economy policies is the Ministry of Environment and Energy (YPEN) which launched the 1st National Strategy for the Circular Economy in 2018. In addition, the "Strategic plan for the development of research, technology and innovation under the National Strategic Reference Framework (NSRF) 2007-13" (aims to restructure the Greek economy, gearing it towards high value-added products and services, and achieve the transition to a knowledge-based economy and society.

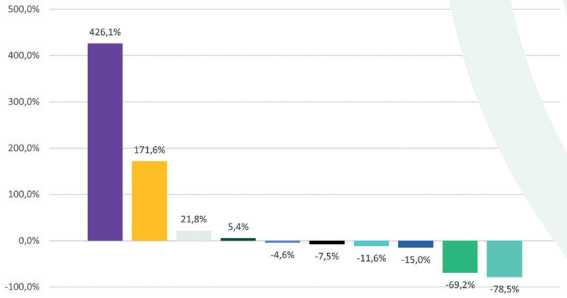
Employment by sector in Greece (2020)

Number of people employed



- Agriculture (453.24k)
- Food, beverage and Tobacco (133.19k)
- Wood products and furniture (11.34k)
- Forestry (9.18k)
- Bio-based chemicals, pharmaceuticals, plastics and rubber (7.21k)
- Paper (8.64k)
- Bio-based textiles (9.08k)
- Fishing and aquaculture (21.89k)

Value added growth between 2008 and 2020 in Greece



- Agriculture (5.4%)
- Food, beverage and Tobacco (-11.6%)
- Wood products and furniture (-69.2%)
- Forestry (-4.6%)
- Bio-based chemicals, pharmaceuticals, plastics and rubber (21.8%)
- Paper (-7.5%)
- Bio-based textiles (-78.5%)
- Fishing and aquaculture (-15%)
- Liquid Biofuels (171.6%)
- Bio-based electricity (426.1%)

Duration

2018 - 2030

Greece

Greece's Action Plan on Circular Economy

Dominant sectors

Waste and water management Infrastructures

Responsible authorities

Ministry of Environment and Energy, Ministry of the Interior, Ministry of Economy and Development, Governmental Economic Policy Council

Greece's Governmental Economic Policy Council endorsed a National Action Plan on Circular Economy (CE) in early 2018 to set the country on a path towards the long-term adoption of CE principles. This supports Greece's economic strategy in its key quest to green the economy in a way that creates jobs, especially for women and youth, and long-term equitable and inclusive growth based on resource efficiency, promotion of SMEs, innovation and investment in new technologies, and boosting of the "social economy" potential.

The long-term (2030) goals of the Action Plan are:

- Preventing waste and improving recycling
- Promoting industrial symbiosis
- Supporting circular consumption patterns
- Enhancing multi-stakeholder partnerships
- Monitoring progress towards a CE model through SMART indicators

Other related strategies

- The Rural Development Programme (2014-2020) 2015
- National Climate Change Adaptation Strategy (NCCAS) 2016
- National RIS for Smart Specialisation - Part 5.4 on Energy - Part 5.5 on Environment and Sustainable Development
- National Strategic Framework for Research and Innovation
- National Energy and Climate Plan 2019

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Bioeconomy country file

Greece

Policy instruments

Pancreta Cooperative Bank

Pancreta Cooperative Bank in cooperation with European Investment Bank, finances investments of businesses in the Agricultural sector & Bioeconomy. Thus, it consists of a credit programme for bio-based production and bioeconomy R&D that aims to facilitate access to financing for bioeconomy investments.

National Action Plan for Green Public Procurement 2021-2023

A plan that introduces and regulates sustainability criteria in public investments. In particular, it will contribute to: reducing the energy and ecological footprint; reducing greenhouse gas emissions and impacts on enviroment; promoting innovation and competitiveness; saving public resources, considering life-cycle costs; stimulating the circular demand for secondary materials by boosting domestic production, entrepreneurship, environmental technologies, repair and maintenance services and reuse; aising social awareness of environmental proterction issues

Hellenic Recycling Agency (HRA/EOAN)

(HRA/EOAN) has an institutional role in recycling in Greece, as it ensures the implementation of waste prevention policies and the alternative management of product waste, for which prevention measures and/or alternative management programmes are being implemented.

National strategic reference frameworks 2021- 2027

Public programmes to fund research and innovation.

The new NSRF Program "Competitiveness" regarding the support for SMEs has been presented in 2022 by the Deputy Minister of Development and Investments. The program amounts to 4 billion euros and has 4 pillars: Enhancing entrepreneurship and competitiveness (41%; Access to financing and funding tools (24%); Enhancing research and innovation (20%); Developing of the human capital (reskilling and specialized training of staff (13%).

The rest of the budget will cover the technical assistance needed for the program's implementation.

Bioeconomy in Greece

Collaborative structures

FoDSA-Regional Solid Waste Association,

Regional Association of Solid Waste Management Agencies of Central Macedonia, aiming at the circular economy, aspires to act as a catalyst through various actions for the support of the green concept.

Greek Bioeconomy Forum

The Greek Bio-economy Forum is a platform where individuals interested in Bio-economy and Circular Economy come together. The forum operates as a think tank and offers individuals and stakeholders the opportunity to meet, share and network with each other. The vision of the forum is to raise awareness about the Bio-economy & Circular Economy and promote transfer of know-how and experience in the EU and world-wide.

The Cluster of Bioenergy and Environment of Wester Macedonia (CluBE)

The Cluster of Bioenergy and Environment of Western Macedonia (CluBE) is a non-profit company established among local actors and stakeholders of the Region of Western Macedonia. CluBE is developing R&D and business activities in the fields of bioenergy and environment, in order to reinforce green economy in the region and the neighbouring area

Showcase

Relief. EuRopean Bio-Economy ALliancE In Farming

RELIEF aims to develop and deliver an innovative approach for teaching bio-economy in farming, by developing specific learning resources addressing HEIs students and farming practitioners. HEIs, VETs, farmer consultants, research institutes, and social partners from Italy, Greece, Sweden, Cyprus and Portugal will deliver a high-quality network within the EU to advance bio-economy in the farming agenda. RELIEF will deliver a training needs analysis and develop two curricula in bio-economy, for HE students, farming practitioners and farmers exploring the key areas that are critical for the implementation of business models and strategies towards bio-economy in farming.

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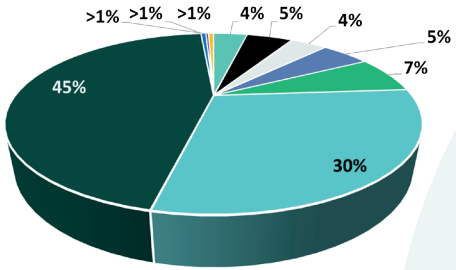
Bioeconomy country file

Hungary

There are numerous different national strategies in Hungary related to biomass, so it is necessary to create policy coherence among them. The bioeconomy concept can create the necessary coherence with the help of a conceptual, umbrella-type document containing the main principles of circular bioeconomy, setting the framework for a national bioeconomy strategy and action plan development, and serving as a reference for future strategies having biomass implications. As circular bioeconomy thinking is at an early stage in Hungary, the main intention of the bioeconomy workshops being led by the Ministry of Agriculture is to make the initial steps toward a deeper dialogue with stakeholders on agricultural challenges to find system-level solutions.

Employment by sector in Hungary (2020)

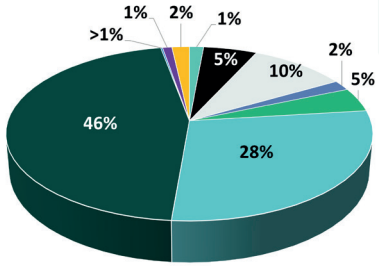
Number of people employed



- Agriculture (169.45k)
- Food, beverage and Tobacco (111.59k)
- Wood products and furniture (25.53k)
- Forestry (18.47k)
- Bio-based chemicals, pharmaceuticals, plastics and rubber (14.13k)
- Paper (18.1k)
- Bio-based textiles (13.3k)
- Fishing and aquaculture (1.96k)
- Bio based electricity (1.08k)
- Liquid and biofuels (2.02k)

Value added by sector in Hungary (2020)

Million euros



- Agriculture (4.42k)
- Food, beverage and Tobacco (2.73k)
- Wood products and furniture (431.62)
- Forestry (238.5)
- Bio-based chemicals, pharmaceuticals, plastics and rubber (954.62)
- Paper (526.31)
- Bio-based textiles (139.17)
- Fishing and aquaculture (17)
- Bio based electricity (92.44)
- Liquid and biofuels (171.37)

Publication date

2023 - 2050

Responsible authorities

Ministry of Agriculture

Hungary

Towards a National Circular Economy Strategy for Hungary

The Towards a National Circular Economy Strategy for Hungary aims to develop a comprehensive plan to transition the country towards a circular economy model. The strategy focuses on promoting sustainable production and consumption practices, reducing waste generation, and increasing resource efficiency. It envisions a future where the Hungarian economy operates within ecological boundaries, minimizing waste and maximizing the value of materials through recycling, reuse, and repair. The strategy aims to create a circular economy ecosystem that promotes innovation, job creation, and economic growth while protecting the environment and natural resources.

Dominant sectors

Agriculture
Wood, wood products and furniture
Food

Other related strategies

- National Climate Change Strategy
- Food Industry Concept of Hungary 2017-2050
- National Energy and Climate Plan for Hungary
- National Clean Development Strategy 2020-2050
- Fifth National Environmental Programme 2021-2026

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Bioeconomy country file

Hungary

Policy instruments

Hungarian Green Investment Scheme (GIS)

(GIS) funds measures to reduce greenhouse gases, with revenue created from trading surplus greenhouse gas emission allowances, following the Kyoto Protocol. These funds are usually allocated to facilate energy efficiency investments in the domestic sector.

National Research, Development and Innovation Fund (NRDI)

NRDI offers grants and funding programs for research and development projects in various areas, including bioeconomy. This can include projects related to bio-based products, agricultural and forestry biotechnology, sustainable resource management.

Hungarian Scientific Research Fund (OTKA)

OTKA plays a crucial role in supporting and fostering scientific research in Hungary, thus contributing to the country's development, technological advancement, and competitiveness in the global scientific community.

Innowwide

Innovative SMEs receive a grant of 60,000 euro to assess the viability of research or commercial ambitions in international target markets. Innowwide is funded by the European Union as part of the European Partnership on Innovative SMEs.

Bioeconomy in Hungary
Collaborative structures

Hungarian Chamber of Agriculture

The task of the Hungarian Chamber of Agriculture, Food and Development (NAK) is to strengthen the domestic agricultural and food sector, promote its interests, support the competitiveness of Hungarian food and provide expert advice and fast, accurate and reliable information to farmers.

Szeged Biotechnology Incubator

SBI supports the growth of bio-based companies by providing access to laboratories, equipment, and business development services. SBI plays a crucial role in advancing the bioeconomy by supporting startups in the development of bio-based products and technologies. The incubator offers various resources and services, including laboratory facilities, technical expertise, business mentoring, and access to funding opportunities.

Hungarian Bioeconomy Cluster

The purpose of the Cluster is to support the emergence of the bioeconomy (economy based on biomass) in Hungary and to support its long-term survival and continuous development.

Biocompack Ltd

A collaborative company that focuses on the research and development of biodegradable packaging materials made from renewable resources, reducing the environmental impact of packaging waste.

Showcase

BIOEAST Initiative

BIOEAST is a strategic initiative that aims to support the development of the bioeconomy sector in Central and Eastern European (CEE) countries, including Slovakia. It focuses on creating sustainable and resource-efficient solutions that contribute to economic growth, job creation, and environmental protection.
BIOEAST provides a platform for collaboration and knowledge exchange among stakeholders from government, academia, industry, and civil society. Through this initiative, Slovakia can benefit from sharing best practices, adopting innovative technologies, and accessing funding opportunities.

