Catalonia Bioeconomy Ecosystem Report

BIO BOOST
Bioeconomy projects accelerator

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PROJECT INFORMATION

Grant agreement number	101060974
Project title	Catalysing Investment into Catalan Bioeconomy via One-Stop-Shop Accelerator
Project acronym	BIOBOOST
Funding scheme	HORIZON Coordination and Support Actions European Research Executive Agency
Start date	June 1st 2022
Duration	48 months
Call identifier	HORIZON-CL6-2021-CIRCBIO-01
Project website	https://bioboost.cat/en/

DELIVERABLE INFORMATION

Deliverable no.	D1.2.
Deliverable title	Catalonia Bioeconomy Ecosystem Report
WP no.	WP1
WP leader	SÍMBIOSY
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Executive summary

This report provides a comprehensive overview of the bioeconomy sector in Catalonia, Spain, including the use and recovery potential of biomass resources. The report will be of interest to policymakers, investors, businesses, and researchers seeking to better understand the circular bioeconomy in Catalonia and to identify potential areas for investment and collaboration. The report is structured into five main sections.

In the first section, the report provides an overview of the bioeconomy sector in Catalonia. The report identifies the regional context, quantifies the sector, and characterises the biomass resources in Catalonia. The report also highlights the role of the Bioboost Project in the Catalan Bioeconomy Strategy.

The second section of the report provides an analysis of relevant policies and strategies related to the bioeconomy at the EU, national, and regional level. This section offers a comprehensive overview of current policies and strategies and assesses their impact on the development of the circular bioeconomy in Catalonia.

The third section identifies Catalan-related Bioeconomy EU Projects. The report highlights the projects and provides a brief description of each project.

The fourth section presents the results of a regional stakeholders mapping exercise. The report identifies key stakeholders in academia, industry and business, public administration, and investors in Catalonia.

Finally, the fifth section identifies relevant financing instruments in Catalonia and Spain. The report provides an overview of the financing instruments and their potential for supporting the growth of the bioeconomy sector in Catalonia.

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Introduction

The concept of bioeconomy has gained significant attention in recent years due to its potential to address global challenges such as climate change, population growth, and resource scarcity. Bioeconomy refers to an economic model that prioritizes the sustainable use of renewable biological resources to create value-added products and services.

Catalonia, with its unique geographic and economic circumstances, is no exception to these global challenges and has recognized the need to transition to a circular bioeconomy model. Catalonia is characterized by its rich natural resources, diverse agriculture, and dynamic industrial sector. The region has a long-standing tradition of innovation, entrepreneurship, and collaboration, which make it well-positioned to embrace the opportunities offered by the bioeconomy.

To guide this transition, the Bioeconomy Strategy of Catalonia 2030 (EBC2030) was developed with the objective of promoting sustainable economic development in the region while mitigating climate change and improving the standard of living in rural and coastal communities. The EBC2030 recognizes the potential of the primary sector and aims to promote sustainable development that balances the conservation and use of natural resources.

This report provides a comprehensive assessment of the current state and potential of the bioeconomy in Catalonia. The report examines the different sectors that make up the bioeconomy and identifies the challenges and opportunities for their development, providing a roadmap for the transition to a circular bioeconomy in Catalonia.

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Characterization of Bioeconomy in Catalonia

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1. Characterization of Bioeconomy in Catalonia

1.1. Regional context

The territory of Catalonia is an autonomous region of Spain, located in the north-east of the country. The current population is 7,758,615 inhabitants, with an unemployment rate of 9.31%. The current Gross Domestic Product (GDP) growth is +4,0% and the estimated annual inflation of the Consumer Price Index (CPI) growth is +8,5%[1].

Table 1 Comparison of key societal and economical parameters between Catalonia, Spain and Europe (2022)[2]

	Catalonia	Spain	Europe
Population	7,758,615	47,432,805	746.4M
Unemployment rate	9,31%	12,5%	6%
GDP growth	+4%	+7,9%	+5.4%
CPI growth	+8,5%	+7,3%	+9%

Spanish Autonomous regions are divided into lower administrative levels known as provinces. A province in Spain is a territorial division defined as a collection of municipalities. In addition to their political function, provinces are commonly used today as geographical references. The autonomous community of Catalonia is divided into 4 provinces: Barcelona, Tarragona, Girona and Lleida (see Figure 1):

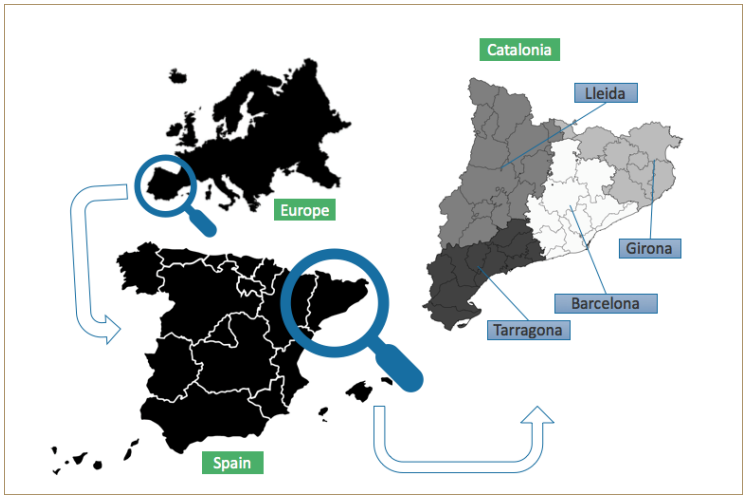

Figure 1. Geographical location of Catalonia and its provinces[3]

[1] Idescat, 2022.
[2] Idescat, INE, Eurostat, 2022
[3] Elaborated by the authors.

Catalonia has a great potential for bioeconomy for several reasons:

- Biodiversity: Catalonia is a region with a rich biodiversity that provides a wide variety of natural resources for the development of a bioeconomy, such as forests, grasslands, wetlands, and marine and freshwater ecosystems.
- Climate: climate in Catalonia is diverse, ranging from Mediterranean to semi-arid, allowing the cultivation of a variety of crops, including fruit trees, olive trees, vineyards, and cereals, all of which can provide raw materials for the bioeconomy.
- Research and development: Catalonia has a strong tradition of research and development in the field of agriculture and biotechnology, with several universities and research institutes working on projects related to the bioeconomy.
- Strong industrial tradition, especially in the chemical and food industries, which provides the necessary infrastructure and expertise to develop a bioeconomy.
- Government support: the Catalan government has shown its commitment on promoting the bioeconomy by providing financial and regulatory support for research and development projects, as well as by establishing a favourable legal and administrative framework for the development of the bioeconomy.

Overall, Catalonia's unique combination of natural resources, research and development capabilities, industrial tradition, and government support makes it an ideal location for the development of a thriving bioeconomy.

In 2017, the Government of Catalonia initiated the Plan for the Implementation of the 2030 Agenda, recognizing the importance of a circular bioeconomy model to achieve the Sustainable Development Goals and address climate change. As a result, the Government Agreement GOV/23/2020, of February 11, 2020, was established, which approved the objectives and content of the Bioeconomy Strategy of Catalonia 2012-2030 (hereinafter, EBC2030). This strategy was assigned to the Department of Agriculture, Livestock, Fisheries and Food[4], along with other relevant departments, for deployment.

Following the guidelines of the European Strategy, the EBC2030 serves as a roadmap for the transition to a decarbonisation of the economy and the implementation of productive systems with a lower ecological footprint, presenting strategies designed to maximise the use of circular bioeconomy sector's potential to generate economic activity[5]:

"The goal of EBC2030 is:

To promote the sustainable growth and development of the Catalan economy by fostering the production of biological resources and local renewable processes."

To achieve the objective, the following criteria has been considered in the EBC2030:

[4] Since 26th May 2021, Ministry of Climate Action, Food and Rural Agenda.
[5] Catalan Bioeconomy Strategy 2030 Executive Summary – Estratègia Catalana de Bioeconomia 2030 (EBC2030)

Table 2 Criteria considered in the elaboration of the EBC2030[6]

WHAT	HOW
Dynamize and enhance the territory and their resources: agroforestry, fishery and aquaculture biomass and natural capital.	Implementation of competitive value chains in the territory that promote resilient landscapes, adapted to climate change.
Become a development opportunity for the primary sector in collaboration with other sectors.	Reinforce rural and coastal areas in Catalonia through the creation of regional value through circular bioeconomy.
Promote the technological transformation of biomass resources biomass in bioproducts, biomaterials and bioenergy.	Use of renewable and local biomass, reduction of waste generation in the supply chain and change in consumption patterns (demand and use of bioproducts).
Search for innovative solutions in the field of bioeconomy.	Biotechnology and digitization.
Reduce emissions (greenhouse gasses, unmanaged surplus nutrients, phytosanitary products, among others) and resource consumption.	Implement productive systems with less environmental impact in terms of emissions and resource consumption.
Decarbonization of the economy and achievement of the Sustainable Development Goals and the Paris Agreement.	Moving towards a healthy and sustainable food and nutrition system and competitive value chains.
Economic, social, and environmental transformation.	Spread and consolidate knowledge and awareness towards the circular bioeconomy.

In order to achieve the goals of the EBC2030 initiative and adhere to the guiding principles of the strategy, the plan aims to implement a range of actions that can transform and advance the circular bioeconomy in Catalonia. These actions will be incorporated into three-year action plans and will be supported by various groups promoting the bioeconomy in the region. The first action plan, EBC2030 Action Plan (2022-24), establishes seven strategic objectives to promote the use of biological renewable and local resources in all Catalan economic sectors before 2030.

[6] EBC2030

Table 3 Strategic objectives proposed by EBC2030[7]

OBJECTIVES LINKED TO THE GENERATION OF ECONOMIC ACTIVITY
1. Improve the use of Catalonia's biomass by characterising it, quantifying it, and optimising its management and distribution.
2. Develop a business community based on the bioeconomy throughout the territory, with special attention paid to the primary sector.
3. Encourage the use and consumption of bioproducts, bioenergy and biomaterials in the market
4. Promote resilient landscapes and the sustainable provision of ecosystem services in the context of the Catalan circular bioeconomy
FACILITATING OBJECTIVES WITH A TRANSVERSAL CHARACTER
5. Situate knowledge as a motor of the circular bioeconomy
6. Strengthen the role of the Administration and adapt the legal and regulatory framework to favour the circular bioeconomy in Catalonia
7. Prepare Catalan society for the change towards the circular bioeconomy

These objectives are backed by numerous research and development initiatives aimed at creating bioeconomy solutions across various industries. These projects aid in the implementation and growth of an economically sustainable transition towards a bioeconomy model (see *Analysis of the Positioning of Bioeconomy R+D in the Catalan region within the EU framework*).

1.2. Quantifying the Bioeconomy sector in Catalonia

The circular bioeconomy is a rapidly growing sector that aims to create a sustainable economic model based on the use of renewable biological resources. Catalonia has been at the forefront of this movement, promoting the development of a circular bioeconomy through various initiatives and projects. In this context, it is important to understand the current state of the circular bioeconomy sector in Catalonia.

Quantifying the value of the circular bioeconomy requires a definition that includes all the sectors producing natural raw materials and those transforming them into bioproducts, biomaterials and bioenergy. Overall, the bioeconomy sector in Catalonia is substantial, generating revenues of €43,476 million, accounting for 9.8% of the overall value of domestic production and 4.5% of the GDP of added value (2018). It also provides employment for 5.2% of the workforce in the region.

[7] EBC2030 Action Plan (2022-24)

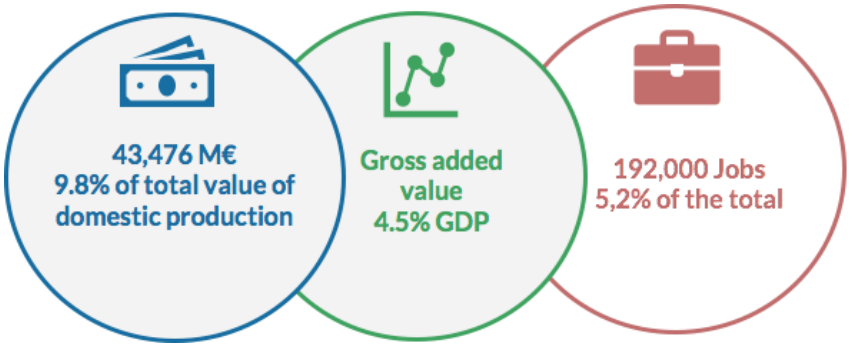

Figure 2 Economic value scorings in the Catalan economy (2018) of all the activity sectors belonging to the circular bioeconomy. [8]

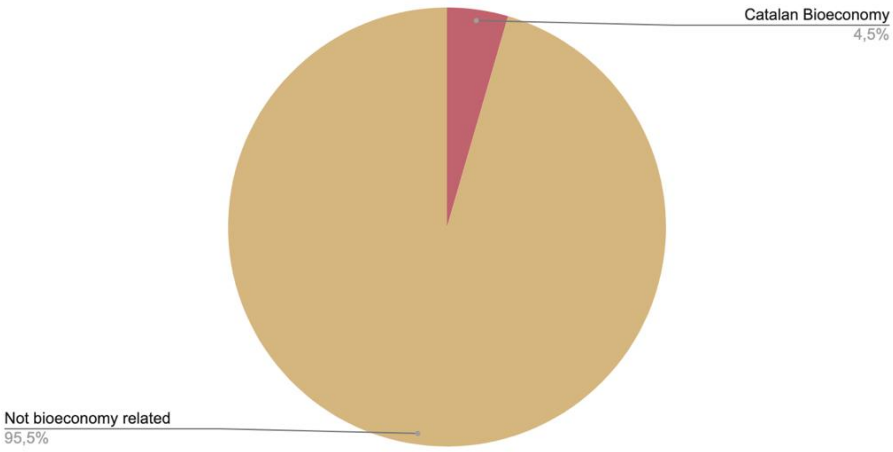

Figure 3 Catalan Bioeconomy GDP contribution to Catalan economy (2018)[9]

In the context of the bioeconomy in Catalonia, the primary sector refers to the traditional agricultural sector, including activities such as agriculture, livestock, forestry, and fishing, which involves the production of raw materials from renewable biological resources. This sector is focused on the production of food and other agricultural products and the management of natural resources.

The industrial sector, on the other hand, encompasses the processing, storage, and distribution of these products from the primary sector. It also includes the development of new technologies to produce bio-based products, such as bioplastics, biofuels, and biochemicals. It includes bio-packaging and paper, bioenergy and fuels, bioproducts (chemistry and pharmacy, cosmetics, fertilizers and bioplastics), construction, forestry linked to first and second transformation of wood and cork, textile and agri-food (by-products). This sector is focused on the transformation of raw materials into finished products and the commercialization of these products in the market.

[8] Idescat, 2018
[9] Idescat, 2018

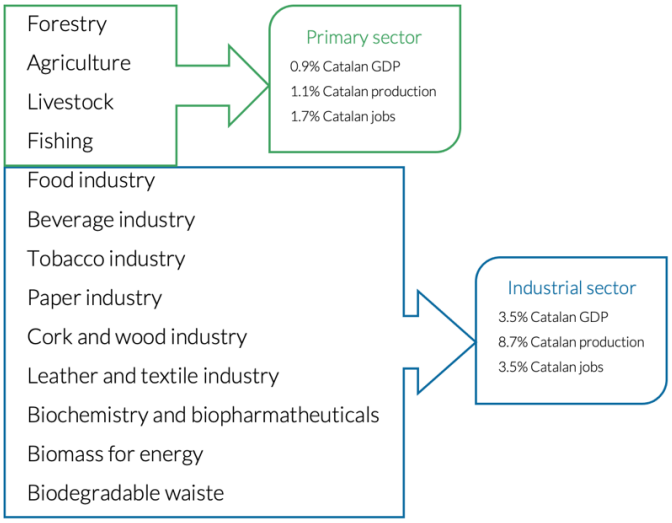

Figure 4 Catalan bioeconomy sectors, grouped in primary and industrial sectors, 2018[10]

In 2019, the primary sector in Catalonia contributed to 0,9% of the Catalan GDP and represented 1,7% of the employed population; however, the primary sector has a huge territorial presence, with a 25% of its territory dedicated to crops and a forest area of 64%[11]. The forestry sector is an important part of the chain of supply of food and industrial products and the supply of biomass to produce bioenergy. The transition towards a bioeconomy model will depend upon a strong, independent, and sustainable primary sector for the provision of food and other essential goods and services. The forest sector is an important part in the food and industrial product supply chain and the supply of biomass to produce bioenergy. On the other hand, on 2018, the industrial sector in Catalonia contributed to 3.5% of the Catalan GDP and represented 8,6% of the regional production and 3.3% of the employed population.

In the bioeconomy, the primary sector and industrial sector are closely linked, as the production of raw materials from the primary sector provides the input for the processing and manufacturing activities of the industrial sector. However, the two sectors have different focuses and objectives, with the primary sector focused on the production of raw materials, and the industrial sector focused on the processing and commercialization of these materials.