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Bioeconomy country file

Ireland

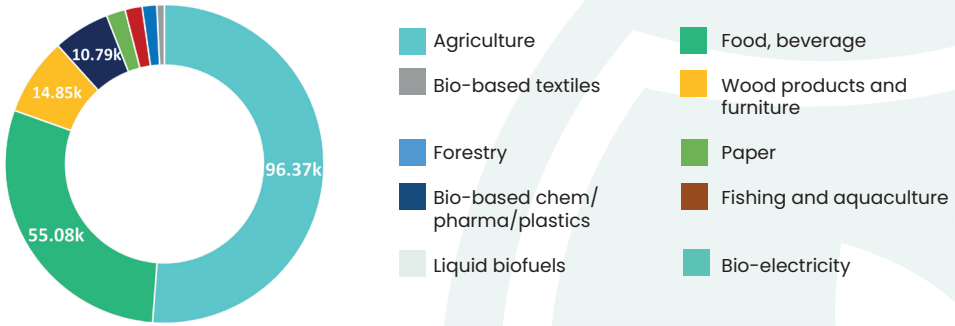
The National Policy Statement published in 2018 with the objective to 'grow Ireland's ambition to be a global leader for the bioeconomy' through a 'coordinated approach that harnesses Ireland's natural resources and competitive advantage and that fully exploits the opportunities available while monitoring and avoiding unintended consequence'. The Irish Government acknowledge bioeconomy as a key to support the transition to a low carbon and circular economy.

The development of the bioeconomy has advanced significantly over the past years (2018-2022) which is evident from the progression across multiple domains:

1. Sectoral coherence: Bioeconomy importance is increasingly recognised in national policies (e.g., Food Vision 2030, the Climate Action Plan 2021, the Circular Economy Strategy, Impact 2030);
2. Research, Innovation and Investment: bioeconomy initiatives including research, innovation, public private partnerships, etc., have been launched such as the Irish Bioeconomy Foundation, national bioeconomy research centre, as well as education and training programmes.
3. Raising awareness: Annual events since 2019 such as Bioeconomy Ireland Week, held in October each year bringing together industry, local communities, producers and researchers to discuss bioeconomy development.

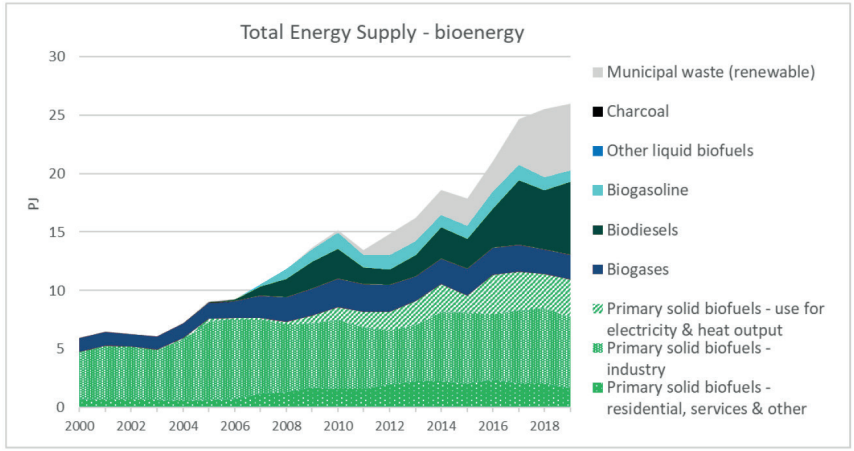
Bioeconomy: persons employed by sector

2020



Development of total energy supply from bioenergy in Ireland

2000-2018



Publication date

2018

(National Bioeconomy Action plan is expected to be launched in 2023)

Ireland Bioeconomy strategy

National Policy Statement on the Bioeconomy

Dominant sectors

Agriculture + Forestry

Bio-based sectors (incl., materials, energy)

Food Systems

Responsible authorities

The Lead Ministry is the Department of the Taoiseach (Prime Minister).

The implementation of the statement is assigned to Bioeconomy Implementation Group (BIG) which is chaired by the Department of Agriculture, Food and Marine and the Department of Environment, Climate and Communications (DCC).

The National Policy Statement on the Bioeconomy sets out the vision, objectives and the framework for the bioeconomy development in Ireland. The Government envision 'Ireland to be a global leader for the bioeconomy by utilising the country's natural resources. The Statement highlights the benefits of the bioeconomy in promoting efficient use of renewable resources, curbing climate change impacts while driving economic development and generating employment opportunities. The Statement identifies some key actions to further develop the bioeconomy that include promoting coherence between the bioeconomy sectors, market development and accessing funding for research and innovation.

Other related strategies

- Food Vision 2030
- Project Ireland 2040
- Climate Action Plan 2023
- National Action Plan for Jobs 2016
- National Action Plan for Rural Development 2017

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Bioeconomy country file

Ireland

Policy instruments

Bioeconomy demonstration fund

Co-funded by the Government of Ireland and the European Union through the EU Just Transition Fund. The funding will support close collaboration between a wide range of stakeholders along the bio-based value chain (including SMEs, research performing organisations, universities, local authorities, etc.,)

Innovation Boost programme

A programme from Inter Trade Ireland to support the development of innovative cross-border business that develop new products or improve production process. Funds available are up to €67,900 (18 months) and €47,400 (12 months).

Policy and Strategic Studies Research Call

€4.2 million fund from DFAM for policy-focused research projects on emerging policy and strategic needs of the agri-food, forest and bioeconomy sectors.

Accelerate Green

Develop and fund further education and training' programmes. The Green Skill Programme designed to progress the green transition in the Further Education and Training sector, support climate action and create awareness of sustainability and bioeconomic issues.

SOLAS

Irish accelerator dedicated to support the scaling up of companies within sustainability and green innovation.

CIRCULÉIRE's Circular Venture Programme

Combination of non-equity funding and mentoring that supports circular entrepreneurs impact Ireland's consumer behaviour, the economy, and accelerate the national transition to a net-zero carbon circular economy.

Bioeconomy in Ireland

Collaborative structures

Bioeconomy Implementation Group

Chaired by the DFAM and DCC to oversee the implementation of the national policy statement and to report back with recommendation to Government.

Irish Bioeconomy Network

The network seeks to promote the collaborations and raise awareness of the bioeconomy.

BiOrbic

The national bioeconomy research centre, established to promote and develop sustainable circular bioeconomy. The centre works with industry, communities, the public, and policy makers.

Irish Bioeconomy Foundation

Promote the transformation of natural resources to high-value products for the development of a sustainable bioeconomy that is globally competitive

CIRCULÉIRE

Public-private partnership working on delivering circular business models.

The Marine Institute

National agency responsible for marine research, technology, development and innovation. The focus is on assessing the economic potential of Ireland's marine resources, promoting the sustainable development of marine industry.

Showcase

AgriChemWhey project

The project is based on building an industrial-scale biorefinery that take the by-products from dairy processing and convert them into lactic acid, which is then used to make bio-based products (biodegradable plastics and bio-based fertilizers).

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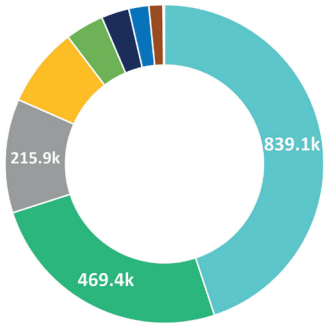
Bioeconomy country file

Italy

Italy is one of the strongest countries in Europe regarding bioeconomy activities.There is a specific strategy fully dedicated to the bioeconomy at national level, BIT (Strategia Italiana per la Bioeconomia- Italian Bioeconomy Strategy). Following an initial strategy in 2017 (BIT I), the current BIT II provides a national assessment and strategic framework for the deployment and development of the bioeconomy in the country. Bioeconomy plays a key role also in regional Smart Specialisation Strategies.

Bioeconomy: persons employed by sector

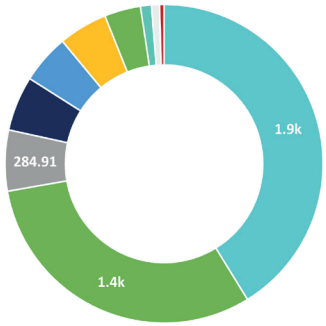
2020



- Agriculture
- Bio-based textiles
- Forestry
- Bio-based chem/ pharma/plastics
- Liquid biofuels
- Food, beverage
- Wood products and furniture
- Paper
- Fishing and aquaculture
- Bio-electricity

Value added by sector (million €)

2020



- Agriculture
- Bio-based textiles
- Forestry
- Bio-based chem/ pharma/plastics
- Liquid biofuels
- Food, beverage
- Wood products and furniture
- Paper
- Fishing and aquaculture
- Bio-electricity

Publication date

2019
(2020-2025)

Responsible authorities

Ministries of the University and Research, the Economic Development, the Agriculture, Food and Forestry Policies, the Environment, Land and Sea.

Italy Bioeconomy strategy

BIT II Bioeconomy Italian Strategy II

The BIT II strategy has recently been supplemented by the Implementation Action Plan (2020-2025) for the Italian bioeconomy strategy. A detailed action plan, including a series of relevant targeted actions which have been clustered into 4 main macro areas (policy/standards, pilot actions, regeneration of ecosystem services and stakeholder' engagement). The pilot actions outlined at local level (rural, coastal and urban areas) prioritize the domains of agri-food, biorefinery, forestry, marine and maritime sectors, waste and waste waters.

Dominant sectors

Agriculture

Food, Feed and Beverages

Bio-based textiles

Paper

Other related strategies

- National Biodiversity Strategy (2010)
- Strategic action plan on innovation & research in agriculture, food and forestry sectors (2015)
- National Smart Specialisation Strategy (SNSI) (2016)
- Sustainable Development National Strategy (2017)
- Towards a Model of Circular Economy for Italy (2017)

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Bioeconomy country file

Italy

Policy instruments

National Smart Specialisation Strategy (NSSS)

Identifies long-term investment priorities in collaboration with the Regions and main stakeholders, ensuring complementarity between the actions planned at central and territorial level, reducing redundancy and strengthening impacts.

Directive (EU) 2015/720

One of the achievements of the Italian strategy was the institutionalization at the European level, in the form of Directive (EU) 2015/720, of Italy's pioneering ban on plastic bags to the benefit of biobased alternatives.

Law 145/2018-Tax credit For purchases of products from recycling

Effective Jan. 1, 2019, this law provides a tax credit, up to 36 % of expenses incurred, to companies that purchase products made from plastic waste, or packaging made from materials recycled paper, plastic and aluminum or biodegradable packaging.

Ministerial Decree 264 of Oct. 13. 2016- Elenco Produttori e Utilizzatori di Sottopr

Addresses support to rural areas, like measures to increase employment, digitalization, improvement of human resources, including bioeconomy sectors.

Bioeconomy in Italy

Collaborative structures

BLUMED

The BLUEMED Initiative aims to advance a shared vision for a more healthy, productive, resilient, better known and valued Mediterranean Sea, promoting the citizens' social well-being and prosperity, now and for future generations, and boosting economic growth and jobs

CL.A.N.- Cluster Agrifood Nazionale, "Agrifood National Cluster"

The aim of the cluster is to promote sustainable economic growth of the Italian agrifood sector, based on research and innovation, increase the competitiveness and potential of SMEs also at the international level.

Fabbrica Intelligente- "Intelligent Industry"

The National Technology Cluster «Fabbrica Intelligente» is a recognized association with the goal of implementing a strategy based on esearch and innovation for the competitiveness of Italian manufacturing.building, stakeholder involvement

SPRING (Sustainable Processes and Resources for Innovation and National Growth)

SPRING's roadmap, brings together regional, national and European institutions which the Cluster, considered as key partners for achieving the long-term objectives related to the transition towards a concept of "Sustainable Regions" and presents the main innovation breakthrough for Italian Biobased Industries.

SUN- Italian network on Industrial symbiosis

ENEA has championed the establishment of Italy's first industrial symbiosis network, SUN - Symbiosis Users Network, which currently brings together 39 partners including universities, political institutions, research organizations, private companies, technology networks and local authorities. The SUN network aims to be an Italian reference for operators who want to apply industrial symbiosis, at the industrial, research and territorial level

Showcase

National flagship project SO.Fi.A.

The Agrifood Cluster has made an important contribution to the Bioeconomy through the national flagship project SO.Fi.A. (Sustainability of the food chain) in terms of:
- Valorisation of dairy by-products, especially cottage cheese residues (scotta) and whey to recover their bio-molecules.
- Strategies for the re-use and valorisation of waste from the beef processing. The production of new foods (the flakes of bone for gelatine, tallow and food proteins) and non-food products food (tallow and animal meal for the production of energy and shaved skins) to be used in various industries nationally and international level, represents the ultimate goal set by the project.
- New solutions for the efficiency of fresh-cut processes of vegetables and the valorisation of residual biomass. Within So.Fi.A. new technologies for reducing the production of residual biomass using an integrated drying process and associated with energy recovery devices.

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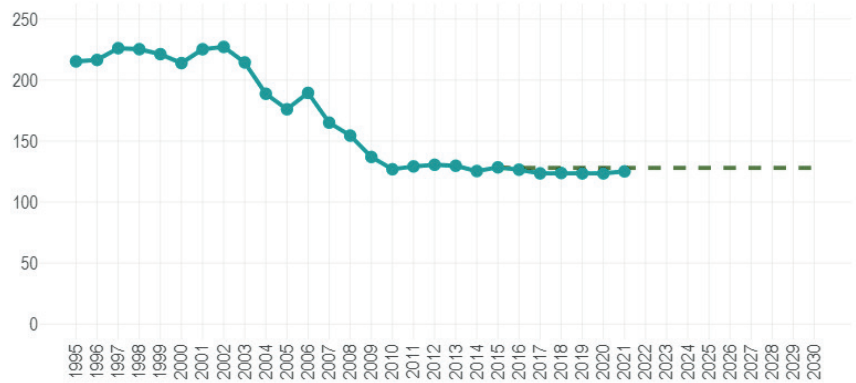
Bioeconomy country file

Latvia

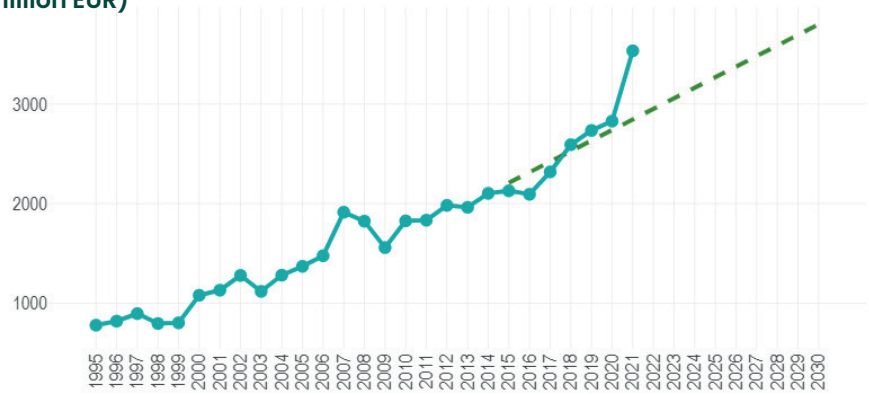
Latvia has made a great progress in bioeconomy in the last decade. It has an infrastructure of universities, research centres and industries, and an active association for bioeconomy research. There is a strong support towards high-tech university spinoffs and start-ups.

Moreover, the country was the first among the Baltic states to issue a dedicated bioeconomy strategy which should be great support for local, regional, and national bio-based operations. The key objective of the national bioeconomy is to preserve natural capital, increase its value and efficiently and sustainably exploit it.

Number of employed individuals in Latvia in the period 1995-2020 and the employment target for the conventional bioeconomy industries until 2030



Value added created by the conventional bioeconomy industries in Latvia in the period 1995-2020 and the value-added target for 2030 (million EUR)



Publication date

2017 – 2030

Responsible authorities

Ministry of Agriculture

Latvia

Latvian Bioeconomy Strategy 2030 (LIBRA)

The strategy sets three overall goals:

- Advancement and retention of employment in the bioeconomy sectors to at least 128 thousand persons
- Increasing the value added of bioeconomy products to at least €3.8 billion in 2030
- Increasing the value of bioeconomy production exports to at least €9 billion in 2030

The Latvian strategy has a business-oriented focus aiming at promoting long-lasting investments in the country's bioeconomy, namely by creating a predictable and stable tax policy, reducing administratively regulated prices for bio-products, promoting a favourable investment environment, and calling for replacement of non-renewable resources with bio- resources in public procurement. The strategy also aims at promoting SME participation in the bioeconomy and providing a level playing field for all actors.

Dominant sectors

Agriculture
Forestry
Fishing

Other related strategies

- Action Plan for Development of a Knowledge-Driven Bioeconomy Innovation Ecosystem in Vidzeme Region in Latvia (2020)
- Vidzeme Planning Region Sustainable Development Strategy 2030
- Smart Specialisation Strategy (RIS3) (2014)

Source: Bioekonomikas rādītāji Latvijā (lbtu.lv)

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Bioeconomy country file

Latvia

Policy instruments

Baltic Innovation Fund 2 (BIF 2)

BIF 2 is a EUR 156m Fund-of-Funds initiative launched by the EIF in co-operation with the Baltic national promotional institutions – KredEx (Estonia), Altum (Latvia) and Invega (Lithuania).

BIF 2 continues to sustain investments into private equity and venture capital funds focused on the Baltic States over a period of 5 years – following its signature in July 2019– to boost equity investments into SMEs with high growth potential.

Fundamental and Applied Research Program

The program financed from the state budget aims to create new knowledge and technological know-how in all Fields of Science. Program is organized as annual open calls.

Bioeconomy in Latvia
Collaborative structures

Latvian Food Bioeconomy Cluster (LFBC)

LFBC is a triple-helix cluster organization, one of the most developed and internationally active bioeconomy clusters in the Baltic.

The Association of the Latvian Chemical and Pharmaceutical Industry (LAKIFA)

LAKIFA brings together companies involved from the pharmaceuticals and chemicals industry. It works also to develop and support dialogue between companies and policy makers in the industry.

The Latvian Rural Advisory and Training Centre

The centre, working under the Ministry of Agriculture, promotes rural prosperity by providing businesses, organizations and farmers with access to knowledge, advice and other industry-related services. The centre actively engages farmers in local pilot activities and promotes student participation in projects.

Green Tech Cluster

The cluster brings together companies, educational and research institutions, as well as other organizations that operate in the industries of green and smart technologies.

Latvian Wood Construction Cluster

The cluster is uniting more than 20 manufacturers of wooden houses, educational and research institutions, and other related companies.

Latvian Forest Industry Federations

The members are associations of the industry, unifying active and socially responsible forestry, primary processing, further processing enterprises, wooden houses, and furniture manufacturers.

Showcase

AS Ziedi JP - circular economy in a Latvian farm

Unique aspect in this case is that the principles of circular economy are well presented in one farm as all the activities and branches on the farm are strongly interconnected and complement each other. Agricultural land is the beginning of production and also the end because the digestate returns to the soil as a fertilizer. One of the products of each industry is the beginning of the production of another branch, thus all raw materials are used in the production process without waste.

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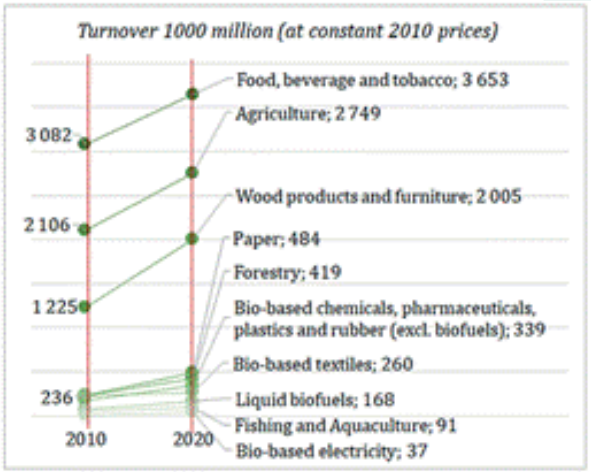
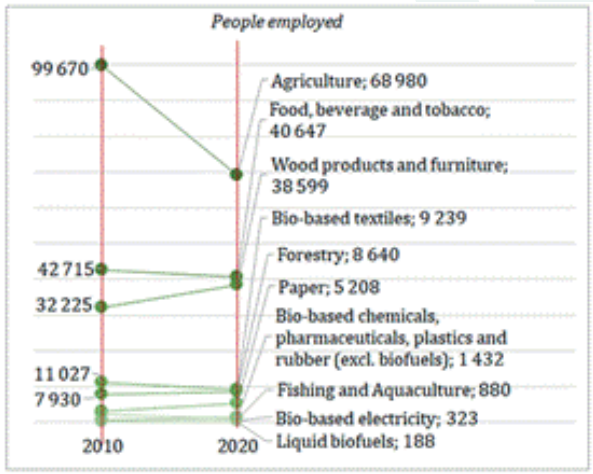
Bioeconomy country file

Lithuania

Turnover across main industries of Lithuanian bioeconomy 2010–2020



Employment across main industries of Lithuanian bioeconomy 2010–2020



Lithuania is strengthening its position as a regional hub for biotech. It has an infrastructure of universities, research centres and industries, and an active national biotech association. There is a strong support towards high-tech university spinoffs and start-ups.
A network of technology parks and incubators has grown in recent years around the three main cities. Key objective is to establish the economy in higher added value production, strengthen high-tech industry, and to be more independent of foreign energy sources. The country is currently drafting a bioeconomy strategy that should be great support for local, regional, and national bio-based operations.

Other related strategies

- National Industrial Biotechnology Development Programme (2011 – 2013)
- National energy and climate action plan for 2021-2030
- Lithuanian National CAP Strategic Plan (2022)
- Lithuania's Smart Specialisation Strategy

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Bioeconomy country file

Lithuania

Policy instruments

Baltic Innovation Fund 2

BIF 2 is a EUR 156m Fund-of-Funds initiative launched by the EIF in co-operation with the Baltic national promotional institutions – KredEx (Estonia), Altum (Latvia) and Invega (Lithuania).

BIF 2 continues to sustain investments into private equity and venture capital funds focused on the Baltic States over a period of 5 years – following its signature in July 2019– to boost equity investments into SMEs with high growth potential.

Tax incentives for investment and innovations

Lithuania offers a one-year corporate income tax holiday for small business start-ups and tax incentives targeting companies developing new technologies and afterwards using them in their activities to generate income.

Large-Scale Projects

Lithuania offers significant tax incentives, including 0% corporate tax for 20 years, and streamlines key processes in land acquisition, planning and migration for large scale projects.

Bioeconomy in Lithuania
Collaborative structures

Association LithuaniaBIO

The association unites business enterprises in Lithuania that develop and manufacture biotechnological products and provide services in the life sciences sector, as well as scientific institutions conducting fundamental and exploratory scientific research in the field of biotechnology.

Smart food cluster

A cluster consists of food industry companies representing individual industry sectors in domestic and foreign markets

Lithuanian Biomass Energy Association (LITBIOMA)

The association involves the producers and suppliers of solid biomass and other renewable local resources, such as wood, straw, energetic willows, peat, as well as the producers and designers of solid biomass boiler rooms and other equipment, developers of plantations and academic institutions. It has currently 39 members.

Lithuanian Biotechnology Association (LBTA)

LBTA represents the interests of the bio-based industry. Its main goal is to support the biotechnology sector to tackle global challenges concerning life quality and the environment. The priority topics of LBTA strategic orientation are Life Sciences, Bioeconomy and Health technologies.

Association of Wood and Furniture Industry

The Association implements and co-ordinates the tasks delegated to it by its members and represents their economic interests to the authorities of Lithuania and inter industrial organizations. The main aim of the Association is to ensure a full development of the Lithuanian wood industry.