As seen, bioeconomy in Catalonia is characterized by a diverse array of economic sectors, stakeholders, and interests. The contribution of the different bioeconomy economic sectors is uneven and diversified, aligning to the industrial diversity and sectorial specialization of the Catalan industrial network. Of these, the agri-food sector stands out as the largest contributor to GDP, accounting for 2.4%. The other economic sectors combined make up 2% of the total GDP[12].

[10] Idescat, 2018
[11] Idescat, 2019
[12] Idescat, 2018

Table 4 Contribution of economic sectors associated with circular bioeconomy to the Catalan economy (2018)[13]

Economic sectors associated with circular bioeconomy	% of Catalan GDP	% of Catalan production	% of Catalan jobs
Agriculture, livestock, forestry, and fishing	0,9%	1,1%	1,7%
Food, beverage, and tobacco industries	2,4%	6.4%	2.6%
Textile industry (natural fibres) and leather	0,1%	1.2%	0.4%
Wood and cork industries	0,2%	0.3%	0.2%
Paper industries	0,5%	0.4%	0.0%
Biochemical and pharmaceutical industries	0,2%	0.2%	0.1%
Biomass for energy	0,1%	0.1%	0.0%
Biodegradable waste	0,1%	0.2%	0.2%

This table shows the contribution of various economic sectors associated with the circular bioeconomy to the Catalan economy in 2018 and provides a useful snapshot of the current state of the circular bioeconomy in the region, highlighting the sectors that are making the most significant contributions to this important economic and environmental paradigm.

The food industries and primary sector, including agriculture, livestock, forestry, and fishing, are the two most significant spheres of activity, offering great potential for the recovery and utilization of biomass in the region.

The food, beverage, and tobacco industries are the largest contributors to the circular bioeconomy in Catalonia, accounting for 2.4% of the region's GDP, 6.4% of its production, and 2.6% of its jobs. This is not surprising given that the food and beverage sector is a significant part of most economies and is often a major contributor to the circular bioeconomy due to its reliance on natural resources.

The paper industry is another important contributor to the circular bioeconomy in Catalonia, accounting for 0.5% of the region's GDP, 1.2% of its production, and 0.4% of its jobs. The use of recycled paper and sustainable forestry practices are important aspects of the circular bioeconomy, and it's good to see the paper industry contributing to these efforts.

The wood and cork industries, as well as the textile industry and leather, are smaller contributors to the circular bioeconomy in Catalonia, accounting for 0.2% and 0.1% of the region's GDP, respectively. However, these industries are also making efforts to reduce waste and promote sustainable practices.

Finally, the biochemical and pharmaceutical industries, biomass for energy, and biodegradable waste sectors are relatively small contributors to the circular bioeconomy in Catalonia, each accounting for less than 0.2% of the region's GDP. However, these sectors have significant potential to contribute to the circular bioeconomy in the future, particularly as technology and sustainability practices continue to advance.

[13] Idescat, 2018

Figure 5 Contribution of the economic sectors associated with circular bioeconomy to the Catalan economy (GVA[14] 2018)[15]

1.3. Use and recovery potential of biomass resources in Catalonia

Characterisation of biomass resources

In the EBC2030, biomass is understood as the set of all organic matter of plant or animal origin, including materials resulting from natural or artificial transformation processes. This can include anything from wood and crop residues to manure and food waste (see Figure 6). The biomass resources that fall within this scope are:

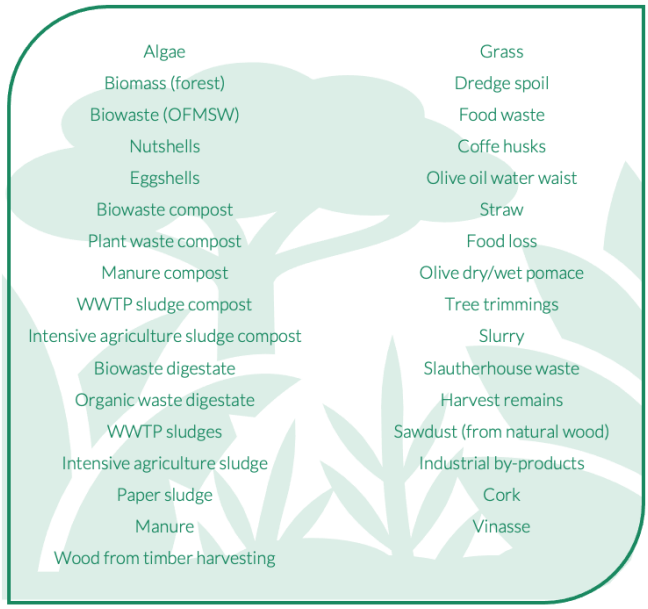

Figure 6 Resources for the biomass potential[16]

14 The gross value added (GVA) is the sum of all additional values acquired by goods and services when transformed in the production process. The GVA is calculated by subtracting the value of the goods and services used during the process of production from the total production value.

15 Idescat, 2018

16 Waste Agency of Catalonia – Agència de Residus de Catalunya (ARC)

The potential use of different biomass resources in specific sectors in Catalonia, as presented in Figure 7, is likely a result of a combination of availability, characteristics and properties, and technological readiness of the organic resources.

	Food and beverage industries	Agriculture, forestry and fishing	Manufacture of paper and paper products	Manufacture of textiles and garments	Manufacture of wood and products from wood and cork. Manufacture of articles of straw	Manufacture of biobased pharmaceutical products	Manufacture of biobased chemical products	Bioenergy
Algae	●					●	●	●
Biomass (forest)		●	●		●	●	●	●
Biowaste (OFMSW[17])		●					●	●
Nutshell	●	●			●	●	●	●
Eggshells	●	●				●	●	●
Biowaste compost		●				●	●	●
Plant waste compost		●				●	●	
Manure compost		●						
WWTP sludge compost		●						
Intensive agriculture sludge compost	●	●				●	●	
Biowaste digestate	●	●				●	●	●
Organic waste digestate	●	●				●	●	●
WWTP sludges		●				●	●	●
Intensive agriculture sludge		●				●	●	●
Paper sludge		●	●				●	●

17 organic fraction from municipal waste

	Food and beverage industries	Agriculture, forestry and fishing	Manufacture of paper and paper products	Manufacture of textiles and garments	Manufacture of wood and products from wood and cork. Manufacture of articles of straw	Manufacture of biobased pharmaceutical products	Manufacture of biobased chemical products	Bioenergy
Manure		✓					✓	✓
Wood from timber harvesting	✓	✓	✓	✓	✓	✓	✓	✓
Grass		✓				✓	✓	
Dredge spoil	✓	✓	✓	✓	✓	✓	✓	✓
Food waste		✓				✓	✓	✓
Coffee husks		✓				✓	✓	✓
Olive oil water waist		✓				✓	✓	✓
Straw		✓			✓	✓	✓	✓
Food loss	✓	✓				✓	✓	✓
Olive dry/wet pomace		✓				✓	✓	✓
Tree trimmings		✓	✓	✓	✓	✓	✓	✓
Slurry		✓				✓	✓	✓
Slaughterhouse waste		✓				✓	✓	✓
Harvest remains		✓	✓	✓	✓	✓	✓	✓
Sawdust (from natural wood)		✓	✓		✓			✓
Industrial by-products		✓				✓	✓	✓
Cork		✓	✓		✓			✓
Vinasse	✓	✓				✓	✓	

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Figure 7 List of potential uses by sectors of the identified biomass resources in Catalonia[18]

Evidently, most potential uses involve agriculture, silviculture, and fishing; manufacture of biobased pharmaceutical products; manufacture of biobased chemical products; and production of bioenergy. These resources and potential uses can be recovered in different ways using diverse technologies and processes.

It is important to note that biomass data in Catalonia is highly dispersed, sometimes missing and/or inconsistent, hampering precise and territorialized quantitative assessments of the different flows of organic resources and biowaste. For this reason, there is a need to characterize better the current amount of biowaste and organic materials available and produced in the territory, to be able to calculate a more precise biomass potential in Catalonia.

The following sections will present updated information in some key sectors, starting with those featured in the EBC2030 due to their link to the primary sector, such as forestry, food production (including the agricultural sector and food transformation and distribution sector), and the maritime industry. We will also include other bio-based industries that are important to the bioeconomy, such as the paper and biochemical industries. For each sector analysed, a description will be provided, along with an explanation of the current resource recovery routes, and highlighting the potential and opportunities for biomass recovery:

I. Forestry sector
II. Food production sector:
    - Agricultural sector
    - Food transformation & distribution sector
III. Maritime sector
IV. Other bio-based industries and refineries:
    - Manufacture of paper and paper products
    - Manufacture of bio-based chemical products

I. Forestry sector

Description

In general terms, Catalonia is an eminently forested region; more than a half of its area is covered by forest terrains: meadows, scrub, natural barrens, especially woodlands. In recent years, the woodlands have grown as a result of intense and progressive abandonment of farmland. This fact is caused by the existing value chains' lack of economic competitiveness given the main type of wood/forest (high density of low-diameter trees). Also, there is a lack of economic viability due to the intrinsic orography and characteristics of Catalan forests that implies rural depopulation linked to the forest sector. In addition, the lack of experts and technicians trained in forest work is a limiting factor.

The forested area of Catalonia accounts for 2,076,134 ha, which represents 64.6% of the total area. 65% of the forested area (1,341,798 ha) corresponds to woodlands. Between the years 1993 and 2018, the wooded forest area of the region has increased in 123,225 hectares. 75.1% of Catalan forests are

[18] Waste Agency of Catalonia – Agència de Residus de Catalunya (ARC)

private and the remaining 24.9% are public[19]. Regarding private forest planning, 40.1% of the area is managed by Forest Planning Instruments[20] and Simple Forest Management Plans[21], while 59.9% is not managed at all. Employment in the forest sector in Catalonia has been decreasing in recent years. In 2000, there were 68,888 workers, while by 2019 there were 30,928 workers. This trend is similar to the number of companies, which went down from 6,360 establishments in 2000 to 2,545 establishments in 2019. Timber harvesting[22] operations have increased in recent years, although they are currently representing only 28% of total forest growth[23].

The main species in terms of wood volume in Catalan forests are Scots pine, Aleppo pine and holm oak. Forests are the largest source of terrestrial biological resources that do not compete with food production. Also, they are the greenest infrastructure in terms of extension, providing a wide range of ecosystem services and play an important role in the economy. Given that, improving the management of forests and use of their resources is key for advancing toward the circular bioeconomy in the region. This entails intervening in the two main flows of the wood value chain:

1) Timber production, which includes raw materials for industry (timber, pulpwood and all its products and by-products) and energy generation (wood chips and firewood).
2) Non-wood products such as cork, mushrooms, truffles, pineapples and pine nuts, honey and wax, and aromatic and medicinal plants[24].

Forest management must guarantee the persistence of forest cover by making it compatible with the supply of goods and services and the multifunctionality of forests. The sustainable use of forest resources must cover the needs of a key economic sector in the territory and thus, allow the persistence and improvement of forests against risks such as forest fires and climate change. While only 28% of the forest growth is harvested for wood and timber production each year, most of the forest remains intact and continues to serve as a vital tool for capturing carbon from the atmosphere.

Current recovery routes

Linked to the resource recovery in the forest chain, in Catalonia, the average production of the forest value chain distinguishes between three (3) main product lines (2014-2018):

- Wood chips: 150.000 m^3 extracted and intended for bioenergy production (15%).
- Firewood: 227.000m^3 extracted and intended for bioenergy production (23%).
- Wood for industry: 610.000 m^3 extracted (62%). The four industrial wood destinations in Catalonia are sawmills, cross-laminated timber (CLT) production, the production of poles, sticks and stakes, and shredding for export.

Table 5 shows the various industrial destinations of wood in Catalonia, including sawmills, the production of cross-laminated timber (CLT), the production of sticks, hangers and stakes, and crushing. For each

19 Land Covers Map of Catalonia (MCSC), 2018

20 Technical Plans for Forest Management and Improvement – Pla Tècnic de Gestió i Millora Forestal (PTGMF)

21 Simple Plan Forest Management - Pla Simple de Gestió Forestal (PSGF)

22 Timber harvesting includes the operations consisting of the partial preparation, extraction and transport of the wood and timber obtained from the cuts effectuated, following a proper planning process, in a forest.

23 Land Covers Map of Catalonia (MCSC), 2018

24 Inventario Forestal Nacional, 2016.

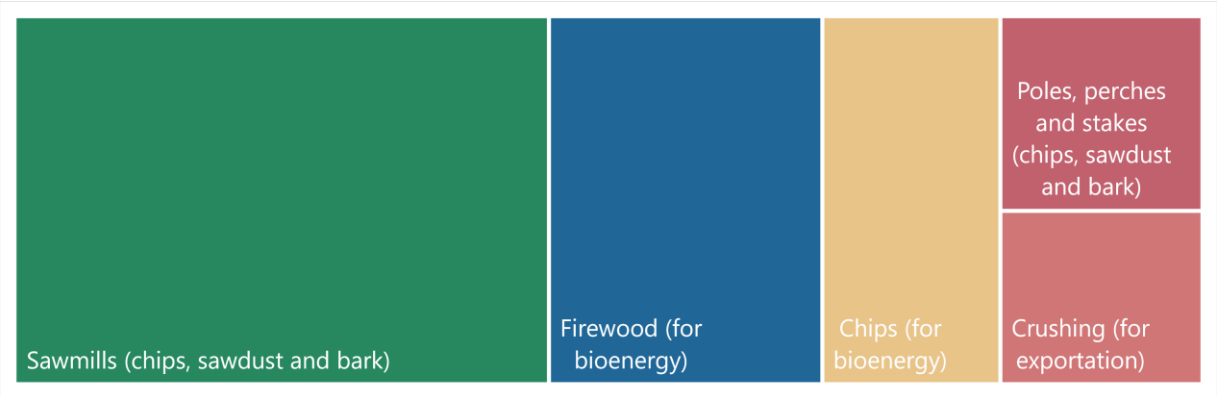
industrial destination, the table lists the elaborated products obtained from the wood, as well as the different types of by-products generated during the manufacturing process.

Table 5 Industrial wood destinations, manufactured products and different types of by-products obtained in Catalonia[25]

Industrial destination	Elaborated products	Obtained by-products
Sawmills	*188.552 m^3* 440.000 m^3 Catalan roll wood 78.000 m^3 imported roll wood	*329.448 m^3* wood chips (167.314 m^3) sawdust (84.434 m^3) bark (77.700 m^3)
Production of cross-laminated timber (CLT)	*2.184 m^3*	*3.816 m^3* wood chips (1.938 m^3) sawdust (978 m^3) bark (900 m^3)
Production of sticks, turning, hangers and stakes	*67.840 m^3* 90.000 m^3 Catalan roll wood 16.000 m^3 imported roll wood	*38.160 m^3* wood chips (16.960 m^3) sawdust (6.360 m^3) bark (14.840 m^3)
Crushing	*74.000 m^3 for exportation*	

With respect to industrial production, the largest proportion (45% of the total felled in Catalonia) is allocated primarily to sawn wood production and the secondary transformation industry, mainly packages and packing material. In addition, a significant number of poles, billets, sticks and stakes (9%) is also produced, as well as pulpwood exported for paper and board production (7.5%). In contrast, the manufacture of CLT currently only accounts for a mere 0.2% of Catalan wood production, despite its great advantages as a construction material.

The graphic on Figure 8 represents the proportions of wood destinations in Catalonia based on the volume of wood processed. Sawmills are the largest consumer of wood, processing 188,552 m^3, followed by the production of sticks with 67,840 m^3, crushing for exportation with 74,000 m^3, and finally, the production of CLT with 2,184 m^3. Sawmills are by far the largest consumer of wood, which could indicate a need for more efficient wood processing methods or greater use of by-products generated during the manufacturing process.



[25] Data from EBC2030 Action Plan (2022-24)

Figure 8 Industrial wood destinations (2014-18) in Catalonia[26]

As for the by-products of the wood processing, three types can be distinguished: chips, sawdust, and bark. An annual average of 371,424 m3 of these by-products is generated, which end up on the market as pellets, animal bedding, etc. This quantity, added to the wood chips and firewood for bioenergy, makes for a total of 748,424 m^3 of forest by-products generated in Catalonia.

Potential and opportunities

There is a great diversity of products that can be obtained from forest biomass:

- Wood construction: one of the most innovative uses of timber is CLT (cross-laminated timber), which represents an opportunity to improve energy efficiency and reduce CO2 emissions in the construction sector.
- Solid biofuels: mainly chips and pellets for thermal uses (boilers) and to generate electricity, whether in its natural state or with thermochemical treatments (torrefied biomass and biochar/biocoal) to increase its heating potential and resistance to degradation.
- Liquid and gaseous biofuels: such as bioethanol, bio-oil (liquids from biomass pyrolysis), biohydrogen, synthetic natural gas (bioSNG), among others.
- Bioproducts: either natural and/or recycled fibres for the manufacture of packaging, textiles and composite products; value-added chemical products for the chemical, pharmaceutical and nutraceutical industry; bioplastics and biopolymers, and fertilizers and biostimulants, manufactured from lignin.