Life Sciences Digital Innovation Hub Cluster

Standard agency specialized on wood value chains. Aims to develop solutions for mitigating resources and energy shortage. with medium-sized businesses. The cluster is a platform for business-research partnership, dedicated to fostering digital innovation in the life sciences, bringing together research, business and public sector institutions and organizations. The cluster develops its activities in Vilnius City Innovation Industrial Park, paying special attention to clustering and strengthening cooperation of companies operating in the fields of biochemistry, biotechnology, molecular biology, clean technologies, and related areas.

Biopower plant development cluster (Adecco)

Addeco engages in developing biopower plants. The cluster seeks to develop biogas production and related technologies that create the conditions necessary for organic farming to receive a good return on investment.

National Food Cluster (NaMŪK)

The cluster creates exclusive and innovative higher value-added products from local raw materials. In collaboration with researchers and with each other, member companies apply the latest food production technologies, expand their product line, and develop new products.

Showcase

Bioeconomy in Lithuania - (Pageldynių plantacija UAB / NutriBiomass 4LIFE)

A full scale self-sustainable closed loop circular economy model for large cities' nutrient rich waste (Pageldynių plantacija UAB / NutriBiomass 4LIFE)

The project represents a full scale self-sustainable closed loop circular economy model for large cities' nutrient rich waste - municipal wastewater treatment sludge and biomass ashes – recycling into renewable energy for city's needs via environment friendly biomass plantation filter.

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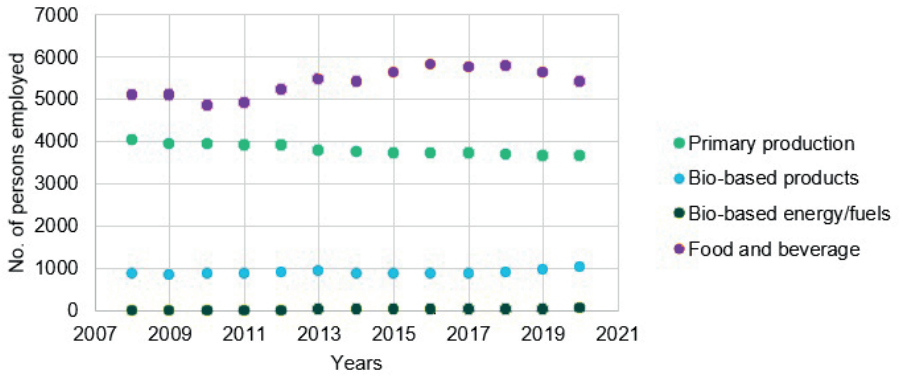
Bioeconomy country file

Luxembourg

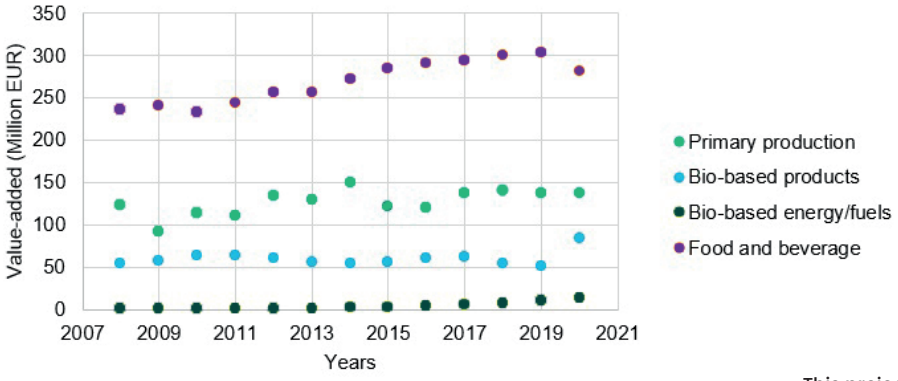
Number of people employed per sector in Luxembourg

Evolution 2008-2020



Value-added per sector in million euros in Luxembourg

Evolution 2008-2020



Luxembourg

With an emphasis on circular economic concepts and sustainable resource management, the bioeconomy is gaining traction in Luxembourg. The promotion of bio-based companies, research and development in biotechnologies, and the integration of bio-based solutions across sectors such as agriculture, food, and materials are important aspects of the development of the bioeconomy in Luxembourg.

Fostering innovation and entrepreneurship in the bio-based industry, encouraging sustainable production and consumption patterns, and supporting Luxembourg's economic diversification and environmental sustainability goals are some of the main goals of the country's bioeconomy policy.Currently, bioeconomy and related policy instruments are not specifically included in any strategic documents of Luxembourg.

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Bioeconomy country file

Luxembourg

Bioeconomy in Luxembourg
Collaborative structures

Luxemburg Institute of Science and Technology (LIST)

The Luxembourg Institute of Science and Technology (LIST) is a research and technology organization that focuses on driving innovation and technological advancements in Luxembourg. It conducts interdisciplinary research in areas such as environmental sciences, materials science, ICT, and renewable energy. With a mission to contribute to the sustainable development of Luxembourg and beyond, LIST collaborates with industry, academia, and public partners to develop cutting-edge solutions and support the country's transition towards a knowledge-based economy.

Biogas association Luxembourg

The Biogas Association Luxembourg is a non-profit organization dedicated to promoting and advancing the production and utilization of biogas in Luxembourg. The association serves as a platform for collaboration, knowledge exchange, and advocacy in the field of biogas. It represents the interests of biogas producers, technology providers, researchers, and other stakeholders, working towards the development of sustainable and efficient biogas projects in the country.

Luxinnovation

Luxinnovation is the national innovation agency of Luxembourg. It serves as a key facilitator and promoter of innovation, supporting businesses, startups, and research institutions in their innovation journey. Luxinnovation provides a wide range of services, including funding support, business development assistance, technological expertise, networking opportunities, and access to research collaborations. .

Showcase

Luxembourg CleanTech Cluster

The Luxembourg CleanTech Cluster, managed by Luxinnovation, operates as a collaborative platform connecting companies, research institutions, and stakeholders in the clean technology sector. It fosters innovation, business development, and cross-sector cooperation, particularly in sustainable living and clean technologies. The cluster aims to diversify local companies' activities in clean technologies, contribute to eco-technologies and sustainable construction, raise awareness of green technologies, and build public-private partnerships for collaborative projects. Additionally, it encourages networking at national and international levels. Specialized support services offered by the cluster include access to information on clean technologies, advice on funding opportunities, and insights into emerging technologies and markets. The overarching goal is to turn the concept of a circular economy into a reality in Luxembourg.

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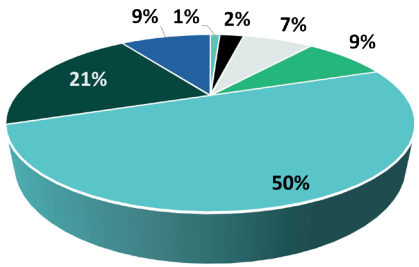
Bioeconomy country file

Malta

Malta does not have an exclusive strategy on bioeconomy, however they do have other related national strategies, such as the recent document published: "Malta's Sustainable Development Strategy for 2050". Since Malta is an island, the most relevant goal is the related with the blue bioeconomy, they actively participates in European project related to this theme, as was the case with BLUE BIO MED, where the National authority of Malta (MCST) was responsible for drafting and overseeing the national RIS3 strategy. This strengthened Malta's current and future commitments in this sector.

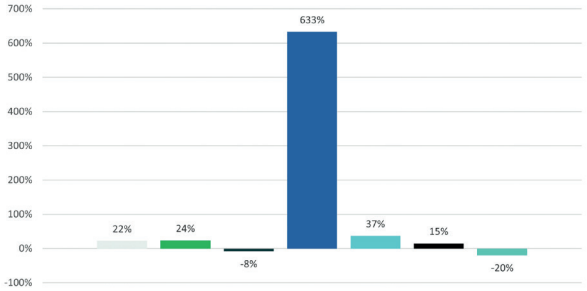
Employment by sector in Malta (2020)

Number of people employed



- Agriculture (1.73k)
- Food, beverage and Tobacco (4.19k)
- Wood products and furniture (721.21)
- Bio-based chemicals, pharmaceuticals, plastics and rubber (630.99)
- Paper (217.81)
- Bio-based textiles (85.6)
- Fishing and aquaculture (810)

Value added growth between 2008 and 2020 in Malta



- Agriculture (-8%)
- Food, beverage and Tobacco (37%)
- Wood products and furniture (24%)
- Bio-based chemicals, pharmaceuticals, plastics and rubber (22%)
- Paper (15%)
- Bio-based textiles (-20%)
- Fishing and aquaculture (633%)

Publication date

2022 - 2050

Malta

Malta's Sustainable Development Strategy for 2050

Dominant sectors

Fishing and Aquaculture
Digital economy

Responsible authorities

Minister for the Environment, Energy and Enterprise

Malta's Sustainable Development Strategy for 2050 is founded on the principle that environmental protection, economic growth and social cohesion are interlinked and therefore cannot function successfully in isolation.
This document lays down Malta's strategic orientation for steering sustainable development by setting out five strategic goals while defining strategic objectives that outline how to effectively achieve the ultimate aim of this Strategy by 2050.

The strategy is divided into 5 goals:

- **Transitioning Towards a Climate-Neutral Green and Blue Economy**
- **Towards the Preservation of Sustainable Urban Development and Cultural Heritage**
- **Ensuring healthy lives and well-being for all**
- **Accelerating Digital Transformation, Smart Mobility and Connectivity**
- **Achieving Social Fairness and Prosperity**

Other related strategies

- **Aquaculture strategy for the Maltese Islands**
- **Malta's 2030 National Energy and Climate Plan**

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Bioeconomy country file

Malta

Policy instruments

Circular Economy Malta (Establishment) Order

Circular Economy Malta (Establishment) Order promote, manage and implement measures,projects and initiatives that support the transition to a morecircular economy.

BlueBio ERA-NET Cofund (BlueBio)

Malta participates in BlueBio Cofund it is a coordinated R&D funding plan aimed at strengthening Europe's position in the blue bioeconomy.

Blue BioCofund

The main objective of the COFUND is to establish a coordinated R&D funding scheme that will strengthen Europe's position in the blue bioeconomy.

Bioeconomy in Malta

Collaborative structures

AquaBio Tech Group

This Group undertakes a variety of aquaculture, fisheries and aquatic enviromental projects through its regional offices and selected partners throughout the world. The vast majority of the company's work is related to the marine or aqueatic environment.

R2Pi project

The international consortium of R2Pi consists of 15 partners from 9 Member states and associated countries. The aim of the R2Pi project is to highlight sustainable business models for circular economy and to propose Policy Packages that will support such business models.

Showcase

Circular Economy Malta (CEMalta)

The Circular Economy Malta (CEMalta) is the designated competent entity, set up by Government, for the Circular Economy under the Environment Protection Act.

The Government of Malta is committed to reduce the volume of waste currently being disposed of at existent landfills, both for environmental and spatial reasons. In view of this, circular economic activities can play a crucial role in the effective reduction of disposal of waste in landfills. The Ministry for Environment, Energy and Enterprise recognises that a shift in national approach is necessary to improve Malta's performance in waste management, through improved regulations and financial incentives in an effort to increase recycling and recovery rates and private stakeholder participation.

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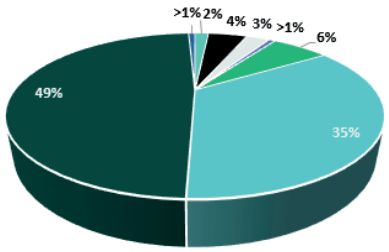
Bioeconomy country file

Netherlands

The Framework Memorandum on the Bio-Based Economy was published by the Dutch Ministry for Economic Affairs in 2012. The Memorandum supplements the innovation contract on biobased business published in 2012 as a result of the cooperation efforts of the government, industry, and research institutes. Both policies recognise the bioeconomy as a common theme among the top sectors: agriculture, transport, and chemicals.
Key focal aspects of the Dutch bioeconomy and biobased economy policy are: Biomass valorisation is the production of biobased materials and Use residues for biofuels, electricity, and heat.
In 2016, more than 1,200 companies were active in the bio-based economy, mostly SMEs that develop and manufacture bio-based materials and chemicals within the agricultural, fishing, and food sectors, with an estimated turnover between €114 billion and €120 billion.
There are several agreements in place between the top sectors, namely, agriculture, transport, and chemicals, to support the development of the bioeconomy. For example, 'Green Deals', within which agreements have been made concerning the production of bio-based chemicals, biopolymers, biofuels, and electricity.
In this regard, there has been a strong link established between bioeconomy and circular economy, given the aim of the Netherlands to become fully circular by 2050. In 2023, the Ministry of Infrastructure and Water Management released the National Programme Circular Economy (NPCE) 2023–2030. Which include comprehensive actions that support the Dutch transition to a circular economy.

Employment by sector in Netherlands (2020)

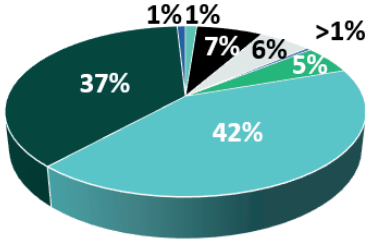
Number of people employed



- Agriculture (198k)
- Food, beverage and Tobacco (140.89k)
- Wood products and furniture (25.98k)
- Forestry (3k)
- Bio-based chemicals, pharmaceuticals, plastics and rubber (10.88k)
- Paper (2.32k)
- Bio-based textiles (6.7k)
- Fishing and aquaculture (3k)

Value added by sector in Netherlands (2020)

Million euros



- Agriculture (12.28k)
- Food, beverage and Tobacco (13.82k)
- Wood products and furniture (1,77k)
- Forestry (169)
- Bio-based chemicals, pharmaceuticals, plastics and rubber (1.81k)
- Paper (224.53)
- Bio-based textiles (397)
- Fishing and aquaculture (288)

Source: https://datam.jrc.ec.europa.eu/datam/mashup/BIOECONOMICS/index.html

Publication date

2016

Netherlands

Government-wide programme for a Circular Dutch Economy by 2050

Dominant sectors

Biomass
Consumer Goods
Manufacturing and Construction

Responsible authorities

Ministry of Infrastructure and Water Management

In its 2016 strategy, the Dutch government has set targets of halving raw material use by 2030 and achieving a fully circular economy by 2050. The aim of the policy is to reduce raw material use and ensure maximum value retention, which requires various circular strategies such as reuse, circular design, sharing, lending, and repair.

The 2021–2023 theme of the policy focuses on a systemic change from a linear to a circular economy by focusing on raw material flow. Focus on:

- **Ensuring the efficient use of raw materials in production processes.**
- **In the event that new raw materials are needed for production, sustainably produced and available raw materials, like biomass, shall be used.**

Other related strategies

- **Raw Materials Agreement 2017**
- **Green growth 2013**
- **2030 Government Vision on Biomass**

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Bioeconomy country file

Netherlands

Policy instruments

SME Innovation Scheme for Top Sectors (MIT) (MKB-innovatiestimulering Regio en Topsectoren)

Small or medium size business owner working on an innovative project in one of the leading sectors (Agri & food, Creative industry, Energy, Life Sciences & Health (LSH), Logistics, High Tech Systems & Materials (HTSM), Horticulture & Starting Materials and Water)

€ 20,000 for an MIT feasibility project and € 350,000 for an MIT R&D cooperation project.

SDE and incentive scheme

A feed-in tariff scheme where producers receive financial compensation for the renewable energy they generate.

€8 billion is available for the SDE++ call 2023.

EIF and Invest-NL, the Dutch national promotional institution

The DFF's investment focus is on digital innovation, artificial intelligence, life sciences and key enabling technologies, as well as thematic objectives such as energy transition, sustainability and circular economy

Bioeconomy in Netherlands
Collaborative structures

Bio Innovation Growth mega Cluster (BIG-Cluster)

Clusters and networks in the trilateral area Flanders-Netherlands-NRW established in 2013. The cluster initiate research and development partnerships for new biobased value chains that fit into a circular economy approach and the use of secondary raw materials and waste, in order to contribute to the realization of a circular economy

Biobased delta (biorizon)

Example for cross-border initiative between NL and BE that works to foster the commercial production of bio-aromatics by 2025 focusing on technology scale-up.

TKI Biobased Economy

Top Consortium for Knowledge and Innovation in Biobased Economy (TKI-BBE). it Initiate new activities and projects to promote more efficient use of biomass for energy in the short term and materials and on the longer term.

Dutch Biorefinery Cluster

Help members to bring biomass fully to economic value in a sustainable way

Green Chemistry Campus

A business accelerator for biobased innovations

Showcase

Royal Cosun

Produces plant-based food and food ingredients, feed, biobased ingredients and green energy through valorisation of arable crops such as sugar beet, chicory and potatoes. Examples include various potato products, plant-based proteins and dietary fibres. It produces sugar, starch and a range of biobased products like plant based yoghurt.

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Bioeconomy country file

Poland

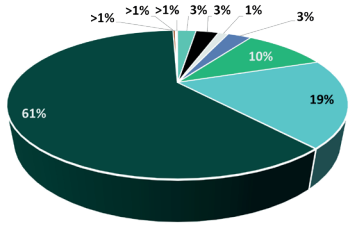
The bioeconomy in Poland has been growing steadily over the past decade and holds great potential for further development. The country has a diverse agricultural sector, extensive forests, and a rich biodiversity, which provide a solid foundation for bioeconomic activities.

Poland is one of the largest producers of agricultural products in Europe, with a strong focus on crops such as cereals, potatoes, and sugar beets. This provides ample resources for the production of bio-based materials, renewable energy, and biofuels.

The bioeconomy in Poland is on a positive trajectory, with increasing investments and a growing number of companies involved in bio-based activities. The government's continued support for bioeconomic development, coupled with the country's ample natural resources and agricultural sector, bode well for the future growth and sustainability of the bioeconomy in Poland.

Employment by sector in Poland (2020)

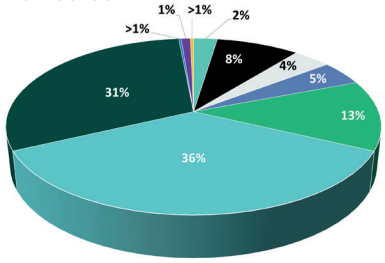
Number of people employed



- Agriculture (1.47m)
- Food, beverage and Tobacco (459.41k)
- Wood products and furniture (246.56k)
- Forestry (71.8k)
- Bio-based chemicals, pharmaceuticals, plastics and rubber (30.57k)
- Paper (69.83k)
- Bio-based textiles (57.17k)
- Fishing and aquaculture (7k)
- Bio based electricity (3.2k)
- Liquid and biofuels (3.6k)

Value added by sector in Poland (2020)

Million euros



- Agriculture (11.69k)
- Food, beverage and Tobacco (13.79k)
- Wood products and furniture (4.94k)
- Forestry (1.73k)
- Bio-based chemicals, pharmaceuticals, plastics and rubber (1.46k)
- Paper (3.22k)
- Bio-based textiles (925.59)
- Fishing and aquaculture (93.2)
- Bio based electricity (359.89)
- Liquid and biofuels (121.41)

Publication date

September 2019

Poland

Roadmap for the Circular Economy in Poland

Dominant sectors

Agriculture
Wood, wood products and furniture
Food

Responsible authorities

Ministry of Agriculture

Poland sees the bioeconomy as a closed-loop economy. i.e., a biological cycle in the economy is one of the two pillars of the CE (Circular Economy), alongside the technological cycle. The biological cycle in CE is related to the management of renewable resources – the so-called biomass – throughout its life cycle. This includes production of agricultural raw materials, production of goods (e.g. food, feed, bioenergy), processing, sale of goods, the use phase, and bio-waste management.

Other related strategies

- National Smart Specialisation Strategy
- Polish National CAP Strategic Plan
- The Strategy for Sustainable Development of Rural Areas
- Roadmap for the Circular Economy in Poland
- Plan for Rural Areas (bioeconomy as one of the priority projects named Agriculture for Ecology)
- National Energy and Climate Plan for the years 2021-2030

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Bioeconomy country file

Poland

Policy instruments

BIOSTRATEG Strategic and Research program "Environment, Agriculture and Forestry

BIOSTRATEG is a strategic programme of scientific research and development works prepared by the NCBR Council and approved by the Minister of Science and Higher Education. The programme covers five strategic problem areas, resulting directly from the National Research Program, in line with the priority research directions currently carried out in the European Union and worldwide.

Operational Program Smart Growth

This European Union-funded program supports research and innovation activities in various sectors, including the bioeconomy. It provides grants for projects focused on developing new biomaterials, bioenergy sources, and sustainable agriculture practices.

National Centre for Forest Development (KRD)

KRD is an implementing agency in Poland, as it is understood according to the Act on Public Finance of 27 August 2009, established to carry out tasks within the state policies on science, innovation, as well as science and technology. KDR provides financial support for projects related to forestry and the sustainable management of forest resources. They offer grants for initiatives focused on bio-based products, forest biomass utilization, and innovative forest management practices.

National Centre for Research and Development (NCBR)

NCBR provides funding for research and development projects in various sectors, including the bioeconomy. They offer grants for research and innovation activities in biotechnology, agriculture and forestry.

National Centre for Agricultural Support (KOWR)

KOWR is a Polish governmental agency, supervised by the Minister of Agriculture and Rural Development. KOWR provides financial support for projects related to agriculture and rural development. They offer grants for activities such as the development of bioenergy, bio-based products, and sustainable farming practices.

Bioeconomy in Poland

Collaborative structures

Bioeconomy Cluster Association

Bioeconomy Cluster Association was established in 2019 and is a voluntary, self-governing association of individuals and enterprises, science and research institutions, and other bodies known as supporting partners. They create a common platform for dialogue and cooperation for the scientific community and entrepreneurship in the broadly understood bioeconomy

Klaster Life Science Kraków

Since October 21, 2016, the Life Science Kraków Cluster has had the status of a National Key Cluster. The LifeScience Kraków Cluster offers access to an organized cooperation network operating in the scientific and business environment of the life science sector.

AgroBioCluster

AgroBioCluster is an agrifood & bioeconomy cluster that brings together 46 companies, local government administration, research and scientific institutes from Central Poland, stimulating their holistic development and international cooperation.

Institute of Soil Science and Plant Cultivation (IUNG)

State Research Institute IUNG is the largest and oldest research-development centre in Poland, conducting agricultural studies under the supervision of the Ministry of Agriculture and Rural Development. The broad range of activities comprises crop production, soil science and fertilisation, as well as recognition and protection of agricultural areas against various forms of degradation.

Polish Bioeconomy Technological Platform

The platform brings together over 60 business partners, research institutions and universities. The Platform prepared INNOBIO sectoral programme worth 550 million zloty and submitted it to the National Center for Research and Development.

Showcase

BIOEAST Initiative

BIOEAST is a strategic initiative that aims to support the development of the bioeconomy sector in Central and Eastern European (CEE) countries, including Slovakia. It focuses on creating sustainable and resource-efficient solutions that contribute to economic growth, job creation, and environmental protection.

BIOEAST provides a platform for collaboration and knowledge exchange among stakeholders from government, academia, industry, and civil society. Through this initiative, Slovakia can benefit from sharing best practices, adopting innovative technologies, and accessing funding opportunities.

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Bioeconomy country file

Portugal

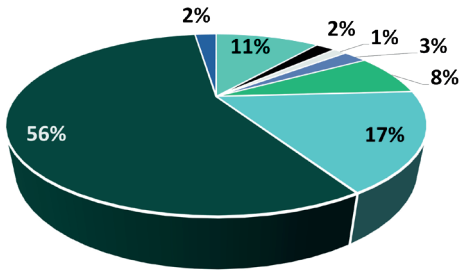
In Portugal, there is a Bioeconomy Strategy initially created with the objective of 2025, but now it has been extended until 2030. It is quite complete but needs updating as it currently does not include the bioenergy sector, for example. It is focus on the sectors of primary production of biological resources.