In the provided diagram (Figure 9), it is evident that integrated forest biorefineries can produce a diverse range of products. The products highlighted in green represent those that are currently being produced, whereas the ones in blue represent new products that have the potential to be developed.

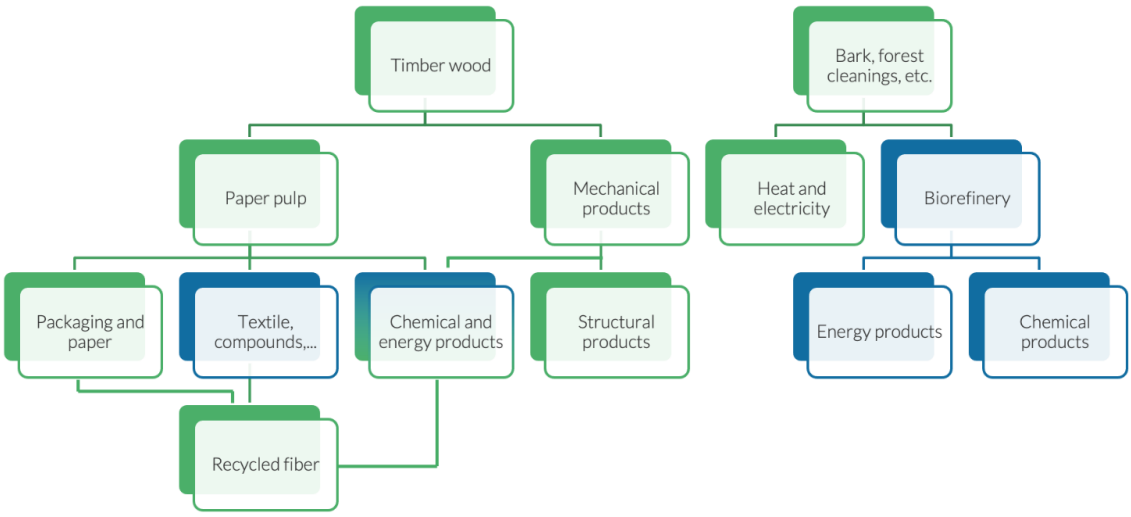


Figure 9 Products which may be obtained from forest biomass[27]

It is worth noting that integrated forest biorefineries are designed to maximize the value of the components of lignocellulosic biomass, such as cellulose, hemicellulose, and lignin. The processing

[26] Data from EBC2030 Action Plan (2022-24)
[27] Adapted from EBC2030

technologies used in these facilities enable the extraction and conversion of these components into a range of products, including biomaterials, biofuels, bioproducts, and bioenergy.

Overall, integrated forest biorefineries represent a promising approach for the sustainable utilization of forest resources, and their potential to produce a broad range of products is indicative of the versatility and flexibility of this innovative technology.

The EBC2030 aims to capitalise on the following value chains in the forest sphere through the development of the bioeconomy[28]:

- Woody resources recovery,
- Wood for construction,
- forest biofuels,
- cork, and
- other innovative uses.

Woody resources recovery

The EBC2030 intends to foster a bioeconomic development scenario in which the Catalan production of roundwood increases by 30%. This increase is justified for the following reasons:

- The last 20 years the aerial biomass accumulated in the forests of Catalonia has increased and around 3 million m^3 of aerial biomass has been added every year during this period.
- The annual pace of timber extraction is about 1 million m^3/y. Thus, the rate of extraction with respect to growth rate is 30-40%, far from the 67% European average.
- These accumulations of biomass and unmanaged forest area are unsustainable in the current context of climate change, since it puts Catalonia at a high risk of large forest fires. In addition, the health of the forests will tend to worsen as a result of droughts, forest diseases and pests, which will make the forests even more vulnerable.
- There is a need to reduce the current external dependence, given that in Catalonia 7 million m^3 of round timber are consumed in products derived from wood, in contrast to the national production of 1 million m^3.
- To reverse this situation, it is considered essential to converge with the European average in terms of levels of extraction and harvesting from Catalan forest as a long-term goal (2050). This policy also contributes to large forest fire prevention, which requires prioritizing and encouraging forest management in certain strategic areas. It is through forest management that significant synergies between ecosystem services can be achieved: reducing the risk of forest fires, erosion control, seasonal water regulation, etc.
- To reach this objective of sustainable harvesting there must be a progressive growth to raise the current 30-40% to 68% in 2050. This increase would make it possible to:

a) Cover the necessities of the Catalan packaging industry, decreasing its dependency from roundwood imports. The growth of Catalan packaging industry is fundamental to stimulate forest management.
b) Obtain 1,000,000 m^3 of roundwood to develop a second processing forestry industry which exploits higher quality wood for construction.
c) Provide raw material to Catalan furniture industry to cover part of its production with local wood.
d) Maintain the production of billets, poles, sticks, etc.

[28] EBC2030 Action Plan

e) Guarantee the export commitments made by some Catalan companies to foreign paper industries.
f) Supply biomass to the current electric power plants and thermal boilers, and also provide enough biomass for the anticipated increase requested in the Strategy for Promoting Farm and Forest Biomass Energy Use in Catalonia (2021-2027).
g) Continue with the current production of firewood.

Wood for construction

Building with wood permits to reduce the use of materials, the waste and the time of installation, because wood is easily manufactured into fit-to-purpose building materials, has a wide variety of applications in the construction sector and its production generates less CO2 emissions than cement, along with its better thermal efficiency compared to other building materials. Thus, to develop new materials based on wood, as for example CLT, means an opportunity to increase energy efficiency and emission reduction in this sector.

In line with the expected bioeconomy scenario, the development of secondary wood processing industry will permit the transformation of 100,000 m^3 of roundwood into CLT, adding maximum value to the highest quality wood and creating jobs in the forest chain.

Forest biofuels

Forest biofuels can be obtained from firewood, wood chips and pellets derived from primary wood processing, as well as by-products from the secondary industrial processing of wood. The Government of Catalonia has approved the Strategy for Promoting Farm and Forest Biomass Energy Use in Catalonia[29] as one of the priority lines in energy policy for its important environmental and socioeconomic benefits, because the CO_2 balance of the biomass combustion is considered neutral if we set aside extraction processes and biomass transport.

Forest harvesting to produce biofuels represents the most environmentally and economically sustainable option for providing a commercial outlet to these products, given the absence of representative Catalan pulp and paper industry which would consume pulpwood or other forest products with lower added value.

Apart from wood combustion, biomass pyrogasification processes have gained significant traction, as they can deliver both syngas, and biochar and bio-oils.

Cork

Cork is a material with a high regeneration capacity and a combination of properties which make it unique for its versatility and suitability for a wide range of applications in various sectors. In 2020, 7,034 tonnes of cork were produced[30]. Catalonia produced 550 million of sparkling wine (including cava) corks and 137 million of still wine corks[31]. However, it must be considered that the material for manufacturing these corks is imported basically from southern Spain and Portugal, because the production of Catalan cork groves is insufficient.

Through the by-product generated in the production of wine and cava corks, the circular bioeconomy contemplates other possible uses for cork: for example, as a structural component in construction (to

[29] Biomass Strategic Plan 2012-27 - Pla Estratègic de la Biomassa 2021-2017
[30] Catalan Forest Observatory – Observatori Forestal Català (OFC)
[31] Catalan Cork Institute - Institut Català del Suro (ICSuro)

make buildings lighter, or as an anti-vibration element or as a thermal and acoustic insulator), coatings in construction and other industries, uses in the sectors of decoration and fashion, or energy-related applications.

Other innovative uses

The potential for innovative uses lies both in non-wood products (resins, mushrooms, truffles, medicinal and aromatic plants) and wood products. Nonetheless, turning them into products of high added value will require the development of biorefineries in the coming years as a key enabler. Some of these bioproducts will be acquired using integrated forest biorefineries, designed to make the best possible use of the various components of lignocellulosic biomass (cellulose, hemicellulose, and lignin) in order to maximise the added value of the great diversity of products obtained from this biomass (biomaterials, biofuels, bioproducts and bioenergy).

In this way, using thermochemical or biological means to process forest biomass, farm biomass, sludges and slurries, biorefineries allow to obtain bioproducts of high added value, such as activated carbon, chemicals, fertilisers, nanocellulose, additives and active ingredients for the cosmetics and nutraceutical industry. In fact, the development of these biorefineries is presented as an opportunity to add value to low value wood and waste derived from clearings and trimming, and thus increase the profitability of the management of forested areas.

As for mushrooms, their use is not restricted merely to food. New uses are being identified, as muskin (an alternative to animal leather), or as natural log biodegraders, or in the development of new medicines not only for humans but also for insects.

II. Food production

No food item can be considered a waste, but, on many occasions, throughout the food chain, large quantities of valuable resources are discarded. To deal with this problem, the European Commission has established an approach from the point of view of waste management and efficient use of resources and defines the term food waste to refer to all those foods that have become waste[32]. Food waste concept is understood as food intended for human consumption, in a suitable state to be ingested or not, which is removed from the production or supply chain to be discarded in the phases of primary production, transformation, manufacturing, transport, storage, distribution and the end consumer, except for those losses in primary production[33] —food waste is recognised as a separate part of the food loss originated in the primary sector.

Food production involves two fundamental sectors: primary production by the agricultural sector and the processing of agrarian products, including their distribution to the final consumer by the food industry. Both sectors have a very important socio-economic role in Catalonia, but they are also responsible for significant impacts on the environment.

[32] Article 3 item 4 of Directive (EU) 2018/851 modifying Directive 2008/98/EC on waste
[33] Law 3/2020, of 11 March, on preventing food loss and waste (Parliament of Catalonia)

The agricultural sector

Description

Primary vegetable production generates a significant amount of biomass available for the circular bioeconomy. In productive and economic terms, in Catalonia the sectors of cereal production (mainly wheat and barley), fruit, winemaking and olive oil stand out.

Also, non-edible biomass is generated annually by the main products which are mostly consumed fresh (and are susceptible to being recovered in the sphere of the circular bioeconomy). When these products have not been subjected to any form of treatment before reaching the consumer, most of this non-edible biomass is generated in the domestic sphere and incorporated into OFMSW[34], whereas the more highly processed organic waste is mainly generated by the food industry.

Regarding animal production, the correct management of livestock waste is one of the main challenges that the sector must face. In Catalonia, there are approximately 7.9 million pigs, 637,000 heads of cattle, and 44.6 million units of poultry that each year generate around 9.4 million tons of slurry and 2.8 million tons of manure[35].

Probably, the most efficient option for waste management in the agricultural context is as fertiliser or soil supplements, using the nutritional content and organic matter contained by these local resources to nourish crops. From the point of view of the bioeconomy, the use of nutrients from livestock waste should be linked to a decrease, not elimination, of mineral fertilisers, which would be used as a supplement when the application of organic fertilizers is not feasible. It is also necessary to promote the use of livestock waste as fertiliser to increase the organic matter of the soils, to make them more fertile and resilient.

The use of livestock waste without receiving any type of treatment has its limitations, among which the high-water content (especially important in slurry), the disproportion of nutrients in relation to the needs of the crops, the variability of composition, or the presence of certain pathogens are relevant factors when applying the fertilizer near the edible parts of certain crops. In these cases, the treatment of livestock waste to adjust it to the needs is a very valid and increasingly implemented option.

Livestock waste in Catalan operations is commonly treated through solid-liquid separation of slurry and composting of solid livestock waste, such as manure. These treatments have several benefits, such as reducing water content, increasing nutrient and organic matter proportions, and sanitizing the product. By generalizing these treatments, nutrients from livestock waste can be utilized more efficiently, benefiting the transportation, commercialization, and application of the materials to crops. The distribution of nutrients and organic matter within Catalan territory is a critical factor for managing livestock waste and the future of the livestock industry.

On the other hand, livestock waste can also be treated outside of farms in centralized processing plants to create organic-based commercial fertilizers or high-value products that cater to specific crop needs. These fertilizers will likely have a significant place in the bioeconomy and a large market.

[34] organic fraction from municipal waste
[35] Guide to Livestock Manure Treatment Technologies in Catalonia - Guia de les tecnologies de tractament de les dejeccions ramaderes a Catalunya, DACC, Generalitat de Catalunya (2020)

In addition to these benefits, the treatment of livestock waste also has energy-related purposes. Anaerobic digestion processes can produce biogas, which can be enriched to create biomethane and injected into natural gas networks. However, implementing anaerobic digestion plants carry along a costly investment, and centralizing the process can result in higher administrative complexity and increased costs for waste transportation. Emerging technologies, such as producing "green hydrogen"[36] from organic waste, may provide new opportunities for utilizing livestock waste.

Developing a value chain for livestock waste and organic waste (see Figure 10) could be translated in a reduction in the dependence on non-renewable raw materials and a decrease in emissions. This could also improve nutrient utilization and increase the sustainability of agri-systems by implementing circular bioeconomy strategies that provide greater economic value.

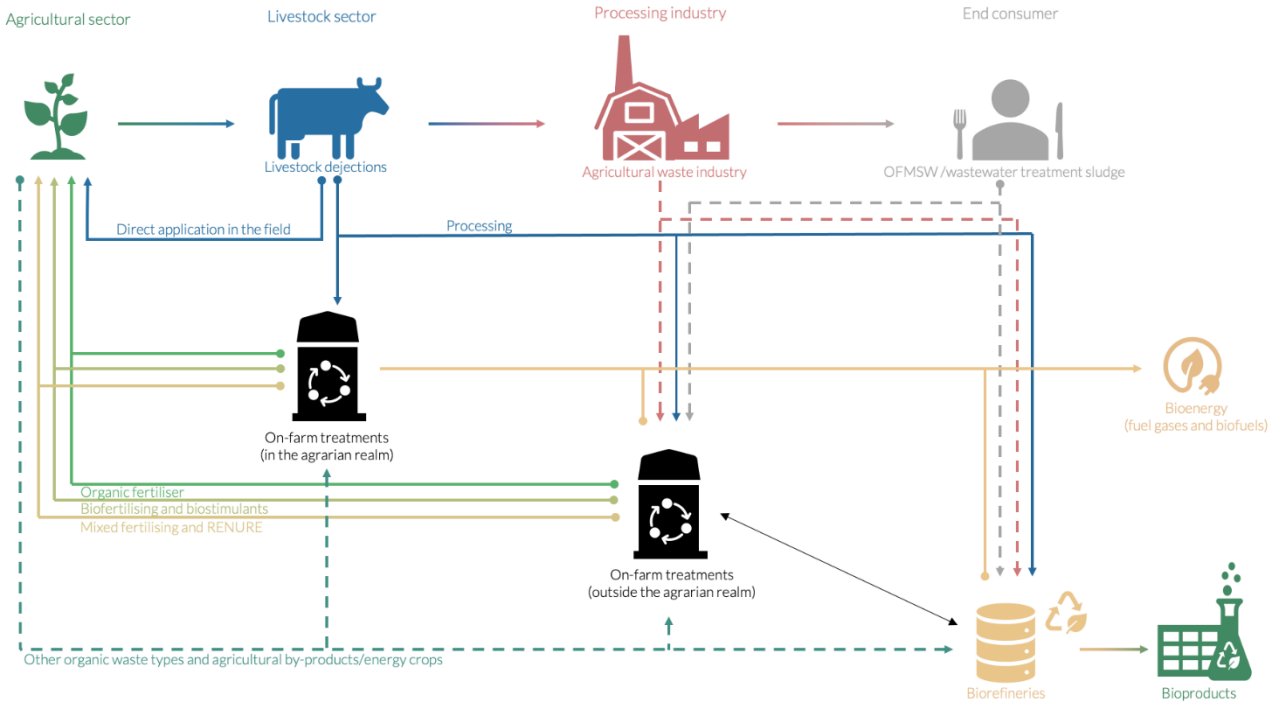


Figure 10 Outline of the livestock waste and organic waste chain[37]

To accomplish these objectives, the value chain must include three main components. First, it is crucial to recover nutrients by producing organic-based fertilizers through direct application or processing. Second, bioenergy production through processes such as anaerobic digestion, pyrolysis, and gasification can be used to generate energy. Lastly, integrating these processes within a biorefinery framework can lead to the extraction and/or synthesis of new bioproducts with a higher added value.

Current recovery routes

The creation of a system that recovers resources from livestock and organic waste would result in a reduction of dependency on non-renewable resources, while also reducing emissions and increasing the sustainability of agriculture systems. This system should focus on recovering nutrients in the form of

[36] Hydrogen is often classified according to the processes involved in the production; "grey hydrogen" is produced as a by-product of an industrial process; "blue hydrogen" is produced through a production process in which CO2 is also generated, captured and stored; and finally, "green hydrogen" is produced completely from renewable resources.
[37] Adaptation from EBC2030 from Institute of Agrifood Research and Technology (IRTA) data

organic fertilizers through direct application or processing, producing bioenergy through various energy recovery processes such as anaerobic digestion, pyrolysis, or gasification, and integrating these processes in a biorefinery to produce new, high-value bioproducts.