Portugal also has an Action Plan for a Sustainable Bioeconomy Horizon 2025

For a better development, policies are shaped in regional strategies.

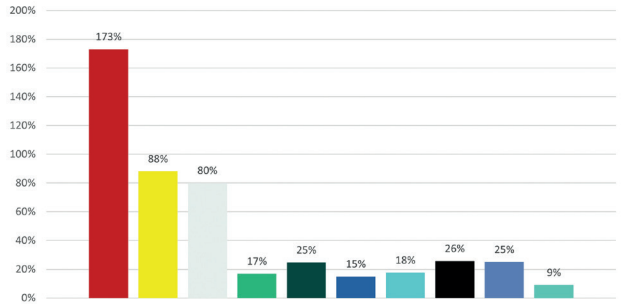
Employment by sector in Portugal (2020)

(Number of people employed)



- Agriculture (352.2k)
- Food, beverage and Tobacco (109.49k)
- Wood products and furniture (47.71k)
- Forestry (14,99k)
- Bio-based chemicals, pharmaceuticals, plastics and rubber (8.37k)
- Paper (12.72k)
- Bio-based textiles (67.47k)
- Fishing and aquaculture (14.02k)

Value added growth between 2008 and 2020 in Portugal



- Agriculture (25%)
- Food, beverage and Tobacco (18%)
- Wood product and furniture (17%)
- Forestry (25%)
- Bio-based chemicals, pharmaceuticals, plastics and rubber (80%)
- Paper (26%)
- Bio-based textiles (9%)
- Fishing and aquaculture (15%))
- Liquid biofuels (173%)
- Bio based electricity (88%)

Duration

2021 – 2030

Responsible authorities

- Ministry of the Environment
- Policy Planning and General Administration Office
- Portuguese Environment Agency

Portugal

National Strategy For the Sustainable Bioeconomy 2030

The objective is to present a vision for the primary production sectors in the context of the sustainable bioeconomy in Portugal. The objectives are to define the strategic axes of action and to clarify the role of public policy in this process.
Promoting the bioeconomy in primary production sectors will be based on the following pillars:

- Protecting and enhancing biodiversity
- Valuing endogenous biological resources and reducing dependence on non-renewable resources
- Sustainable management of biological resources, respecting ecological limits
- Pursuing the goal of carbon neutrality
- Capitalizing on the advantages of digitization for the bioeconomy and promoting innovative, intelligent and competitive production processes
- Promoting the development of rural areas
- Adoption of the principle of using biomass in cascade

Dominant sectors

Fishing and Aquaculture
Agriculture
Forestry

Other related strategies

- Roadmap For Carbon Neutrality 2050 (RNC2050)
- Blue Bioeconomy roadmap
- Action Plan for a Sustainable Bioeconomy Horizon 2025

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Bioeconomy country file

Portugal

Policy instruments

Portal "BioRecursos.PT"

IT and technological infrastructure capable of: i) aggregating and integrating data from multiple sources and formats, and guaranteeing systematic monitoring of the availability and flows of biological resources (main product, by-products and waste) supplied by the primary production sectors and the associated manufacturing industries, throughout the national territory; ii) support the communication of information according to the needs of bioeconomy agents; and iii) promote, through the launch of an open data area, a favorable environment for the co-creation of information.

Ordinance No. 262/2021, of November 23

Regulation of the Incentive System for Companies «Promotion of Sustainable Bioeconomy»

Resolution of the Council of Ministers No. 183/2021, of December 28

The regulation approves the Action Plan for a Sustainable Bioeconomy (PABS)

Environmental Fund

The Environmental Fund aims to support environmental and climate action policies to achieve sustainable development goals, contributing to the fulfillment of national and international objectives and commitments, particularly those related to climate change, renewable energy sources, energy efficiency, water resources, waste management, nature conservation and biodiversity, well-being of companion animals, forestry and forest management, landscape planning and management.

Support Office for Bioeconomy Entrepreneurs

Technical and administrative support to companies and entities that intend to undertake a project in the field of bioeconomy. The office centralizes information from different sources (for example, applicable legal/regulatory requirements and procedures; available funding sources, requirements and application process) and conducts process instruction with the different services of the Ministries of Agriculture, Environment and Action for Clima y do Mar, and other external entities, simplifying their complexity, streamlining processes and increasing response speed.

Bioeconomy in Portugal

Collaborative structures

BIOBANKS

EBB involves biobanks and culture collections in all the Atlantic EU member states (France, Ireland, Portugal, Spain, and UK), and one associated state (Norway).

B2E CoLAB

The main objective of the B2E CoLAB is to promote the creation of highly-skilled jobs that can actively contribute to enhance the economic and social value of new and existing bio-based products and services inspired by the ocean, supporting the Blue Growth sectors with the highest potential: natural resources, marine biotechnology and sustainable aquaculture.

BlueBio Alliance

Is a non-profit Portuguese association, which represents a wide variety of players in the marine bioresources and blue biotech value chain, ranging from raw material producers, R&D units, biotech SMEs, transforming centres and manufacturers, public sector & governmental entities, support companies and final consumer product developers.

Showcase

Portuguese Blue Biobank (BAP)

The Interdisciplinary Centre of Marine and Environmental Research at the University of Porto (CIIMAR-UP) is leading the establishment of the Portuguese Blue Biobank (BAP), one of the 10 pillars of the Pact for Blue Bioeconomy.

The initiative aims to position Portugal at the forefront of knowledge and preservation of its marine bioresources, contributing to its economic development.

The Project started on 21th April 2023 and is planned to be implemented by the end of 2025.

This project has received funding from the European Union's Horizon Europe Programme under Grant Agreement number: 101060252 www.shapingbio.eu

Funded by the European Union

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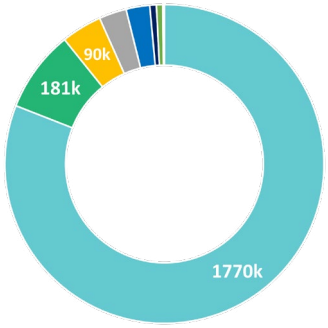
Bioeconomy country file

Romania

Romania has one of the largest agricultural sectors in Europe and a strong (petro)chemical industry. These two factors, combined, concur to make it an ideal candidate for bio-based chemistry. The concept of bioeconomy as a multi-sectoral discipline is just surfacing in Romania and the massive amount of biomass available is un-or under-exploited. However, relevant bioeconomy themes are included in the Smart Specialisation Strategy of the Country.

Bioeconomy: persons employed by sector

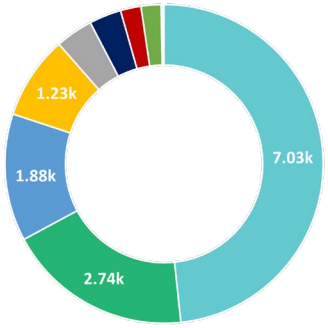
2020



- Agriculture
- Bio-based textiles
- Forestry
- Bio-based chem/ pharma/plastics
- Liquid biofuels
- Food, beverage
- Wood products and furniture
- Paper
- Fishing and aquaculture
- Bio-electricity

Value added by sector (million €)

2020



- Agriculture
- Bio-based textiles
- Forestry
- Bio-based chem/ pharma/plastics
- Liquid biofuels
- Food, beverage
- Wood products and furniture
- Paper
- Fishing and aquaculture
- Bio-electricity

Publication date

2020

(Duration: 2020-2023)

Responsible authorities

Romanian Government, Department of Sustainable Development.

Romania Bioeconomy strategy

National circular economy strategy

This National Circular Economy Strategy (SNEC) provides an overview of 14 economic sectors in Romania from the circularity potential perspective. The energy, water and waste are addressed in all 14 sectors in a cross-cutting manner. Water and waste are also presented separately to highlight their circularity challenges and potential, given Romania's still underdeveloped infrastructure in these areas. Based on a preliminary analysis, we can conclude that Circular Economy (CE) improvement has the greatest potential in agriculture and forestry, automotive sector, construction, consumer goods such as food and beverages, packaging, textiles, and electrical and electronic equipment.

Dominant sectors

Agriculture

Food & Beverages

Forestry and wood products

Other related strategies

- Strategy for the development of the agri-food sector in the medium and long term 2020-2030
- National Strategy for Research, Innovation and Smart Specialization 2022-2027
- The 2021-2030 Integrated National Energy and Climate Plan
- Romanian Sustainable Development Strategy 2030

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Bioeconomy country file

Romania

Policy instruments

National Programme for Research and Development

The Romanian government provides funding through this program to support research and development projects in various sectors, including the bioeconomy.

Sustainable Development Operational Program (POSDRU)

POSDRU is a Romanian funding program that aims to foster social and economic development. While not specific to the bioeconomy, it includes support for projects related to sustainable practices, including those within the bioeconomy sector.

Romanian Research and Innovation Fund (FUIR)

This fund focuses on supporting research and innovation projects in Romania across various sectors, including the bioeconomy. It provides grants and financial assistance to projects that demonstrate scientific and technological excellence.

Bioeconomy in Romania

Collaborative structures

Romanian Institute of Bioeconomy

Aims: promote the concept of bioeconomy, inform the public on the importance of bioeconomy in the Romanian and international society, investigate and contribute to the development of bioeconomy. These include objectives to involve new technologies and processes for the development of bioeconomy; new markets and competitiveness in bioeconomy sectors; ensure close cooperation between policy makers, NGOs, academia and civil society environment in developing and marketing bioeconomy, environmental protection and renewable resources.

AICAR

Government-supported, nationwide network of incubators, associations, NGOs from Alba Iulia, Brasov, Mangalia, Sfantu Gheroghe, Targu Mures, Cluj Napoca, Bacau, Satua Mare, Dorotoi, Campia Tutzii, Timisoara

IND-AGRO-POL competitiveness pole

The Cluster groups 95 members, including 50 SMEs. Its mission is to stimulate innovation and collaboration in the agro-industrial sector (technologies and technical equipment construction for agriculture and food industry) and in related sectors (Bio-economy, renewable energy, environment and climate changes, eco-technologies and advanced materials, information technology and communications), in order to strengthen the competitiveness and sustainable development of these sectors, regional development and intelligent growth, sustainable and favorable to social inclusion.

AGROPRO Oltenia Cluster

The Cluster membership consists of 11 industries, 4 universities and research centres, 11 associations and public institutions. It is incorporated within the Regional Development Agency of Oltenia, which corresponds to South-West.

CLUSTERO

CLUSTERO gathers 49 of the most active Romanian clusters in fields such as: textiles, renewable energy, electronics and software, machine building, wood and furniture, agrifood.

Inter-Bio

A membership organisation that supports its members to interact with the governing bodies, to internationalise their production, to gain business skills, increase RDI development, links to consumers and other sectors in bioeconomy, networking.

Showcase

ASIMCOV

Agrofood Regional Cluster's project (of local importance) Consolidation of smart bioeconomy development capacity in Covasna County project is financed by the Romanian Administrative Capacity Operational Program. Its main objective is to evaluate and strengthen the development capacity of the intelligent bioeconomy ecosystem in Covasna County for sustainable development through the involvement of local communities, economic actors and local public administration.