Direct application

The traditional method for managing livestock waste is to apply it directly to crops without any processing. However, this method has several drawbacks, including the difficulty of applying the appropriate amount of nutrients, emissions of greenhouse gases and foul odours, and the presence of harmful microorganisms. In addition, transporting waste from high-density livestock areas to farmland is not economically viable because of the low nutrient concentration in the waste. Consequently, efforts are being made to develop application systems that reduce emissions, such as injecting or burying waste in the soil, or using in situ nutrient monitoring and geolocation to tailor the fertilization approach to the specific crop needs. This approach is also important for compliance with environmental regulations in areas where there is a risk of nitrate pollution.

Processing

Livestock waste can also be managed by processing it to produce organic fertilizers that meet the nutrient requirements of crops. This processing can be done through physicochemical and biological treatments. In the agricultural sector, the practice of treating waste on the farms themselves is becoming more common as a means of improving the management of organic nutrients. This approach can also be used in non-farm settings to produce commercial fertilizers made from organic materials, although this requires more complex processing.

External plants that produce organic fertilisers require technical expertise and large-scale operations. In Catalonia, the most common treatments for managing livestock waste on farms are the solid-liquid separation of slurry and composting of manures, litters, and solid waste separated from slurry. By treating livestock waste, some of the disadvantages associated with using untreated waste can be addressed, such as reducing water content, increasing the proportion of certain nutrients and organic matter, and sanitizing the final product in the case of composting. Some livestock operations also choose to eliminate excess nitrogen through nitrification-denitrification processes.

The food transformation and distribution sector

Description

A significant amount of residual biomass also comes from the food industry. For example, in the apple production chain, which is the source of the vast majority of food waste biomass in the production of fruit and vegetable juices, there is great potential to develop new products. Another example would be bread, bakery products and fresh pastries that generate 4,191.8 tons of organic matter every year that does not reach the consumer: 79% correspond to dry bread, hard bread or bread that does not meet the market specifications, 17% is organic matter left over from production, and 4% fats and oils used in the production process. These discarded foods have an important potential for reintegration into the food chain as co-products, which would avoid the generation of waste[38].

38 Annual industrial waste declarations (DARIS) of the Catalan Waste Agency (ARC).

On the other hand, there is the waste from the animal industry, such as waste from slaughterhouses. During the slaughter and cutting of animals for meat production, a wide variety of by-products is generated, and are currently used in various value chains, especially in animal feed and cosmetic and pharmaceutical industry. The utilization of these fractions is subject to the European Union Regulation on animal by-products not intended for human consumption to ensure that during these operations no risks are generated for human and animal health or the environment and the safety of the food chain.

Regarding the final consumer, and according to the data on waste managed at municipal level in Catalonia, in 2019 selective collection reached 45% of the total. The amount of biodegradable waste recovered (mainly pruning residues and organic fraction from municipal waste) rose by 6% compared to the previous year and will follow this tendency due to door-to-door selective collection implemented in the recent years. This waste is mainly intended to produce compost and biogas[39].

Current recovery routes

Agricultural products

There are many opportunities for the agricultural product sector to use and recover discarded materials. One option is to consume fresh products that are discarded due to aesthetic or market standards. Another option is to transform fresh product into processed ones, which can be used in a variety of food product categories. For example, horticultural co-products can be used in sauces, spreads, vegetables, pre-cooked meals, side dishes, snacks, soups, dairy products, baked goods, processed meat and fish, or sweets. Discarded fruit can be used to make juice, fruit salads, canned goods, candied as an ingredient in traditional desserts, jams, or transformed into different ingredients used in other food products such as yoghurt, ice cream, and confectionery, or used in alcoholic and non-alcoholic beverages.

Plant by-products such as peels, seeds, or flours are also valuable for therapeutic, aromatic, dietetic, or gastronomic purposes, due to their high content of substances or active ingredients. Bioactive compounds extracted from plant material are widely used in the food and agriculture sector to replace synthetic dietary complements or serve as functional supplements.

Alternativerly, composting and animal feed are common methods for reusing these products. In addition, some waste can be used in anaerobic digestion to produce biogas, although not all waste types have the same potential for biogas production.

Livestock products

The primary methods for recovering animal by-products involve processing the animal after slaughter and butchering. The internal organs, blood, fur, skin, claws, fat, and bones can all be used to produce a diverse range of products for both human and animal consumption. These products can include functional ingredients, collagen, gelatine, and protein hydrolysates, as well as items for the pharmaceutical industry like insulin, heparin, hormones, and enzymes.

In the case of fish processing, the entrails, heads, skin, eyes, spines, and muscle tissue scraps (aquaculture coproducts) can also be utilized. These by-products can be transformed into products suitable for human consumption such as surimi, and for animal consumption such as fishmeal, fish oil, and protein

39 Catalan Waste Agency (ARC), 2019

hydrolysates. Additionally, they can be used in the cosmetics and pharmaceutical industry to create items such as bioactive peptides, collagen, vitamins, hyaluronic acid, and protamine.

Potential and opportunities in the food production sector

The complexity of food production, as well as the wide variety of companies involved, offers a broad range of opportunities for implementing new circular bioeconomy-based models, with the goal of exploiting the secondary biological resources which are currently lost or inefficiently used. Figure 11 outlines the interrelationships between the streams of the main types of raw materials and bioproducts, bioenergy and biomaterials which can be obtained, in the food production sphere.

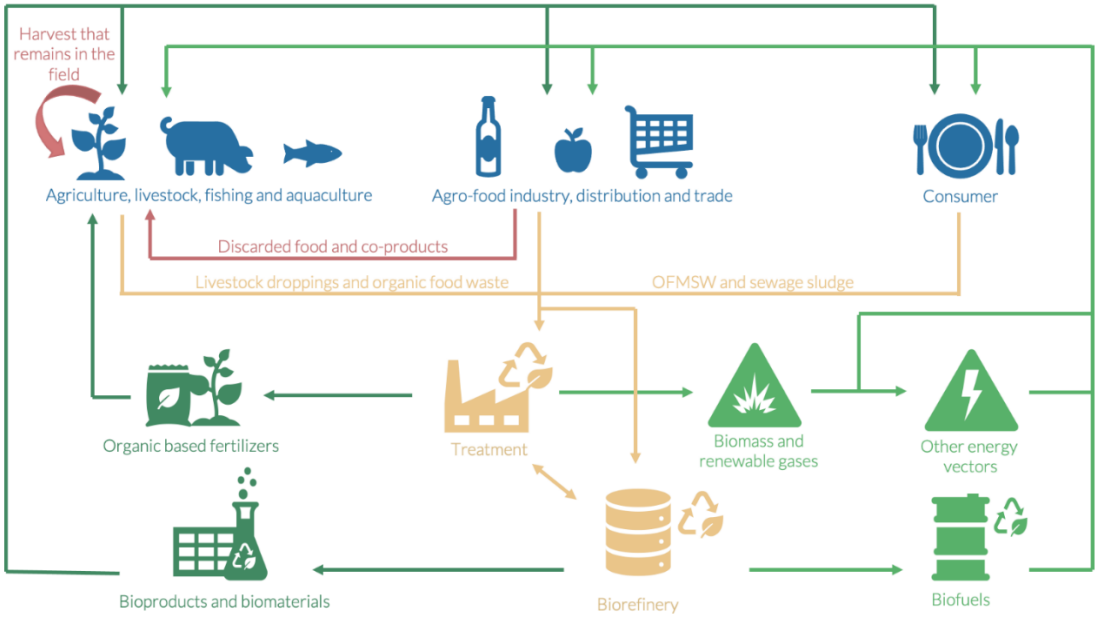


Figure 11 Diagram of the food production system with the interrelationships in the agricultural production sectors, and the transformation and distribution of foods, in terms of the principal value chains related to the circular bioeconomy[40]

The main organic material streams generated during the production and transformation of foods, once they have acquired the condition of waste (in brown) are grouped into three main categories:

- organic food waste
- organic fraction from municipal waste (OFMSW)
- sewage sludge

There are two more categories of secondary biomass that are derived from food manufacturing but have not yet received the consideration of waste (in red): the part of the harvest that remains in the field and the discarded food. Also, the range of benefits that set up the main value chains in circular bioeconomy are divided in two groups: biomaterials (in dark green) and bioenergy (in light green), that include the following types of products:

[40] Adapted from EBC2030

Table 6 Types of products from the value chain in circular bioeconomy[41]

PRODUCTS			DESCRIPTION
Biomaterials	Organic fertilizers		Nutrients that generally come from organic waste, transformed to a greater or lesser extent, and are used as fertilizers and agricultural amendments. The best-known example is the compost.
	Bioproducts	Products for animal feed	Nutrients added to the diet of farm animals, which come from discarded food (co-products), or from the transformation of residual biomass in accordance with biosecurity regulations.
		Specialized chemical products	Bioactive substances and compounds with an added value as food additives, or for the chemical and pharmaceutical industry.
	Biomaterials		Fibres made from plant remains that can be used for different purposes, such as in the manufacture of bio packaging, or bioplastics and biopolymers obtained by fermentation processes.
Bioenergy	Liquid and gaseous biofuels		Mainly biogas/biomethane from anaerobic digestion, synthesis gas from the pyrolysis of organic matter, as well as bioethanol or biodiesel which are generally obtained by different fermentation and/or chemical processes.

In addition, with the aim of reducing food loss and waste, the EBC2030 presents a food use hierarchy that outlines various options for the utilization and recovery of biomass generated from food chains meant for human consumption. The hierarchy describes different levels for the reuse of discarded food as co-products and the recovery of food waste. The approach to develop a strategy for the circular bioeconomy should prioritize the upper levels:

1) reuse for human consumption,
2) reuse for animal consumption,
3) recovery for non-food industrial uses,
4) recovery for the obtainment of quality compost,
5) energy recovery for the obtainment of biogas,
6) other types of energy recovery, and
7) disposal.

On the other hand, the opportunities linked to the agricultural sector are linked to the development of the following value chains around livestock waste:

- biogas and biomethane,
- innovative organic fertilisers, and

41 ECB2030

- other high-added value products.

Biogas and biomethane

Anaerobic digestion is a promising treatment method with significant potential in the bioeconomy. This process yields two products: biogas, which is a fuel gas, and digestate, which is a stabilised organic fertiliser. However, the installation of anaerobic digestion plants can be a costly investment and may not be feasible for smaller livestock operations. Centralised plants located outside of the agricultural sector that serve multiple livestock companies can take advantage of economies of scale, but they require more complex administrative management and face higher costs and health risks associated with the transport of livestock waste.

One new opportunity for anaerobic digestion is the co-digestion of organic waste from the food production industry, which has the potential to generate more methane and can be enriched to produce biomethane. Biomethane can be compressed and used on-site as fuel for vehicles, or it can be sold and injected into the natural gas network, which is currently permitted by legislation.

Innovative organic fertilisers

The European Union (EU) introduced a new fertiliser regulation in 2019[42], which entered into force on 16 July 2022, aimed at standardising the definition of various products. This move is expected to make the production of fertilisers more transparent and facilitate trade within the European market. Furthermore, the EU published a technical report in 2020[43] that proposed a new category of fertilisers made partly or wholly from livestock waste, known as "recovered nitrogen from manure" (RENURE). In areas susceptible to nitrate pollution, RENURE fertilisers could be used in the same way as nitrogenous chemical fertilisers, thereby encouraging the replacement of inorganic nutrients with organic ones that have a lower environmental impact on a global scale.

Other products of hight added value

The integration of livestock waste recovery processes in the context of a biorefinery can not only recover nutrients and bioenergy but also facilitate the extraction and/or synthesis of new products with higher added value. Currently, these resource recovery routes are still in the early phase of development and, apart from a few niche products, processes mature enough to result in marketable products are yet been identified. Some of the emerging processes include the manufacturing of biomaterials through fibre (cellulose) extraction or biosynthesis of polymers (polyhydroxyalkanoates for the bioplastics manufacture), or the production of new sources of biomass derived from livestock waste (insects, algae, mould, etc.) that may serve to synthesise new bioproducts.

The **opportunities linked to the food transformation and distribution sector** are linked to the development of the following value chains around co-products and by-products of the food chain through the bioeconomy: plant-based products and animal products.

[42] Regulation (EU) 2019/1009 of the European Parliament and of the Council of 5 June 2019 laying down rules on the making available on the market of EU fertilising products and amending Regulations
[43] Technical proposals for the safe use of processed manure above the threshold established for Nitrate Vulnerable Zones by the Nitrates Directive (91/676/EEC)

Plant-based products

Due to the high volume of plant by-products and coproducts that are unable to enter the market chain when they are fresh, there is an ongoing research into alternative recovery pathways. One of the paths is the incorporation of these by-products into other food products to add nutritional value, such as processed snacks, appetizers, and baked goods. For example, incorporating broccoli stems, which are rich in fibre, glucosinolates, and phenolic compounds, into crackers, baked goods, or soups/sauces can be an effective way to promote their health benefits. Similarly, tomato pulp can be reused as an ingredient in other foods, or intermediate food products (IFP). Additionally, processing the pulp and peels of fruits like apples or peaches into highly nutritious powders with antioxidant, colour, thickening, and nourishing properties opens up a range of possibilities for use in different products.

Another promising option that is currently being researched is the use of pulp and peels in biorefineries, using sequential extraction to obtain products with a higher added value, such as compounds with functional or techno-functional properties, or aromas for the food, cosmetics, or pharmaceutical industry. Examples include the potential source of polyphenols in by-products from the olive oil industry or wine sector, pectins in plant products derived from citrus fruit, apples, and peaches, or high β-glucan content in cereal flours. Bioconversion with insects / mushrooms / microorganisms may also be an interesting method for obtaining biomass rich in proteins and bioactive components.

In any case, the waste produced in the extraction process at these biorefineries can be repurposed for animal feed, fertilizer, compost, or biofuels. For instance, pomace/bagasse can be reused for technical applications associated with food production, such as the production of xylitol, lactic acid, and prebiotics. It is also a source of phenolic compounds and can be used as a substrate for the growth of various microorganisms.

Animal products

There are different paths to adding value to the products obtained from animal co-products, which can be classified according to what purpose they are used for:

1. Human consumption: protein recovery can be more effective if different fractions like proteins and fats, and protein isolates and hydrolysates are developed with various functionalities that can be modified as needed. These protein isolates can be adapted to the food industry's needs based on properties like emulsification, thickening, foaming, and texturizing. Whey protein, which is a cheese co-product, can be a good source of peptides and proteins with high biological value for the development of dairy and plant-based creams and beverages.
2. Animal feed: the development of pet food ingredients makes it possible to obtain higher added value products than when these substances are allocated to livestock. However, at the same time it is necessary to develop certain very specific product characteristics for each application. The use of fermentation and bioconversion processes can be exploited through the transformation of different organisms (bacteria, moulds, yeasts, insects, etc.).
3. Pharmaceutical industry: there is potential to produce new bioactive compounds like enzymes, peptides, and protein hydrolysates or to develop more efficient processes for obtaining these compounds that offer both performance and stability.

III. Maritime sector

Blue bioeconomy[44] refers to any economic activity associated with the use of renewable aquatic biological resources to manufacture products. Some examples of these products include new foods and food additives, animal feed, nutraceuticals, pharmaceuticals, cosmetics, materials (for example, clothing and construction materials) and energy. Traditional aquaculture and fishing (where fish or seafood is captured or produced for human consumption, is excluded from this definition, with two exceptional cases: fish waste (part currently unused for human consumption) and algae.

The blue bioeconomy sector in Catalonia is a clearly emerging sector with great developing potential, depending on the use of marine organisms not yet exploited and based on the utilization of by-products from fishing and aquaculture, and its commercial applications.

Currently, in Europe the most prominent subsector in the field of bioeconomy and blue biotechnology is the algae production and has a great development potential in Catalonia. An example is spirulina, which started being farmed in Catalonia in 2018 for direct consumption, for the manufacture of food supplements, or for its use in nutraceuticals and cosmetics.

On the other hand, approximately half of the total weight produced from fishing and aquaculture activities is made up of by-products that are not consumed, including fins, heads, skin, and others. This results in both environmental and economic concerns regarding their disposal. However, these by-products hold great promise for the bioeconomy and marine biotechnology which could help address these problems while creating new economic opportunities. This could lead to the creation of new jobs and diversification of the fishing industry, which is crucial considering the need to reduce fishing efforts to allow for resource recovery.

Aquaculture also provides a range of biocomponents with a wide range of industrial uses. Mollusc shells, which make up 40-70% of the total weight, are the primary source of bioproducts. These shells have potential uses in biomedicine and cosmetics, as well as in construction, agriculture, and as an animal feed component.

Lastly, the use of non-native species, such as the blue crab (*Callinectes sapidus*), which is currently an invasive species in Catalonia, holds significant potential. Bioactive compounds have been identified in the shell of the blue crab which could be used in the production of pigments or biodegradable films.

Activities related to the Catalan maritime space are included in the 2030 Maritime Strategy of Catalonia, which considers this space's economic sectors, leisure, culture, and research as well as its economic, social and environmental sustainability.

IV. Other bio-based industries and refineries

The bio-based industry and refineries in Catalonia offer significant potential for biomass recovery and the production of new, sustainable products. In addition to the forestry, agricultural, maritime, and food production sectors discussed previously, other sectors are also potential sources of biomass products, such as construction and demolition waste, wastewater treatment, and municipal solid waste also present opportunities for biomass recovery. However, these sectors are less significant in Catalonia and have limited data available for their analysis.

[44] Following the criteria of the European Commission in its various reports

The production of new derivatives from organic matter is a key area of focus, with biorefineries emerging as industrial plants that can extract a diverse range of new compounds and recycled materials, as well as energy, from biologically based raw materials. The resulting products include substitutes for petroleum derivatives such as biolubricants, bioplastics, food additives, cosmetics, varnishes, and solvents, as well as advanced biofuels, thermal or electrical energy, and composite materials that combine organic derivatives with those of fossil origin. This section will explore the biomass recovery potential in Catalonia's bio-based industry and refineries and the opportunities they offer for the production of sustainable products.

Therefore, by promoting innovations related to the production and use of organic matter, traditional agro-industrial and forestry sectors are supported, while facilitating the development of new activities that contribute to the transition from an economy based on the use of fossil fuels to one based on renewable resources, which must be much more efficient and, in turn, sustainable from an economic, social, and environmental point of view. This statement is particularly true if we concentrate the activity of these biorefineries on the use of biomass obtained at a local or regional scale, ensuring that triple impact.

Catalonia has a strong tradition in agriculture and food production, which forms the basis of its bio-based industries. The region is home to a number of large multinational food and beverage companies, as well as many smaller, local producers. Catalonia is also a major producer of biofuels, including ethanol and biodiesel, made from crops such as corn, sugarcane, and sunflowers.

In recent years, the Catalan government has made significant investments in research and development to support the growth of its bio-based industries, with a focus on sustainability and reducing the region's carbon footprint. The bio-based industries in Catalonia are also a significant source of employment, particularly in rural areas, providing job opportunities in areas such as agriculture, food processing, and biofuel production. The region is also working to promote the use of bio-based products and materials, both within Catalonia and beyond, through initiatives such as the Catalan Biotechnology Cluster and the Catalan Bioeconomy Strategy.

Overall, the bio-based industries in Catalonia play an important role in the region's economy and are a key driver of sustainable development and growth.

In Catalonia, there are several facilities producing bio-based products. The bio-based industry in Catalonia is supported by a network of research institutions, universities, and technology centres, as well as a strong innovation ecosystem. This ecosystem helps companies to develop and commercialize new products and technologies and provides a platform for knowledge sharing and collaboration. Overall, Catalonia is a hub for bio-based product development and production in Europe, offering a supportive environment for companies operating in this field.

In the year 2020, the region of Catalonia was home to 33 production facilities which were engaged in the manufacture of diverse categories of bio-based products. These facilities can be classified under four broad categories: pulp and paper industries (16), chemical industries (12), composites and fibre industries (3), and starch and sugar industries (2), as depicted in Figure 12. The feedstock utilized by these facilities can be characterized based on its origin, which can be traced to three main sources: agriculture (12), forestry (19), or waste (2), as illustrated in Figure 13.

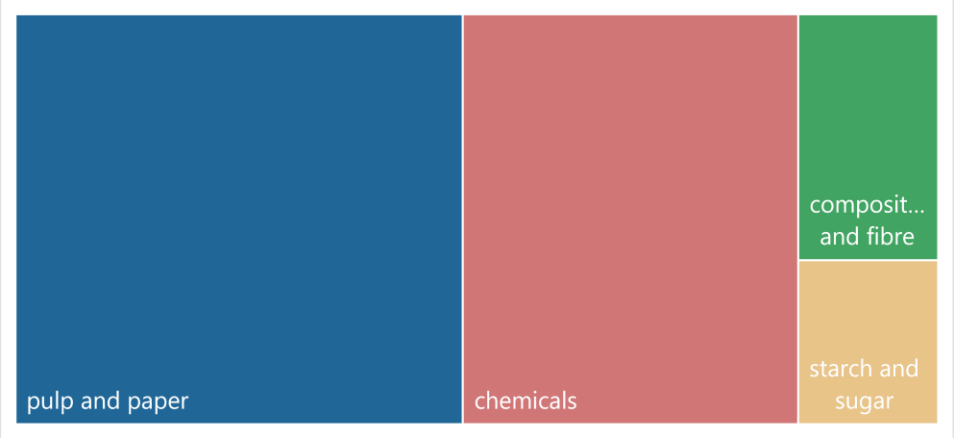


Figure 12 Facilities by product category in Catalonia, 2020[45]

Figure 13 Facilities by feedstock origin in Catalonia, 2020[46]

These two graphics would help visualize the distribution of bio-based products facilities in Catalonia and the origin of their feedstock. In Figure 14 there is a quick visual comparison between the categories of bio-based product industries and their respective feedstock sources.

45 Parisi, Claudia; Baldoni, Edoardo; M'barek, Robert; European Commission, Joint Research Centre (2020): Bio-based industry and biorefineries. European Commission, Joint Research Centre (JRC)

46 Bio-based industry and biorefineries. European Commission, Joint Research Centre (JRC)

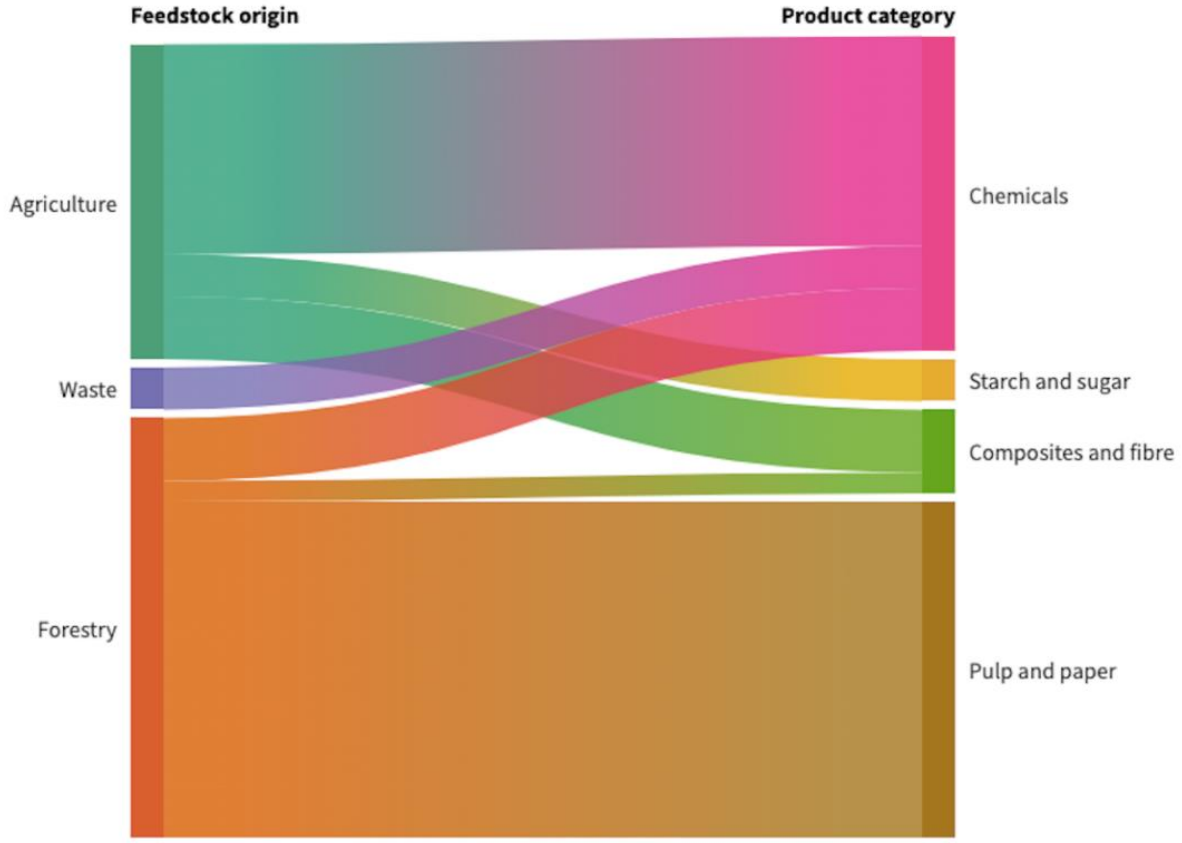


Figure 14 Fluxes map with feedstock origin by product category in Catalan biorefineries, 2020[47]

Manufacture of pulp and paper products

The paper industry, as a driving force behind a powerful value chain for job creation and wealth, presents strong reasons to be one of the leading sectors in the reindustrialization process. It is a sector committed to eco-efficiency, a leading industry in the new bioeconomy, and a benchmark for the new circular economy industrial model. Working always from sustainability, key sectoral issues are raw material procurement, energy costs, and a commitment to high-quality employment.

The pulp and paper sector in Spain has a significant economic impact on the country. Spain is the fifth-largest producer of pulp in Europe, alongside France, which indicates the country's significant contribution to the production of this raw material. Additionally, Spain is the sixth-largest paper manufacturer in the EU, indicating its substantial production capacity.

[47] Elaborated by the authors from the European Comission Joint Research Center data (2020)

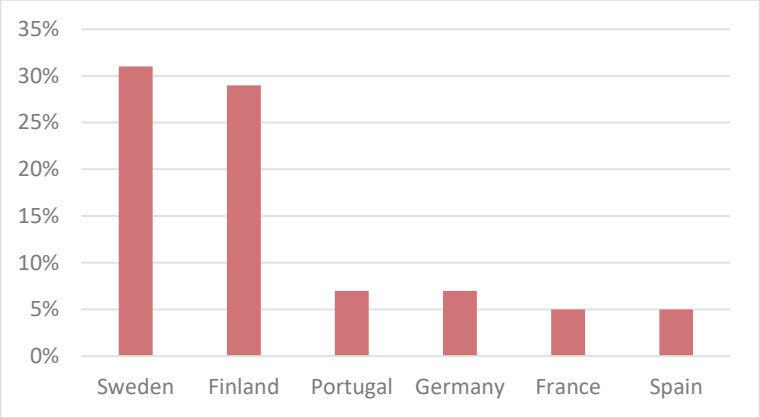


Figure 15 Pulp manufacturer. % of total production in the UE (2018) [48]

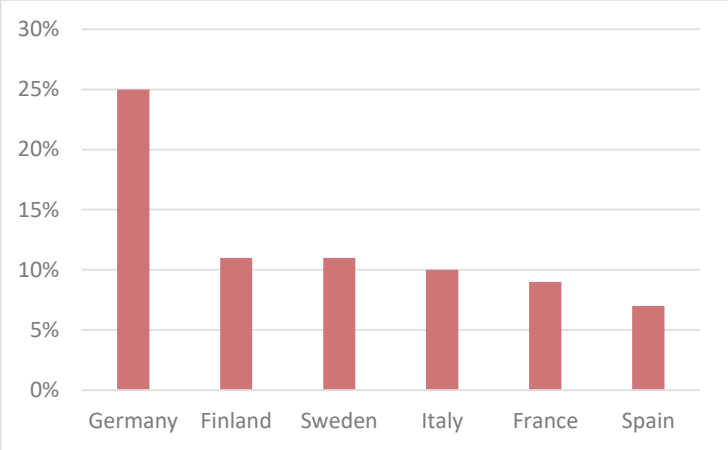


Figure 16 Paper manufacturer. % of total production in the UE (2018) [49]

The paper & pulp industry in Spain boasts several strengths, making it a significant player in the European market. It is characterized by:

[48] Industrial Paper Sector Agenda, 2018 - Agenda Sectorial Industria Papelera, 2018
[49] Agenda Sectorial Industria Papelera, 2018

Figure 17 Spanish paper industry strengths[50]

The Catalan paper industry is a part of the larger Spanish paper industry, so there are certainly similarities between the two. Both industries are characterized by being investment-intensive, export-oriented, and significant employers in their respective regions. They also use local, renewable, and recyclable raw materials and are leaders in decarbonization. In terms of product mix, both industries offer a wide variety of paper products and demonstrate innovation capacity.

However, there may also be some differences between them. Catalonia is a highly industrialized region with a strong tradition of papermaking, and some may argue that the Catalan paper industry has a greater emphasis on traditional, high-quality paper products. Additionally, the Catalan language has been an important factor in the development of the region's printing and publishing industries, which may also influence the Catalan paper industry in some ways.

With a history of papermaking dating back to the medieval period, Catalonia is home to several large and well-established pulp and paper companies, which use a variety of raw materials, including wood pulp, recycled paper, and agricultural waste such as sugarcane bagasse. The Catalan pulp and paper industry is highly innovative and has embraced new technologies and sustainable practices, such as the use of renewable energy sources, the recycling of waste materials, and the development of new, eco-friendly products. The industry is also focused on reducing its environmental impact, through initiatives such as the use of bio-based raw materials, the recycling of waste materials, and the reduction of greenhouse gas emissions.

Packaging is another important aspect of the bio-based industries in Catalonia, with a significant impact on the region's economy and environment. The use of bio-based packaging materials, such as paper, cardboard, and bioplastics, is seen as a way to reduce the environmental impact of packaging and support the growth of the region's bio-based industries. The Catalan packaging industry is highly

[50] Agenda Sectorial Industria Papelera, 2018

innovative, with companies working to develop new and more sustainable packaging solutions, such as biodegradable and compostable packaging materials, as well as more efficient production processes.

The industry is also focused on promoting the use of bio-based packaging materials to a wider audience, through education and outreach programs, as well as partnerships with retailers and other stakeholders. The packaging industry is an important source of employment in Catalonia, providing jobs for thousands of people, both directly and indirectly. The Catalan government has supported the development of the packaging industry through initiatives such as funding for research and development, tax incentives, and support for the development of new technologies.

Overall, the pulp and paper industry and the packaging industry play an important role in the bio-based industries in Catalonia, generating significant revenue and providing employment for thousands of people. Despite facing challenges such as increasing competition and declining demand for certain types of paper, the industry continues to evolve and adapt to changing market conditions. Together, the pulp and paper industry and the packaging industry form a crucial part of the bio-based economy in Catalonia, contributing significantly to the region's economy and sustainability efforts. The industry's focus on innovation and sustainability is helping to position Catalonia as a leader in the development of bio-based products and technologies, paving the way for a more sustainable future.

Manufacture of bio-based chemical products

The Catalan chemical industry is a key contributor to the region's economy, representing the second largest manufacturing sector. The industry is well-established, with two differentiated chemical poles located in Barcelona and Tarragona. These poles host chemical companies at different levels of the value chain which also offer a range of services for chemical companies. The industry is supported by a robust private and public partnership that fosters innovation and collaboration within the ecosystem.

In addition to its strong industrial base, the Catalan chemical industry benefits from superior logistics infrastructure. The region has a logistics network that serves 400 million consumers in Europe and the Mediterranean in less than 48 hours. The Port of Barcelona and the Port of Tarragona have excellent multimodal distribution facilities for the chemical sector. The Port of Tarragona is the logistics platform responsible for importing the raw materials required for the production processes in the chemical sector and exporting the products derived from them. It is also the biggest petrochemical cluster in Southern Europe.

The Catalan chemical industry has a high level of technological readiness, with renowned applied and research groups supporting technological transfer. The region also boasts a complete network of scientific and technological centres that represent Catalonia's research and innovation program. The industry is also a major contributor to the region's economy as the first exporting industry in Catalonia. Over the last decade, 48.2% of Spanish chemical exports have come from Catalonia and 17% of total Catalan exports have come from the chemical industry. This has increased by 12.8% in the same period. Also, Catalonia is a leader in the chemical industry in Western Europe. It ranks third in the number of projects, fifth in terms of capital investment, and fifth in job creation in the chemical industry from 2016 to 2020. These factors demonstrate the region's strength and potential in the chemical industry[51].

The bioeconomy offers an opportunity for the chemical industry to diversify its raw material base. The contribution of the chemical industry is also essential for the success of the bioeconomy, since many products and solutions that enable the bioeconomy are based on chemicals. The chemical industry is

[51] The chemical industry in Catalonia, 2021 (ACCIÓ)

gradually increasing its production and integrates biological processes, the conversion of renewable biological resources and the associated waste streams. This represents a transition towards a more sustainable chemical industry[52].

Overall, chemistry is a critical component of the bioeconomy, enabling the use of bio-based raw materials in a wide range of applications. The biochemical industry in Catalonia is a growing and important sector, and it is playing a key role in the region's efforts to promote sustainability and support the growth of its bio-based industries.

The Catalan chemical industry has multiple development paths related to the bioeconomy, including bio-health, bio-energy, bio-industrial, and agri-biotech (see Figure 18). To fully unleash the potential of the bioeconomy in the region, the industry should prioritize capacity-building initiatives that focus on developing new value chains and bioeconomy-oriented research and development (R&D).