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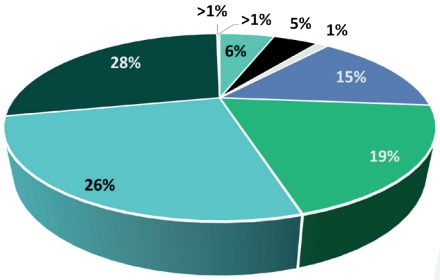
Bioeconomy country file

Slovakia

Employment by sector in Slovakia (2020)

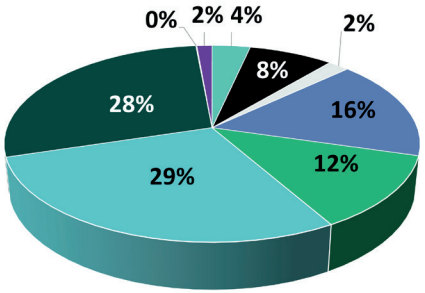
Number of people employed



- Agriculture (45.59k)
- Food, beverage and Tobacco (42.88k)
- Wood products and furniture (31,24k)
- Forestry (24.57k)
- Bio-based chemicals, pharmaceuticals, plastics and rubber (1.96k)
- Paper (7.41k)
- Bio-based textiles (9.05k)
- Fishing and aquaculture (220)
- Bio based electricity (292)

Value added by sector in Slovakia (2020)

Million euros



- Agriculture (1.02k)
- Food, beverage and Tobacco (1.03k)
- Wood products and furniture (440.49)
- Forestry (593.1)
- Bio-based chemicals, pharmaceuticals, plastics and rubber (70.2)
- Paper (247.48)
- Bio-based textiles (125.47)
- Fishing and aquaculture (3.9)
- Bio based electricity (50.94)

Publication date

December 2020

Slovakia

Vision and strategy of the development of Slovakia until 2030

Dominant sectors

Agriculture
Forestry
Wood products and furniture
Food

Responsible authorities

Ministry of Investments, Regional Development and Informatization of the Slovak Republic

Slovakia 2030 defines Slovakia's development priorities and goals in three integrated development programs covering key areas of development: protection and development of resources, their sustainable use and development of communities. The task of the document is not only to project and concretize the priorities of the 2030 Agenda and the European Green Deal in the specific conditions of Slovakia, but at the same time as an integrated development strategy to frame the public policies of the state and the development policies of local governments with the aim of ensuring their coordination, synergy, stability and more efficient use of public resources

Other related strategies

- Research and Innovation Strategy for Smart Specialisation of the Slovak Republic
- Strategy of the Economy policy until 2030
- Updated strategy on biodiversity protection until 2020
- Greener Slovakia – The Strategy of the Environmental Policy of the Slovak Republic until 2030
- Integrated National Energy and Climate Plan
- Low-carbon development strategy of the Slovak Republic until 2030 with a view to 2050

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Bioeconomy country file

Slovakia

Policy instruments

National Agricultural and Food Centre (NAFC)

NAFC provides grants and funding for research and development projects related to agriculture, food, and bioeconomy.

Operational Programme Research and Innovation (OPVaI)

This program provides funding for research and innovation projects, including those related to the development of bioeconomy solutions.

Slovak Innovation and Energy Agency (SIEA)

SIEA offers various funding programs and grants to support projects focused on renewable energy sources, energy efficiency, and sustainable solutions in different sectors, including bioeconomy.

Slovak Research and Development Agency (APVV)

APVV provides financial support for research projects, including those in the field of bioeconomy, to enhance innovation and competitiveness.

Bioeconomy in Slovakia

Collaborative structures

The National Platform AgroBioFood Nitra

The platform links education, research and business, i.e., the entities of the knowledge triangle; contributes to the promotion of innovation and to the transfer and implementation of R&D results and creates the conditions for engaging in international cooperation projects, transnational consortia, as well as in research and innovation activities and transfer of knowledge into practice.

Bioeconomy Cluster

Promotes cooperation, networking, innovation and mutual exchange of information between cluster members and other stakeholders in the agri-food and bio-based sectors. The cluster focuses on solving joint projects within the scope of bioeconomy.

National Agricultural and Food Centre

The National Agricultural and Food Centre focuses on comprehensive research and knowledge gathering regarding sustainable use and protection of natural resources, especially soil and water resources, for crop production and animal husbandry, quality and safety, innovation and competitiveness of food and non-food products of agricultural origin, productive and non-productive impact of agriculture on the environment and rural development, and the transfer of knowledge from agricultural and food research to end users

The Union of Slovak Clusters

UKS supports the creation and development of a cluster policy in Slovakia and promotes the exchange of information at a national and international level. Membership in UKS grands access to the latest information about possibilities to support clusters, expands the network of partners, strengthens intercluster collaboration and enhances participation in numerous interesting events.

Slovak academy of sciences

he SAS is the authoritative public institution undertaking academic non-university research in Slovakia.

The Danube Transfer Center Network

The Danube Transfer Center Network is a dynamic transnational structure dedicated to fostering innovation and knowledge transfer between academia and the economic environment. The network is composed of 13 members from 9 Danube region countries, who create their own local network of offices serving interested beneficiaries.

In Slovakia, the Slovak University of Agriculture in Nitra is a member of DTC Network, while the Bioeconomy Cluster became a DTC office supporting the university in knowledge and technology transfer towards industrial actors.

Slovak Investment and Trade Development Agency (SARIO)

SARIO offers assistance and support to investors and businesses interested in developing projects related to the bioeconomy sector in Slovakia.

Showcase

BIOEAST Initiative

BIOEAST is a strategic initiative that aims to support the development of the bioeconomy sector in Central and Eastern European (CEE) countries, including Slovakia. It focuses on creating sustainable and resource-efficient solutions that contribute to economic growth, job creation, and environmental protection.
BIOEAST provides a platform for collaboration and knowledge exchange among stakeholders from government, academia, industry, and civil society. Through this initiative, Slovakia can benefit from sharing best practices, adopting innovative technologies, and accessing funding opportunities.

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Bioeconomy country file

Slovenia

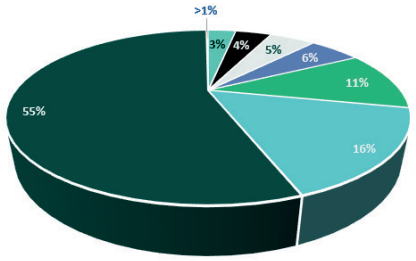
Slovenia presents a promising landscape for bio-based production chains across agriculture, forestry, and waste management. The country's substantial forest coverage (58% of surface area) provides a solid foundation for bio-based endeavors, although raw wood exports to neighboring countries pose a challenge. The nation's waste management and recycling practices, led by modern facilities like RCERO, offer accessible biomass sources.

The domestic chemical sector shows a keen interest in transitioning to bio-based solutions, spanning polymers, coatings, wood-derived chemicals, and more. The absence of local bio-refining capacity remains a hurdle.

While bioeconomy isn't central in current Slovenian strategies, the country holds notable potential for its growth due to its strong foothold in wood processing and the food and beverage industry. Stakeholders' involvement will benefit on steps to foster communication, establish bioeconomy-focused organizations, and introduce eco-friendly financing.

Employment by Sector in Slovenia (2020)

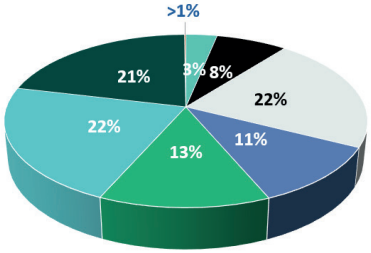
Number of people employed



- Agriculture (64.1k)
- Food, beverage and Tobacco (18.6k)
- Wood products and furniture (12.9k)
- Forestry (6.2k)
- Bio-based chemicals, pharmaceuticals, plastics and rubber (5.6k)
- Paper (4.5k)
- Bio-based textiles (3.5k)
- Fishing and aquaculture (0.2k)

Value added by sector in Slovenia (2020)

(million euros)



- Agriculture (641.7)
- Food, beverage and Tobacco (667.8)
- Wood products and furniture (397.21)
- Forestry (338.4)
- Bio-based chemicals, pharmaceuticals, plastics and rubber (659.7)
- Paper (224.53)
- Bio-based textiles (98.3)
- Fishing and aquaculture (4.4)

Source: https://datam.jrc.ec.europa.eu/datam/mashup/BIOECONOMICS/index.html

Slovenia

Slovenian Industrial Strategy 2021–2030

Publication date

2021 - 2030

Responsible authorities

Ministry of Development and Technologies

The aim is to create a sustainable industrial strategy aligned with the European Green Deal, and other guidelines. This strategy will foster innovation, adopt modern technologies, drive digital transformation, and transition to a low-carbon circular economy. Considering Slovenia's comparative advantages and the evolving global landscape shaped by climate change and the pandemic, including the need for technological sovereignty, the new industrial strategy must enable industries to effectively manage and adapt to change and technological progress. Collaboration among the country, enterprises, research institutions, education bodies, and stakeholders is crucial. Through product design that embraces circular and digital aspects, sustainable technologies, domestic renewable resources, job creation, and re-skilling, the strategy should facilitate and manage change. Establishing a system for continuous learning and adaptation is a key challenge, emphasizing the importance of innovation, investment, and the development and strengthening of knowledge and skills.

Dominant sectors

- Agriculture
- Forestry
- Pulp & Paper & Printing
- Chemicals, Pharma & Plastics
- Wood, incl. furniture
- Sustainable tourism

Other related strategies

- Roadmap Towards the Circular Economy in Slovenia
- Slovenian Smart Specialisation Strategy S5

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Bioeconomy country file

Slovenia

Policy instruments

Slovenian Enterprise Fund – SPS

SPS focuses on providing financial support, guarantees, and programs to foster the growth and development of SMEs, start-ups, and scale-ups, both domestically and internationally, while promoting sustainable development.

Slovenian Regional Development Fund – SRSS

Slovenian Regional Development Fund (SRDF) acts as one of the key institutions of regional development policy that aims for a more sustainable achievement of long-term public goals in the development of regions, rural areas and protected areas. Beneficiaries are SME's, farmers, holdings, co-operatives, municipalities and non-profit organisations. As a primary form of incentive, the Fund grants loans with a favourable interest rate and a long maturity. Other forms are guarantees, subsidies, soft loans, capital investments and pre-financing. As of end-2021, SRDF had an outstanding guarantee volume of around EUR 1.6M and supported around 150 SMEs

Ekosklad

This is a Slovenian Eco Fund that supports activities related to nature protection. It builds on the experience and examples of good practice to date with new findings and measures that improve the state of the environment. The transition to renewable energy sources, efficient use of energy, handling of waste and wastewater, permanent mobility and public awareness are challenges that it addresses

Bioeconomy in Slovenia
Collaborative structures

Bogatin, part of EIT Climate-KIC Accelerator

A Slovenian representative in the frame of ClimeAccelerator, an accelerator created because of a partnership of five different countries

(Czech Republic, Serbia, Croatia, Greece and Slovenia) and EIT Climate-KIC organizations. It helps innovation and startup ecosystem builders understand the challenges that the companies with high growth potential are facing – and the policies that could help solve them.

Technology Park Ljubljana

Development Collaboration & Global Commercialization - connects technology and knowledge providers in common market and product development projects and supports their global expansion.
The Technology Park Ljubljana supports collaborative innovation ecosystems by co-creation and implementation of internationally recognized, tailored and efficient strategies, programs and services to increase regional innovation capacity with the carriers of regional development.

ABC Accelerator

Acceleration program for startups and scaleups designed to support business growth and increase company valuation with an option for 100k-250k€ investment to scale.

All participants in the accelerator get the opportunity to work with a Cross-Border acceleration team, connecting startups with foreign entrepreneurs, companies and investors in our network capable of establishing new partnerships and boosting your sales in Italy, Austria, Germany and all Ex-Yugoslavian countries.

SRIP

SRIP is Strategic Research and Innovation Partnership – Networks for the transition into circular economy. Its vision is to rise the recognisability of Slovenia as a circular economy hub that will set the reference standard for top professionals and foreign investors through its knowledge, R&D infrastructure, breakthrough technologies and services, as well as its regulatory support environment. It's a cluster-like national stakeholder.

Showcase

CircAgro

Aims at developing circular system solutions for replicable and scalable circular business models, adding value to the side-streams and by-products of primary agricultural production. Its outputs (product prototypes, technological concepts, business model designs, suggested policy framework) will correspond to the specific needs and conditions of Slovenian agriculture, pursuing the benefits of farmers, other value chain actors and society.