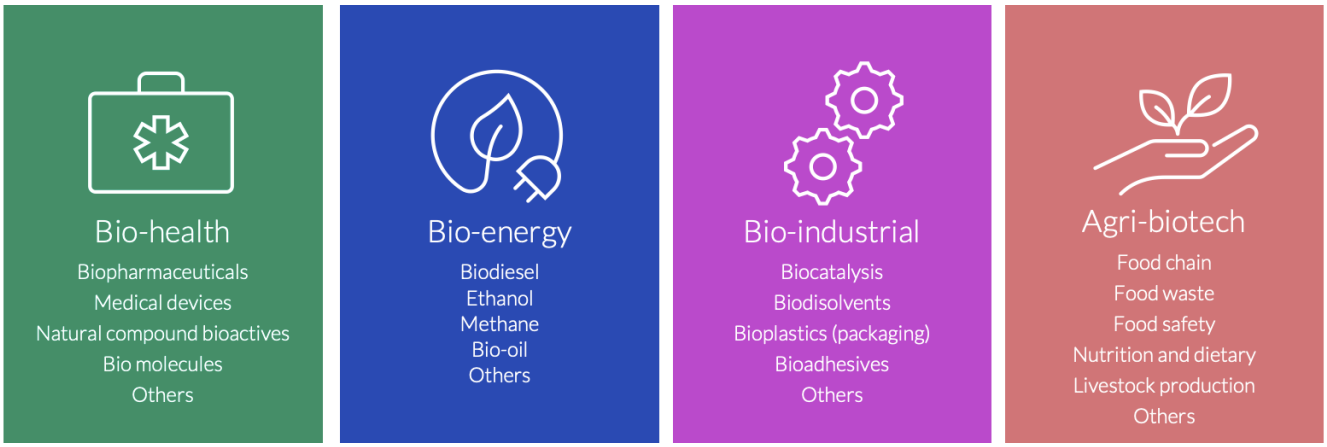


Figure 18 Development paths for the Catalan bio-based industries[53]

According to the Bioeconomy development in EU regions (2017) by the European Commission (EC), Catalonia's characterization suggests that biorefining processes and applications could be key for defining new and modified value chains in many different areas. Following the typology of regional bioeconomy profiles elaborated in the EC report, Catalonia belongs to *Type 5: Regions with an industrial biotech profile*. The region has strong industrial sectors that focus on bio-based products, innovative companies, and medium-high maturity in R&D in biochemistry and advanced manufacturing. The value generation approach involves technological conversion, integrating fossil-based and bio-based technologies, and developing new value chains. Although Catalonia has a medium-high maturity level (7/10), its value chain approach currently focuses on biomass processing and conversion, which is a characteristic of regions with low bioeconomy maturity. Nonetheless, the regional bioeconomy maturity level enables creating and sustaining a new value chain approach.

Table 7 Needs of EU regions to deploy the bioeconomy, according to a type 5 bioeconomy profile[54]

Type 5: Regions with an industrial biotech profile	
Bioeconomy drivers	• Strong industrial sectors that focus on bio-based products (e.g. chemical) • Innovative companies

[52] Bioeconomy in Catalonia, 2018 - La bieconomia a Catalunya, 2018 (ACCIÓ)
[53] The chemical industry in Catalonia, 2021
[54] Bioeconomy development in EU regions, 2017

Bioeconomy capacities (Maturity, R&I competences)	• Middle-high maturity • R&I in nanotechnology, biochemistry, chemistry, engineering, advanced manufacturing, LCA/LCD
Approach to bioeconomy value generation	• Technological conversion • To develop new value chains • To integrate fossil-based and bio-based technologies • To develop circular approaches
Strategy and governance	• Bring together biomass supply with industrial conversion of biomass (bioeconomy networks) • Establish a regional bioeconomy council in order to coordinate support. • Promote technological conversion (bring together researchers with innovative companies in clusters)
Value cycle development	• Identify and close regional loops (e.g. agri-food with residues/waste and energy and fuel production, maritime with NFF and algae, wood with paper, packaging and fibre products) • Introduce circular management (waste, logistics, production)
Technology and skills	• R&I should focus on the optimisation of value chains and new technologies (biorefineries), as well as on the conversion from fossil-based to bio-based technologies. • R&D with pilot plants is required to discuss and improve on technical maturity (TRL) of new technologies. • Biotechnology, nanotechnology, engineering, and other relevant skills are needed in multidisciplinary teams
Awareness and public acceptance	• Raise awareness on the potential benefits of new/modified value chains in industrial/agricultural sectors. • Raise awareness on the benefits of a circular economy and the use of bioproducts. • Raise awareness on new cascading uses of biological resources and residues/by-products

When considering biotech focus profile and a maturity index that indicates a mid-high level of development, it suggests that the region has a strong focus on industrial sectors that produce bio-based products, such as chemicals, and that there are innovative companies operating in the area. Additionally, the region likely has a significant amount of research and development in biochemistry and advanced manufacturing.

Given this context, the European Commission suggests that biorefineries and biorefining processes and applications could be key in defining new and modified value chains in various sectors. It is likely that a region with a strong biotech focus and a mid-high maturity index would prioritize the development of biorefineries as a means of generating new value chains and driving economic growth.

Moreover, Catalonia has tonnes of underutilized biomass and around 60% of the organic waste generated in the region is available for conversion into new products, chemicals, or energy through biorefining processes. The region is well-positioned for developing biorefineries due to the availability

of biomass, involvement of primary and secondary sectors, scientific and technological capabilities, environmental benefits, job creation potential, and promotion of rural development.

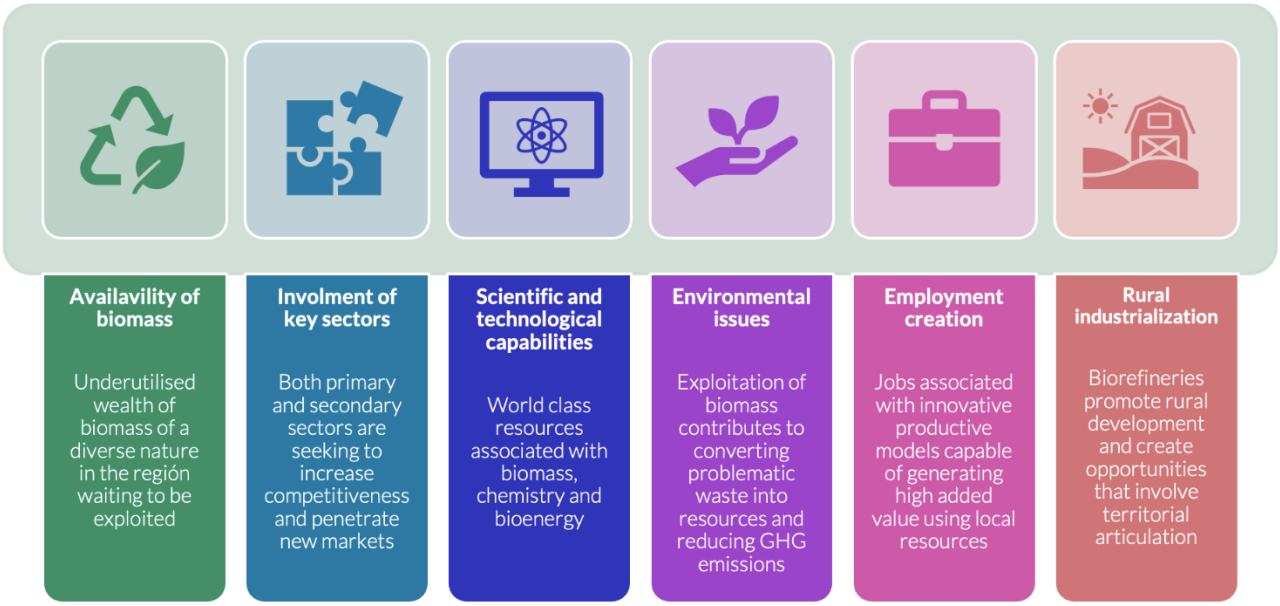


Figure 19 Key point for a strategic position for the development of biorefineries in Catalonia[55]

Investment in R&D-oriented initiatives could also benefit the Catalan chemical industry's transition to a bio-based portfolio and competitive success. The European RoadToBio project aims to help the chemical industry transition from fossil-based to bio-based chemicals to meet societal needs in 2030. The development of bio-based drop-in and smart drop-in chemicals could help the industry fight commoditization, shift focus on the bioeconomy and green chemistry, and produce products with unique and superior properties unattainable with fossil-based alternatives.

Overall, the Catalan chemical industry has numerous opportunities related to the bioeconomy, including developing new value chains and investing in bio-based R&D. Biorefining processes and applications, utilizing underutilized biomass and organic waste, and the development of bio-based drop-in and smart drop-in chemicals could help the industry transition towards a more sustainable and competitive future

1.4. Analysis of the positioning of Bioeconomy R+D in the Catalan region within the EU framework

Research and innovation strategies for intelligent specialization (RIS3) are transformative research and innovation agendas that analyse the innovation potential for particular regions, and set, prioritize, plan and monitor territorial objectives and goals aligned to the detected innovation specialization.

The Catalan Bioeconomy RIS3CAT report (henceforth, RIS3CAT) identified the main bioeconomy projects financed with European funds as well as the main actors in Catalonia who carry out research and innovation in the field of the circular bioeconomy. This data unlocks the relative positioning of Catalonia in relation to the leading regions in Europe, a relevant analysis for public policies that allows

[55] From: The chemical industry in Catalonia, 2021

to identify strengths and weaknesses of the research and innovation ecosystem and promote public actions that are more grounded in evidence.

With 131 projects, Catalonia ranks fourth in the ranking of European regions that participate in circular bioeconomy projects of the Horizon 2020 Program (11.2% of the projects have a Catalan partner).[56] By number of projects, ahead of Catalonia there are only three regions: Île-de-France, the Community of Madrid and the Brussels Region, that are home to large national research bodies, such as the Centre National de la Recherche Scientifique (CNRS) or the Consejo Superior de Investigaciones Científicas (CSIC) or actors linked to the European Commission, and therefore account for projects carried out in other territories. Catalonia stands out in the number of projects in relation to other European regions where these sort of national research bodies are not located.

In relative terms, Catalonia presents a specialization in circular bioeconomy projects (4.85% of the total Horizon 2020 projects in Catalonia) higher than the European average (3.81%). However, among the regions with more circular bioeconomy projects, only three have a lower relative specialization than Catalonia: Île-de-France (3.98%), Upper Bavaria (3.65 %) and Inner London West (3.66%). The rest of the regions have a higher relative specialization. Gelderland (15.16%), Helsinki (7.66%), the Valencian Community (9.38%) and Andalusia (9.54%) stand out, with a high number of projects and a high degree of specialization[57]. Therefore, another distinctive feature of Catalonia is the lack of focus or prioritisation, though Catalonia presents a lower relative specialization (both in number of projects and financing per million inhabitants) in relation to the regions that capture more projects.

Thematic areas and specialization of R+D in Catalan circular bioeconomy

RIS3CAT has established thirteen thematic areas to classify the different circular bioeconomy projects: Agrifood; Ecosystems, ecosystem services and climate change; Intermediate products and basic chemicals; Bioenergy and biofuels; Valorisation of organic waste; Chemical engineering (including biotechnology); Forestry and wood products; Aquaculture and marine ecosystems; Bioeconomy and policies in urban areas; Wastewater and sewage sludge; Collaboration in research, education and systemic approaches; Digitization; and Governance, participation and monitoring of actors[58].

The thematic area with the largest number of R+D projects is the agri-food, with a total of 48 projects. The agri-food sector is followed by ecosystem services and climate change (30 projects), intermediate products (25 projects), bioenergy and biofuels (24 projects), valorisation of organic waste (23 projects), forestry (21 projects), chemical engineering (21 projects) and aquaculture (19 projects), followed by others (see Figure 22). This diversity of thematic areas reflects the wide range of application and development of the bioeconomy and is consistent with the economic relevance of the sectors involved in the each of the thematic areas.

[56] Eurostat, 2019
[57] RIS3CAT, 2021
[58] RIS3CAT, 2021

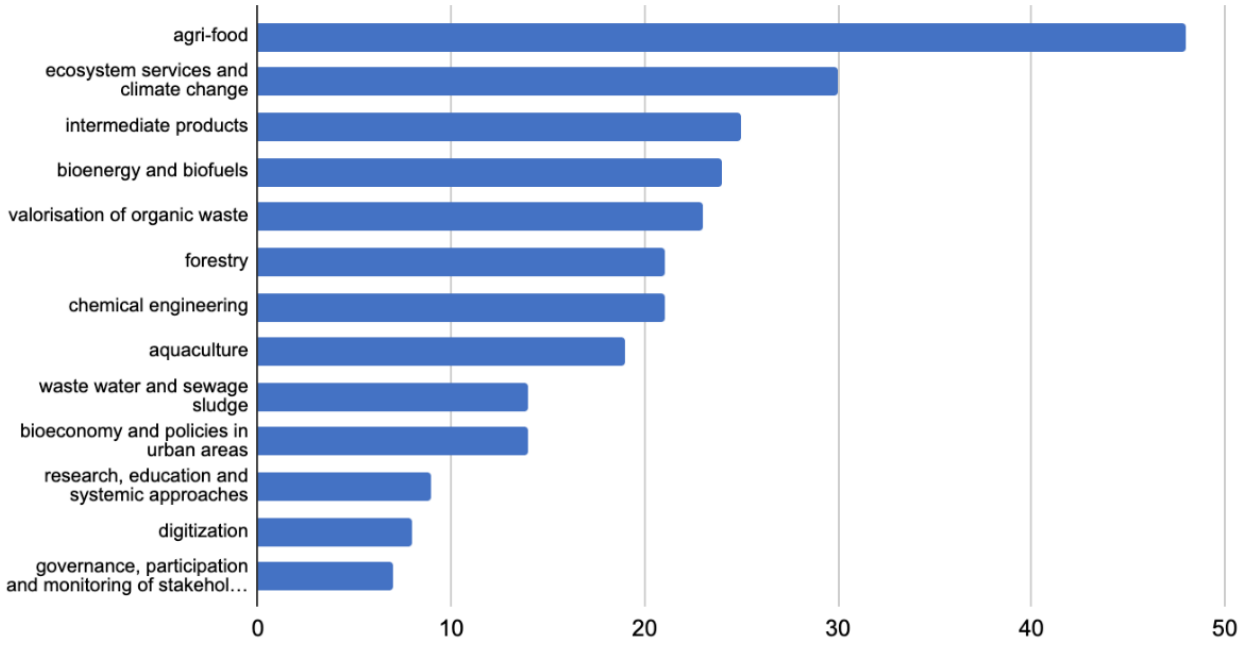


Figure 20. Number of R+D projects by thematic area in Catalonia[59]

The direction of research and innovation in the field of the bioeconomy is strongly influenced by the priorities of the EU calls for proposals. In areas such as ecosystems, ecosystem services and climate change, aquaculture and marine ecosystems or bioeconomy in urban areas, funding mainly comes from EU calls.

When comparing the specialization of Catalonia respect to the EU average based on the percentage of Horizon 2020 projects for the 13 thematic areas, Catalonia presents greater relative specialization in ecosystem services and climate change, aquaculture, forestry and bioeconomy in urban areas. On the other hand, there is less specialization in areas such as agri-food, bioenergy and biofuels and chemical engineering. This lesser specialization in areas so relevant to the Catalan economy requires a more in-depth analysis, to identify the causes and assess, if appropriate, public policy actions.

Despite being the fourth region with the highest concentration of circular bioeconomy projects, Catalonia occupies the 10th position in agri-food and the 13th position in bioenergy and biofuels, two fundamental thematic areas in terms of sector and green transition. On the other hand, Catalonia has a good position in ecosystems, ecosystem services and climate change (3rd), aquaculture and marine ecosystems (3rd), forestry and wood products (4th), valorisation of organic waste (4th), bioeconomy and policies in urban areas (2nd) and wastewater and sewage sludge (2nd)[60].

As said, Catalonia presents a diversified pattern of specialization, with a high number of projects in a diversity of thematic areas. This diversification makes it difficult to achieve the critical mass necessary to lead the large transformative projects promoted by the EU within the framework of the Green Deal.

Within the scope of the circular bioeconomy, Catalonia shows greater relative specialization in research related to the primary sector (agriculture, aquaculture, and forestry). Catalonia also excels in the areas of ecosystem services and climate change, organic waste recovery, policies in urban areas and

[59] RIS3CAT, 2021
[60] RIS3CAT, 2021

wastewater treatment. On the contrary, Catalonia presents a lower relative specialization in the areas of chemical engineering (biotechnology) and biofuels. The number of projects focused in general interest research areas and applications to specific challenges in the primary sector, stand out; though, there are few technological actors and industrial companies that develop new technologies and solutions[61].

Analysis of the Catalan bioeconomy research and innovation ecosystem

Regarding the territorial distribution, the entities based in the province of Barcelona participate in 135 circular bioeconomy projects in Catalonia, while the entities based in Girona, Lleida and Tarragona participate in 62 projects. It is possible to observe the strong relative weight of the entities of the demarcation of Lleida, which participate in 13.7% of the circular bioeconomy projects and only in 3.2% of the total projects[62]. Thus, the funding of research and innovation in the circular bioeconomy has an important territorial rebalancing effect, providing resources in a differential way, particularly in the provinces of Lleida and Girona.

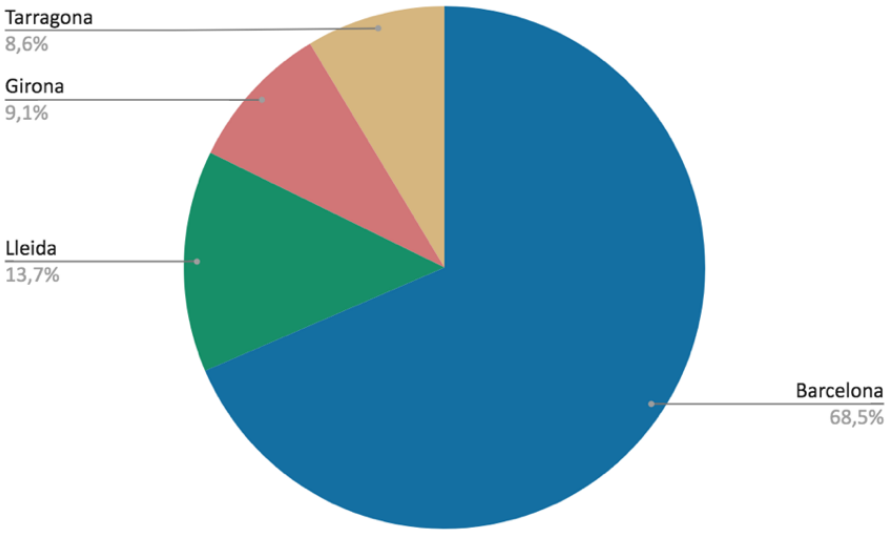


Figure 21 Catalan circular bioeconomy projects distributed by province[63]

In Lleida, the specialization in agri-food stands out, but also in forestry. Girona is strongly specialized in agri-food and ecosystem services, while in Tarragona the fields related to chemistry (chemical engineering, chemical products and biofuels) stand out. Barcelona, on the other hand, does not show any particular specialisation.

In relation with the leadership of Catalan entities in circular bioeconomy projects, the entities that have more participation are Leitat Technological Centre (18 projects), Autonomous University of Barcelona (12), University of Lleida (11), Polytechnic University of Catalonia (10), Institute for Research and Agro-Food Technologies (10), Balmes University Foundation (9), University of Barcelona (9) and Centre for

[61] RIS3CAT, 2021
[62] RIS3CAT, 2021
[63] Elaborated by the authors from RIS3CCAT data

Ecological Research and Forestry Applications (8). The company that participates in the most projects is AERIS Tecnologías Ambientales, with 4 projects[64]. AERIS is part of the BioBoost project consortium.

In relative terms, the entities that have greater specialization in circular bioeconomy projects are Forest Technology Centre of Catalonia (50%), AERIS (50%), Balmes University Foundation (47%), Catalan Research Institute of Water (32%), University of Lleida (30%) and Centre for Ecological Research and Forestry Applications (30%). Nonetheless, unlike other European regions, there is no Catalan entity that exercises leadership in the field of bioeconomy research and innovation, neither in Catalonia nor in Europe.

To sum up, within Catalonia, the territories that show a greater specialization of research and innovation in the circular bioeconomy are Lleida and Girona. According to experts, the low participation of private companies in the field of the circular bioeconomy (compared to the European average) and the specialization of research and innovation in basic science and sustainability challenges, reflect the need to promote policies and actions so that companies in Catalonia take advantage of the business opportunities linked to the circular bioeconomy.

[64] RIS3CAT, 2021

BIO BOOST

Acceleradora de projectes de bioeconomia

Analysis of relevant policies and strategies related to bioeconomy

02

2. Analysis of relevant policies and strategies related to the bioeconomy at EU, national and regional level

To further support the development of the bioeconomy, various types of support instruments are implemented by governments, organizations, and other stakeholders. These support instruments are aimed at fostering growth, increasing competitiveness, and promoting sustainability within the bioeconomy sector.

Some of the commonly used support instruments include financial incentives and subsidies, such as grants, low-interest loans, and tax credits, which help to encourage investment in bioeconomy-related activities. Additionally, research and development funding are also provided to improve the efficiency and sustainability of bioeconomy processes and technologies.

Market development programs aim to increase demand for bioeconomy products and services and improve the access to the market. Meanwhile, capacity building and training programs are designed to develop human capital and expertise within the sector. Policy and regulatory frameworks, such as standardization and certification, help to create a favourable environment for bioeconomy activities and technology transfer programs are implemented to promote the uptake of new technologies and processes in the sector.

It's crucial to note that the support instruments may vary between countries and regions, and the specific instruments used may be influenced by the unique needs and priorities of each region's bioeconomy sector.

Also, the European Union is dedicated to supporting the growth of the bioeconomy through various instruments and initiatives. To promote the development of new technologies and solutions, the European Commission provides funding for research and innovation projects through its Horizon 2020 program. Another public-private partnership, the Bio-based Industries Joint Undertaking, works towards developing and commercializing new bio-based products and technologies. The Bioeconomy Stakeholder Platform is a platform where stakeholders can discuss and exchange information on the development of the bioeconomy in Europe. These support instruments aim to encourage innovation, create jobs, and drive sustainable economic growth in the sector.

The most important initiatives are explained in the following tables and are divided between those at the European level, those at the national level (Spain), and those at the regional level (Catalonia).

Europe

Table 8 Relevant policies and strategies related to bioeconomy at a European level

EUROPE	
Agenda 2030 for sustainable development[65] (United Nations)	The Sustainable Development Goals (SDGs) are a universal call to action to end poverty, protect the planet and improve the lives and prospects of everyone, everywhere. The 17 Goals were adopted by all UN Member States in 2015, as part of the 2030 Agenda for Sustainable Development which set out a 15-year plan to achieve the Goals. The SDGs are:

[65] https://sdgs.un.org/goals

	1. No poverty 2. Zero hunger 3. Good health and well-being 4. Quality education 5. Gender equality 6. Clean water and sanitation 7. Affordable and clean energy 8. Decent work and economic growth 9. Industry, innovation and welfare 10. Reduced inequalities 11. Sustainable cities and communities 12. Responsible consumption and production 13. Climate action 14. Live below water 15. Life on land 16. Peace, justice and strong institutions 17. Partnership for the goals
European bioeconomy strategy[66] (European Commission)	The bioeconomy strategy aims to accelerate the deployment of a sustainable European bioeconomy through 3 main strategies: 1. strengthen and scale-up the bio-based sector; 2. rapidly spread bioeconomies across the whole of Europe; and 3. understand the ecological limitations of the bioeconomy. It has 5 goals: 1. ensure food and nutrition security; 2. manage natural resources sustainably; 3. reduce dependence on non-renewable, unsustainable resources; 4. limit and adapt to climate change; and 5. strengthen European competitiveness and create jobs. The strategy contributes to the European Green Deal, as well as industrial, circular economy and clean energy innovation strategies. They all highlight the importance of a sustainable, circular bioeconomy to achieve their objectives.
European Green Deal[67] (European Commission)	Climate change and environmental degradation are an existential threat to Europe and the world. To overcome these challenges, the European Green Deal will transform the EU into a modern, resource-efficient and competitive economy, ensuring: no net emissions of greenhouse gases by 2050 economic growth decoupled from resource use no person and no place left behind. The European Commission has adopted a set of proposals to make the EU's climate, energy, transport and taxation policies fit for reducing net greenhouse gas emissions by at least 55% by 2030, compared to 1990 levels.
Farm to Fork strategy in the framework of the Green Deal[68] (European Commission)	The European Green Deal is an opportunity to reconcile our food system with the needs of the planet and to respond positively to Europeans' aspirations for healthy, equitable and environmentally friendly food. The aim of this strategy is to make the EU food system a global standard for sustainability. The transition to sustainable food systems requires a collective approach involving public authorities at all levels of governance (including cities, rural and coastal communities), private sector actors across the food value chain, non-governmental organisations, social partners, academics and citizens. The Farm to Fork Strategy aims to accelerate our transition to a sustainable food system that should: • have a neutral or positive environmental impact • help to mitigate climate change and adapt to its impacts • reverse the loss of biodiversity

[66] https://research-and-innovation.ec.europa.eu/research-area/environment/bioeconomy/bioeconomy-strategy_en
[67] https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_en
[68] https://food.ec.europa.eu/horizontal-topics/farm-fork-strategy_en

	• ensure food security, nutrition and public health, making sure that everyone has access to sufficient, safe, nutritious, sustainable food • preserve affordability of food while generating fairer economic returns, fostering competitiveness of the EU supply sector and promoting fair trade
Common Agricultural Policy 2023-27 [69] (European Commission)	This legislation, which is due to begin in 2023, paves the way for a fairer, greener and more performance-based CAP. It will seek to ensure a sustainable future for European farmers, provide more targeted support to smaller farms, and allow greater flexibility for EU countries to adapt measures to local conditions. Agriculture and rural areas are central to the European Green Deal, and the new CAP will be a key tool in reaching the ambitions of the Farm to Fork and biodiversity strategies. The policy focuses on ten specific objectives, linked to common EU goals for social, environmental, and economic sustainability in agriculture and rural areas. The objectives are: • to ensure a fair income for farmers; • to increase competitiveness; • to improve the position of farmers in the food chain; • climate change action; • environmental care; • to preserve landscapes and biodiversity; • to support generational renewal; • vibrant rural areas; • to protect food and health quality; • fostering knowledge and innovation. Each EU country will design a national CAP strategic plan, combining funding for income support, rural development, and market measures.
Common Fisheries Policy[70] (European Commission)	The Common Fisheries Policy (CFP) is a specific legislation and structural policy for fisheries, a set of rules for sustainably managing European fishing fleets and conserving fish stocks. With the latest reform from 2013, the common fisheries policy is the first comprehensive legal framework, featuring: • attention to the environmental, economic and social dimensions of fisheries • fish stock management at maximum sustainable yield by 2020 for all managed stocks • gradual introduction of a landing obligation by 2019 • continued application of the so-called multiannual plans (MAPs) to manage fisheries in different sea basins • regionalisation to allow EU countries with a management interest to propose detailed measures, which the Commission can then adopt as delegated or implementing act and transpose them into EU law • fleet capacity ceilings per EU country in combination with the obligation for EU countries to ensure a stable and enduring balance between fishing capacity and fishing opportunities over time. EU countries may

[69] https://agriculture.ec.europa.eu/common-agricultural-policy/cap-overview/new-cap-2023-27_en
[70] https://oceans-and-fisheries.ec.europa.eu/policy/common-fisheries-policy-cfp_en

	need to develop action plans to reduce overcapacity (for which they can use scrapping money) After the evaluation of the current control system, the Commission decided in 2018 to initiate a revision of the fisheries control system. The overall objective of the revision is to modernise, strengthen and simplify the EU fisheries control system, ensure sustainability and increase the level playing field in fisheries control.
Action plan for the circular economy[71] (European Commission)	The EU's new circular action plan paves the way for a cleaner and more competitive Europe and it is one of the main building blocks of the European Green Deal. The EU's transition to a circular economy will reduce pressure on natural resources and will create sustainable growth and jobs. It is also a prerequisite to achieve the EU's 2050 climate neutrality target and to halt biodiversity loss. The action plan presents initiatives along the entire life cycle of products. It targets how products are designed, promotes circular economy processes, encourages sustainable consumption, and aims to ensure that waste is prevented, and the resources used are kept in the EU economy for as long as possible. Also, it introduces legislative and non-legislative measures targeting areas where action at the EU level brings real added value. The objectives of the action plan include: • make sustainable products the norm in the EU • empower consumers and public buyers • focus on the sectors that use most resources and where the potential for circularity is high • ensure less waste • make circularity work for people, regions and cities • lead global efforts on circular economy
RIS3 – Research and Innovation Strategies for Smart Specialisations[72] (European Commission)	National/regional research and innovation strategies for smart specialisation (RIS3) are integrated, place-based economic transformation agendas that do five important things: they focus policy support and investments on key national/regional priorities, challenges and needs for knowledge-based development, including ICT-related measures; they build on each country's/region's strengths, competitive advantages and potential for excellence; they support technological as well as practice-based innovation and aim to stimulate private sector investment; they get stakeholders fully involved and encourage innovation and experimentation; and they are evidence-based and include sound monitoring and evaluation systems.
Horizon 2020 – Research and innovation framework program[73] (European Commission)	Horizon 2020 was the EU's research and innovation funding programme from 2014-2020 with a budget of nearly €80 billion. The programme has been succeeded by Horizon Europe.

[71] https://environment.ec.europa.eu/strategy/circular-economy-action-plan_es
[72] http://www.gsrt.gr/Financing/Files/ProPeFiles18/RIS3%20Guide%20March%202012final_0204_en.pdf
[73] https://research-and-innovation.ec.europa.eu/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-2020_en

Horizon Europe – Research and Innovation Framework Program[74] (European Commission) 2021-2027	Horizon Europe is the EU's key funding programme for research and innovation until 2027 with a budget of €95.5 billion. It tackles climate change, helps to achieve the UN's Sustainable Development Goals and boosts the EU's competitiveness and growth. The programme facilitates collaboration and strengthens the impact of research and innovation in developing, supporting and implementing EU policies while tackling global challenges. It supports creating and better dispersing of excellent knowledge and technologies.
Circular Bio-based Europe Joint Undertaking[75] (CBE JU)	The Circular Bio-based Europe Joint Undertaking (CBE JU) is a €2 billion public-private partnership between the EU and the Bio-based Industries Consortium. The main goals of CBE JU are to accelerate the innovation process, developing novel bio-based solutions; accelerate market deployment of existing mature and novel bio-based solutions; and ensure a high level of environmental performance by bio-based industrial systems. Concretely, the partnership is funding projects across Europe that aim to support research and innovation in sustainable bio-based solutions; reduce the risks of investing in circular bio-based production plants; address the technological, regulatory & market challenges facing the bioeconomy; strengthen collaboration among all groups in the bioeconomy sector; and engage with more stakeholders along the value chains. The role of Circular Bio-based Europe is to bring together various groups from bio-based industries, ranging from farmers to scientists, to solve the technological, regulatory and market challenges facing the sector. Its public-private funding scheme boosts innovation and market deployment and paves the way for future investment.
Bioeconomy Stakeholder Platform[76] (European Commission)	The Bioeconomy Stakeholder Platform (BSP) is a website platform hosted by the European Commission that provides a space for stakeholders to discuss and exchange information on the development of the bioeconomy in Europe. The platform brings together a wide range of stakeholders, including researchers, policymakers, industry representatives, and civil society organizations, to facilitate dialogue and promote collaboration. The BSP aims to increase awareness and understanding of the bioeconomy, support the development of policies and initiatives that support the sector, and provide a platform for the exchange of best practices and knowledge.