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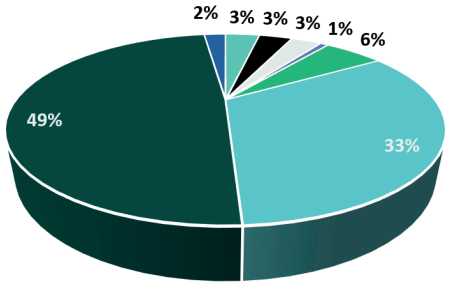
Bioeconomy country file

Spain

In Spain, there is a comprehensive Bioeconomy Strategy that includes all the important sectors in the EU's economic activity. However, its implementation is not progressing as planned due to it not being a priority in the working agenda of the responsible Ministry. Nonetheless, its development is taking place individually by some Spanish regions without considering the actions of the rest of the country, where regional strategies have been established and they have been promoting the bioeconomy in their respective regions. It's important to highlight that the bioeconomy sector generated an approximate business volume of 220 billion euros in Spain in 2020. But nowadays its development is stopped.

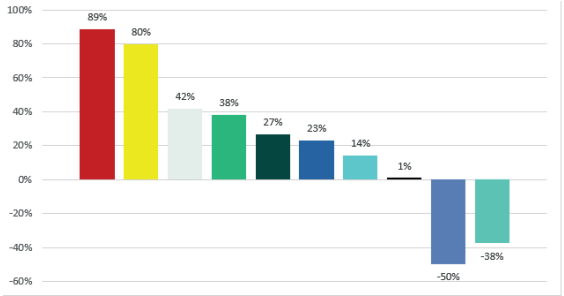
Employment by sector in Spain (2020)

Number of people employed



- Agriculture (684.1k)
- Food, beverage and Tobacco (461.82k)
- Wood products and furniture (80.21k)
- Forestry (11k)
- Bio-based chemicals, pharmaceuticals, plastics and rubber (42.02k)
- Paper (46.12k)
- Bio-based textiles (47,6k)
- Fishing and aquaculture (29,9k)

Value added growth between 2008 and 2020



- Agriculture (27%)
- Food, beverage and Tobacco (14%)
- Wood product and furniture (38%)
- Forestry (- 50%)
- Bio-based chemicals, pharmaceuticals, plastics and rubber (42%)
- Paper (1%)
- Bio-based textiles (- 38%)
- Fishing and aquaculture (23%))
- Liquid biofuels (89%)
- Bio based electricity (80%)

Publication date

2015 - 2030

Responsible authorities

Ministry of Science and Innovation

Spain

Spanish Bioeconomy Strategy: Horizon 2030

Its objective is the production and commercialization of food, as well as forest products, bioproducts, and bioenergy, obtained through physical, chemical, biochemical, or biological transformations of organic matter not intended for human or animal consumption, involving environmentally friendly processes, as well as the development of rural environments.

On the other hand, there is also a Circular Economy plan that reinforces the bioeconomy strategy and is developed in strategic lines with a duration of 3 years (currently, the 2021-2023 plan is in effect).

Dominant sectors

Agriculture
Forestry
Fishing and Aquaculture

Other related strategies

- Circular Economy Action Plan (2021-2023)

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Bioeconomy country file

Spain

Policy instruments

Aid to finance 23 innovative projects in the agri-food and forestry sector

Example of a launch of aid to promote the bioeconomy, in this case in the agricultural sector.

Order TED/408/2023, of April 24

This call aims to encourage the advancement of groundbreaking projects that support the growth of the bioeconomy, ecological transition, the resolution of demographic challenges, and the enhancement of capabilities. These projects emphasizing a scientific and technical approach, especially in the context of forest ecosystems and sustainable forest exploitation.

Subsidies for the promotion of forestry bioeconomy

Execution of transformative projects of a scientific-technical nature that contribute to the conservation, improvement and restoration of the biodiversity of ecosystems and forest species.

Bioeconomy in Spain
Collaborative structures

Basque Alliance for the Bioeconomy

The Basque Government, in collaboration with a group of companies, has promoted the creation of this Alliance in response to the need to diversify the economy towards a model based on the use of biological resources.

Interreg VA Spain-Portugal (POCTEP)

In the field of bioeconomy and circular economy, three joint projects have been identified, with one of them having full involvement and the other two being relevant. mitigating resources and energy shortage. with medium-sized businesses.

REDR

Project that focuses on the challenges and opportunities of the bioeconomy in rural areas

COOPID

This project identifies successful bioeconomy project cases in the EU and organizes visits for primary producers to learn from and gain expertise from these experiences.

Extremadura's Forest Bioeconomy Program

Specific Collaboration Agreement between the Regional Ministry of Agriculture, Rural Development, Population, and Territory and the Business Association of National Agri-Food Technological Research Center of Extremadura (CTAEX), for the development of the technical foundations for the Forest Bioeconomy Strategy of Extremadura.

Bioeconomy Ventures

BioeconomyVentures aims at creating an entrepreneurial ecosystem within the bio-based industry sector by offering support, brokerage and networking services to the relevant stakeholders.

Showcase

The Biorefinery CLaMber

The Spanish region of Castilla-La Mancha developed the CLaMber Project, which lays the foundation for making this region a benchmark in southern Europe for research related to biomass utilization.

Two different but complementary actions were carried out:

- The construction of a Research Center housing a Biorefinery where companies can conduct experiments o a scale closer to reality.
- A Pre-Commercial Procurement to carry out R&D projects with the aim of using organic waste from agriculture, livestock, municipalities, etc., generated in the region and considered problematic, in order to turn them into an opportunity and produce high-value compounds. This approach minimizes production costs and opens up new business lines.

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Bioeconomy country file

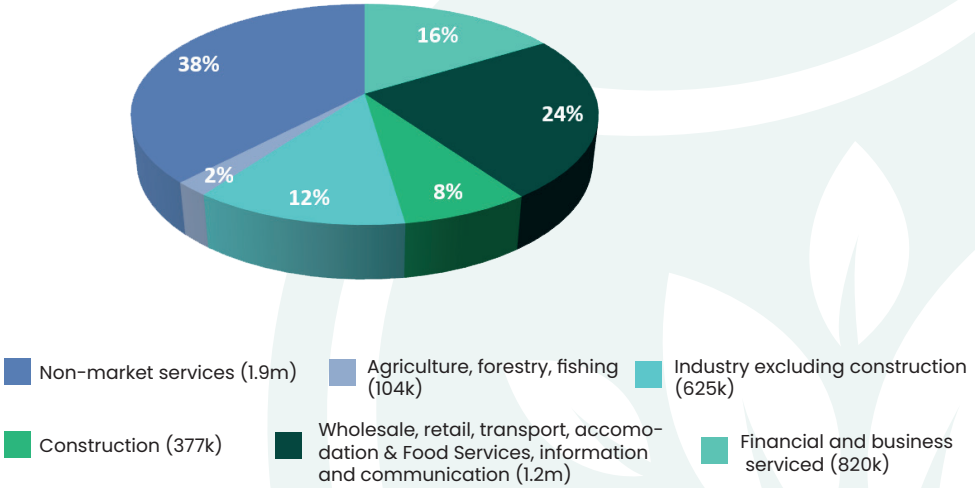
Sweden

The Swedish bioeconomy 2019 accounted for approx. 7 % of Sweden's total processing value and 21 % of total goods export (SCB Statistics Sweden).

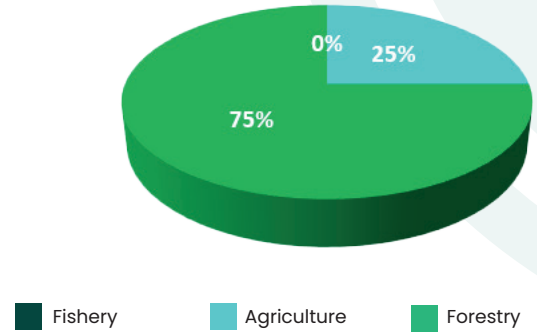
The Swedish bioeconomy is dominated by the forest industry and the products that are created with the forest as raw material. There is increasing attention to food, but a large part of primary production is in Skåne and therefore it is mostly in the south to the middle, where these themes are higher on the agenda.

A national bioeconomy is under development and expected to be completed on 31. October 2023. At the regional level, bioeconomy has been integrated into a wide range of different regional strategies in recent years.

Bioeconomy: people employed by sector



Biomass production per source



Source: JRC DataM

Publication date

2020

Sweden

National Strategy for Circular Economy

Dominant sectors

Plastic
Textiles
Food

Responsible authorities

Swedish ministry of the Environment

In 2020, the Swedish government launched its first national strategy for the circular economy

The vision for the Swedish strategy is to create a society where resources are used efficiently in non-toxic circular flows to replace virgin material. The overall goal is to create a shift from a linear economy to a circular economy, and thereby contribute to achieving the environmental and climate goals, as well as the global goals in Agenda 2030.

Several resource streams are highlighted as prioritized in the transition to a circular economy. These are mentioned as important to create fast, comprehensive, and coordinated actions and consist of i) plastic, ii) textiles, iii) food, iv) renewable and bio-based raw materials, v) the construction and real estate sector, and vi) innovation-critical metals and minerals.

Other related strategies

- Circular economy – A strategy for change in Sweden (2020)
- Circular economy – Action plan for the transformation of Sweden (2021)
- The government's action plan for plastics Part of the circular economy (2022)
- To do more with less – A national waste management plan and waste prevention program 2018 - 2023

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Bioeconomy country file

Sweden

Policy instruments

BioInnovation

An innovation program that promotes research and innovation for bio-based development. BioInnovation is being phased out and will be replaced by Bioimpact.(https://bioimpact.se/)

Bioeconomy arena

Public funding program is focused on Artificial The Swedish Government has allocated RISE a supplement of SEK 350 million to intensify work on sustainable solutions in bioeconomy, to strengthen RISE's investment in test beds for biorefinery.

As part of Bioeconomy Arena, a new pilot plant in Örnsköldsvik will be fully up and running by the end of 2023. – an area that is a world leader in forestry, wood, and paper industry.

Eu's Rural Development Program

Sweden uses funds under the EU's agricultural policy to finance activities within bioeconomy, including specifically as part of the Rural Development Program

Bioeconomy in Sweden
Collaborative structures

Fossil Free Sweden

Fossil Free Sweden was started at the initiative of the Swedish Government in 2015 and has a unique role between the business sector and politics. 22 business sectors have produced roadmaps for fossil-free competitiveness within the framework of Fossil-Free Sweden. The roadmaps contain both commitments and political proposals.

Swedish Bioenergy Association

Standard agency specialized on woodSvebio is a commercial environmental organization for companies and individuals (around 300 members). Is playing an active part in all major political decisions concerning bioenergy and bioenergy-related matters in Sweden.

Sweden Food Arena

Sweden Food Arena is a national arena where food industry stakeholders collaborate for an innovative, sustainable, and competitive food sector. The arena is a result of the government's Food Strategy, which aims to increase production and contribute to a competitive food supply chain, as well as increase employment, exports, innovation power, and profitability while achieving relevant environmental goals.

TreeSearch

A collaboration platform that creates an open research environment between academia, industry, research institutes, private foundations, and the Swedish government. It is a national effort that lays the foundation for future innovations from the forest.

Bioeconomy Graduate Research School (GRS)

Bioeconomy GRS aims to act as a collaborative platform at Lund University allowing researchers and PhD students, across faculties/disciplines and research areas, as well as non-academic stakeholders, to meet each other to identify, carry out, and communicate innovative, analytically advanced, and yet problem-oriented research for a sustainable future circular bioeconomy covering the whole biomass value chain

SwedenBio

The national organization of the life science industry in Sweden. SwedenBIO improves the business climate for 300+ member companies and the life science industry. In addition to advocacy and promotion of industry interests, through member services, They enable professional development, knowledge and experience exchange.

Processum Biorefinery Cluster (part of Bioeconomy Arena)

Aims to strengthen the cooperation World-leading cluster for the development and commercialization of biorefinery processes based in Örnsköldsvikpublic decision-makers.

Showcase

Domsjø Fabriker AB

Domsjø Fabriker AB is one of Europe's premier biorefineries based on wood as a raw material. The company utilizes renewable wood raw materials and converts them into various green products. The main products are cellulose, lignin, and bioethanol. In addition, they also manufacture other biorefinery products such as carbon dioxide, biogas, bio-resin, soil conditioner improvement, etc.

ShapingBio

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The bioeconomy of the future

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