[74] https://research-and-innovation.ec.europa.eu/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-europe_en
[75] https://european-union.europa.eu/institutions-law-budget/institutions-and-bodies/institutions-and-bodies-profiles/circular-bio-based-europe-joint-undertaking-cbe-ju_en
[76] https://commission.europa.eu/research-and-innovation_en

Spain

Table 9 Relevant policies and strategies related to bioeconomy at national level

SPAIN	
Spanish Bioeconomy Strategy: Horizon 2030[77] (Ministry of Economy and Competitiveness) *Estrategia española de bioeconomía: Horizonte 2030 (Ministerio de Economía y Competitividad)*	This strategy intends that the advances that are taking place in the field of biotechnology, agricultural and food sciences, with the technological and innovative support of other areas (as engineering, organization or logistics), improve the competitive position of these sectors, in particular of the Spanish agri-food and forestry sector, both to meet domestic demand and to advance its export and internationalization strategy. In addition, it seeks to promote the comprehensive use of biological resources, as a substantial raw material to produce various biomaterials (bioplastics, lubricants, etc.), using different bioprocesses, as well as bioenergy (advanced biofuels or other energy uses of biomass). The purpose of the strategy is to promote economic activity and improve the competitiveness and sustainability of the productive sectors that are linked to the use of bio-based resources, promoting the development and application of technologies generated through collaboration between the scientific system and technology and Spanish companies. The strategic objectives of the strategy are: 1. Promote the development of the bioeconomy in Spain through permanent collaboration between the Spanish administrations and the productive sectors and the participation of society; 2. Promote interaction between the Spanish and international science and technology system, public and private, with the productive sectors and their companies to stimulate the creation of multidisciplinary teams capable of developing technologies that diversify and improve the efficiency of the use of energy resources. biological origin, consolidating the already operative structures. 3. Facilitate and promote the creation of scientific knowledge and its application to the market and to innovation, through the creation and consolidation of technology-based companies, as well as their incorporation into national and international knowledge networks.
Circular Economy Spanish Strategy[78] (Ministry for Ecological Transition and the Demographic Challenge) *Estrategia española de economía circular (Ministerio para la Transición Ecológica*	The Spanish Strategy for the Circular Economy, called España Circular 2030, establishes the bases to promote a new production and consumption model in which the value of products, materials and resources are maintained within the economy for as long as possible, with minimal waste and reusing as much as possible the waste that cannot be avoided. This strategy contributes to Spain's efforts to achieve a sustainable, decarbonized economy, which uses resources efficiently and is competitive. This strategy will be materialized in successive triennial action plans. The following strategic guidelines are provided as a decalogue: 1. Protection of the environment 2. Product life cycle

[77] https://www.mapa.gob.es/ca/desarrollo-rural/temas/innovacion-medio-rural/estrategiaenbioeconomia23_12_15_tcm34-560119.pdf
[78] https://www.miteco.gob.es/es/calidad-y-evaluacion-ambiental/temas/economia-circular/estrategia/

y el Reto Demográfico)	3. Waste hierarchy 4. Reduction of food waste: 5. Production efficiency 6. Sustainable consumption 7. Communication and awareness 8. Employment for the circular economy 9. Research and innovation 10. Indicators Additionally, developing the Circular Economy Strategy and achieving the described strategy objectives should lead to attain a series of quantifiable goals by the end of the decade. Therefore, the Strategy establishes the following goals for year 2030: • Reducing by 30% domestic material consumption in relation to national GDP, taking 2010 as a reference. • Reducing waste by 15% with regard to 2010 waste levels. • Reducing food waste throughout the entire food chain: 50% reduction per person in retail and households and 20% in production chains and supplies from 2020, thus advancing towards the Sustainable Development Goal (SDG). • Promoting reuse and reuse enabling activities until reaching 10% of municipal waste. • Reducing greenhouse gas emissions to under 10 million tonnes of CO_2eq. • Improving water use efficiency by 10%.
Andalusian Circular Bioeconomy Strategy[79] (Andalusian Government) *Estrategia Andaluza de Economía Circular (Junta de Andalucía)*	Andalusian Circular Bioeconomy Strategy focuses on the areas of bioeconomy activities that are less developed in the community and, therefore, need greater institutional support through the implementation of specific actions that facilitate its take-off and consolidation in the medium-long term. The relevant sectors for the bioeconomy include agriculture, forestry, fishing, food and paper production, as well as part of the chemical, biotechnology and energy industries. The time horizon of the strategy is 2030 and for this it has resources worth around 1,400 million euros aimed at specific actions that have been developed with the collaboration of more than 50 external experts from the sectors of interest. The main objective of Andalusian Strategy of the Circular Bioeconomy is to contribute to sustainable growth and development in Andalusia by foresting actions towards the production of renewable and biological products and processes, specifying in this document three strategic objectives: 1. Increase the availability of sustainable biomass for its use through innovative treatments. 2. Increase the number of bio-industries and biorefineries in Andalusia.

[79] https://www.bioeconomiaandalucia.es/la-eab2030

	3. Increase markets and the consumption of bioproducts and bioenergy in Andalusia. This document establishes four strategic lines that encompass measures and actions to achieve these objectives: promote production and availability of biomass; improve Infrastructures and logistics of biomass; facilitate industrial transformation processes of biomass resources and industrial production capacities of bioproducts and bioenergy; and development of markets for bioproducts and bioenergy.
Green and Circular Economy Strategy Extremadura 2030[80] (Extremadura Government) *Estrategia de economía verde y circular Extremadura 2030 (Junta d'Extremadura)*	This Strategy aims to unite and align the largest part of the existing material and human resources in Extremadura in search for a greener and more circular society and economy, where natural resources are a permanent source of obtaining opportunities for the population of Extremadura. A social and sustainable economy where the people who live in each of the towns and cities of Extremadura are the protagonists of innovation, creativity, the respectful production of goods and services, the creation of green business initiatives and the enhancement of the natural resources. The strategic objectives refer to the generality of the strategy, have a general character and are the following: • Generate a sustainable development model based on the green and circular economy, combining environment, economy and society around the regional environmental potential and promoting the transition of the business fabric of Extremadura towards the new model, mainly in the agricultural, agro-industrial, services, industrial and construction sectors. • Design and develop a process of citizen participation to build the Extremadura strategic model on green and circular economy, extended throughout the region, with citizens as protagonists and with municipalities and territories as scenarios. • Promote a social transformation based on the massive training of the population, job training and citizen empowerment, from the development of new skills, to face the challenges of the future and the transformation of mentalities and attitudes. • Turn Extremadura into an international laboratory of reference in research and innovation around the green economy, the bioeconomy, the circular economy and the fight against climate change. • Identify, value and align actions of all Extremadura agents around the green and circular economy.

[80] https://extremadura2030.com/wp-content/uploads/2018/05/estrategia2030.pdf

Catalonia

Table 10 Relevant policies and strategies related to bioeconomy at regional level

CATALONIA	
Strategic food plan for Catalonia 2021-2026[81] (Department of Agriculture, Livestock, Fisheries and Food) *Pla estratègic de l'alimentació de Catalunya 2021-2026 (Departament d'Agricultura, Ramaderia, Pesca i Alimentació)*	The Strategic Food Plan of Catalonia (PEAC) 2021-2026 is the result of more than a year of collaborative and intensive work by all the actors in the food value chain, from primary production to consumer persons, through the processing, distribution, trade and restoration industries. The process of preparation has been completed by December 2020 and Catalonia already has a food strategy that will start to be implemented in 2021 and will be implemented until 2026. Its design has been the result of the integration of the works of the various expert and specialist groups and of a participatory process open to the sector and to citizenship initiated by the Department of Agriculture, Livestock, Fisheries and Food in the face of the need to have a single country food policy shared with the whole society and built by all the actors involved. This is the beginning of a collective path for all, in which only by continuing the joint effort will we achieve the milestones we have set ourselves as a country.
Strategic plan for agrifood research, innovation and transfer of Catalonia 2030[82] (Department of Agriculture, Livestock, Fisheries and Food) *Pla estratègic de recerca, innovació i transferència agroalimentària de Catalunya 2030 (Departament d'Agricultura, Ramaderia, Pesca i Alimentació)*	The Strategic Plan for Agrifood Research, Innovation and Agri-food Transfer of Catalonia 2013-2020, it is a programme of interdepartmental actions for the promotion of research, development and innovation in the service of the agri-food sector. To follow up this line of work, the Strategic Plan for Agrifood Research, Innovation and Transfer of Catalonia 2021-2030 (PRITAC 2030) is currently being drawn up to improve the agri-food innovation system and its capacity to respond to its challenges and strategies.
Maritime Strategy of Catalonia 2030[83] (Department of	Five initiatives of the Local Action Groups Fishing Sea of the Ebro (GALP) for the period 2019-2020 have been recognised by the Department of

[81] https://agricultura.gencat.cat/ca/ambits/alimentacio/estrategia-alimentaria/pla-estrategic/
[82] https://govern.cat/salapremsa/notes-premsa/412086/obert-el-proces-de-participacio-publica-per-a-l-elaboracio-del-pla-estrategic-de-recerca-innovacio-i-transferencia-agroalimentaria-de-catalunya-2021-2030-pritac-2030
[83] https://govern.cat/salapremsa/notes-premsa/400347/l-estrategia-maritima-de-catalunya-2030-reconeix-la-contribucio-d-iniciatives-del-grup-d-accio-local-pesquer-mar-de-l-ebre

Agriculture, Livestock, Fisheries and Food) *Estratègia marítima de Catalunya 2030 (Departament d'Agricultura, Ramaderia, Pesca i Alimentació)*	Agriculture, Livestock, Fisheries and Food with the hallmarks of the 2030 Maritime Strategy of Catalonia (EMC). The aim of these badges is to recognise those initiatives that have contributed to the implementation of the 2030 Catalonia Maritime Strategy, a consensual tool among all the Government of Catalonia's departments to promote sustainable and respectful blue economy development for sea use, the creation and maintenance of marine ecosystems resilience, improving the quality of life of citizenship and an innovative participatory governance framework. Diplomas have been delivered within the framework of the Conference on Participative Local Development in the Ebro Sea Group in which the results and opportunities for implementing the 2030 Catalonia Maritime Strategy have been evaluated in the territory.
Strategy to promote the energy utilization of forest and agricultural biomass[84] (Catalan Energy Institute) *Estratègia per promoure l'aprofitament energètic de la biomassa forestal i agrícola (Institut Català d'Energia)*	The Government of Catalonia renews the Strategy for the Agricultural and Forestry Biomass in Catalonia for the period 2021-2027. The aim is to further enhance the energy use for thermal uses of this proximity renewable resource. The review updates the lines of action of the Strategy and sets new objectives with the aim of further advancing the energy uses of biomass and deepening the benefits involved. Forest biomass is a renewable energy source of local origin, and its exploitation contributes to better management of the country's resources. The strategy will continue to give priority to the thermal uses of forest biomass, and its content has adapted to the new European and Catalan regulatory environment, which in recent years has focused on tackling climate change and transforming the economy and energy model in order to decarbonize them. The actions proposed aim to increase the exploitation of this resource, and also to ensure that this growth is sustainable, that it makes it possible to replace fossil fuels and that it results in a sector of technical activity that is rooted in the territory. With the review of the Strategy, it is planned to achieve a consumption of 770,000 tons per year of biomass at the end of the period and install equipment and boilers to up to 844 MW of power. Since the implementation of the strategy in 2014, the consumption of this proximity renewable resource has increased by 81.6%.
Forest agenda 2020-2025 Rural development program of Catalonia[85] (Department of Agriculture, Livestock, Fisheries and Food) *Agenda forestal 2020-2025*	The 2020-2025 forest agenda creates a space for dialogue with the main stakeholders in the forestry sector, and those structural measures that the sector needs to improve and prosper have been evaluated. The aim of the Forest Agenda is to determine the road map of forest policies in Catalonia and to create a common starting point for the future of the sector with all the actors involved. The Agenda has been drawn up on the basis of meetings with the primary forestry sector. The actors identified and related to each other have been: forest owners, administration and business sector. Eight measures have been established on which a number of actions have been defined for implementation or start in the period 2020 –2025. 1. Improved governance and administrative restructuring.

[84] https://icaen.gencat.cat/ca/plans_programes/estrategia_biomassa/
[85] https://agricultura.gencat.cat/ca/ambits/medi-natural/gestio-forestal/planificacio-forestal/agenda-forestal/

Programa de desenvolupament rural de Catalunya (Departament d'Agricultura, Ramaderia, Pesca i Alimentació)	2. Technical and health and safety training, modernisation and study of techniques adapted to the Catalan forest. 3. A campaign of outreach, transfer and education. 4. Diversification of industrial uses with greater coniferous/planifolious added value and boost to bioeconomics. 5. Grouping ownership at different levels and ownership. 6. The creation of a legal framework guaranteeing the safety of authorisations. 7. Organization of strategic secondary products. 8. Development and coordination of actions for environmental goods and services
Program for women in the rural and maritime world of Catalonia[86] (Department of Agriculture, Livestock, Fisheries and Food) *Programa de dones del món rural i marítim de Catalunya (Departament d'Agricultura, Ramaderia, Pesca i Alimentació)*	The Rural and Maritime Women's Programme 2022-2025 aims to promote women's initiatives and create equal conditions in agri-food and forestry production activities in Catalonia, and in economic activities related to the sea sector, within the framework of sustainable agri-food systems. To achieve this goal, four areas of incidence are considered, referring to: · Visibility, recognition and dissolution of stereotypes. · Promotion of employment and entrepreneurship. · Participation of women. · Transversalization of the gender perspective. The programme was based on the Second Rural and Maritime Women's Programme 2016-2020 and its evaluation, to respond to the new challenges, update the objectives and collect and structure the actions to be developed according to today's needs. Furthermore, it has been the result of a participatory process that has included three phases: · a first phase of orientation and specification of the process, · a second phase of diagnosis of gender inequalities, involving the collaboration of the Gender Equality Observatory and Idescat; · and a third phase of identification of objectives, lines of action and priority actions, in which the Gender Transversality Working Group (DACC), territorial references of the DACC itself, of the Advisory Council for Women in the Rural and Maritime World, of women associated with the Association of Rural World Women and the Catalan Association of Sea Women, of women experts in various sectors related to the fields included in the PDMRM and of society in general, through a survey aimed at citizenship.
General program for the prevention and management of waste and resources in Catalonia[87] (Waste	The General programme of prevention and management of waste and resources of Catalonia 2020 (PRECAT20) is the instrument provided by the Generalitat de Catalunya to address the strategic and objective challenges in the field of waste prevention and management over the coming years. The new PRECAT20 integrates the previous waste management programmes of Catalonia formulated based on the origin of generation (municipal, industrial and construction), in a new general programmee based on the material streams

[86] https://agricultura.gencat.cat/ca/departament/politiques/dones-mon-rural/programa-dones-mon-rural-maritim/
[87] https://residus.gencat.cat/web/.content/home/ambits_dactuacio/planificacio/precat20_resum_executiu_en.pdf

Agency of Catalonia) *Programa general de prevenció i gestió de residus i recursos de Catalunya (Agència de Residus de Catalunya)*	of waste. This inclination strengthens the situation of waste as a resource, as well as the existing synergies within the management of the different material streams regardless of their origin and allows the limits of classic management strategies to be overcome.
Catalan strategy for adaptation to climate change[88] (Catalan Climate Change Office) *Estratègia catalana d'adaptació al canvi climàtic (Oficina Catalana del Canvi Climàtic)*	Adaptation to the impacts of climate change is the other pillar of climate policies and, unlike mitigation, has a more local character. Adaptation is the ability of natural or human systems to adjust to climate change and its impacts in order to moderate its damage or take advantage of its opportunities, that is to say, the ability to reduce our vulnerability (social, territorial, economic, environmental) to the impacts and risks arising from climate change. One of the purposes of Law 16/2017, of August 1, on climate change is precisely to reduce the vulnerability of the population, the socio-economic sectors and terrestrial and marine ecosystems to the adverse impacts of climate change, and also create and strengthen national capacities to respond to these impacts. The new Catalan strategy for adapting to climate change 2021-2030 will replace the current one and will become the strategic reference framework for adapting to climate change in Catalonia.
National Pact for the Energy Transition of Catalonia[89] (Catalan Energy Institute) *Pacte Nacional per a la Transició Energètica de Catalunya (Institut Català d'Energia)*	The National Pact for Energy Transition of Catalonia is born out of the need to generate a dialogue between all political forces and representatives of civil society to agree a new Catalan energy model that is renewable, clean, decentralised, democratic, and sustainable, in line with the European Union's energy objectives. The basic document approved by the Catalan Government to be presented to the Parliament of Catalonia, was the result of a concertation process involving the Table of Entities of the economic, social and energy sectors, the Table of Political Parties and the Catalan Government Departments related to the energy field.
Catalonia's Energy and Climate Change Plan[90] (Catalan Energy Institute) *Pla de l'energia i canvi climàtic de Catalunya (Institut Català d'Energia)*	This new Energy and Climate Change Plan for Catalonia 2012-2020 addresses the new direction that the current Government of the Government of Catalonia wants to give to Catalan energy policy, integrating those aspects of climate change mitigation related to energy. From a climate perspective, this Plan is a very significant part of climate policy planning. It should be borne in mind, however, that the Plan does not include other aspects of climate change such as emissions of non-energy greenhouse gases, the so-called sinking effect (forests, agriculture, ...), adaptation to the impacts of climate change or the development of regional climate models,

[88] https://canviclimatic.gencat.cat/ca/ambits/adaptacio/estrategia-catalana-dadaptacio-al-canvi-climatic-2021-2030/
[89] https://icaen.gencat.cat/ca/plans_programes/transicio_energetica/
[90] https://icaen.gencat.cat/ca/plans_programes/pecac/

	which according to the Government Plan 2011-2014 will be subject to treatment in the Migation Plan and the Adaptation Strategy.
RIS3CAT[91] (Department of the Vice-Presidency and of Economy and Finance) *RIS3CAT (Departament de la Vicepresidència i d'Economia i Hisenda)*	The document RIS3CAT: Research and innovation strategy for smart specialisation in Catalonia defines a vision for Catalonia: an industrial-based country, which has an open, competitive, and sustainable economy, combining talent, creativity, a diversified business fabric and its own system of excellence research, within the framework of a dynamic, entrepreneurial and inclusive society. Multinationals and local companies, consolidated sectors with international leadership and emerging technology sectors coexist. To help make this vision a reality, the actions of RIS3CAT must focus on the following four strategic objectives: 1. Strengthening the competitiveness of the business fabric, by improving the efficiency of production processes, internationalisation and the reorientation of consolidated sectors towards more value-added activities. 2. To promote new emerging economic activities, based on research, creativity and innovation, to create and exploit new market niches. 3. To consolidate Catalonia as a European pole of knowledge and connect technological and creative skills with the sectors that exist in the territory and those that emerge there. 4. To improve the Catalan innovation system globally, strengthen the competitiveness of companies, particularly SMEs, and guide public policies towards promoting innovation, internationalisation and entrepreneurship.
Promotion strategy for the green economy and the circular economy. Circular economy roadmap[92] (Territory and Sustainability Department) *Estratègia d'impuls a l'economia verda i a l'economia circular. Full de ruta de l'economia circular (Departament de Territori i Sostenibilitat)*	The promotion strategy for the green economy and the circular economy is based on the continuity of policies on the creation of the business fabric, industrial strategy, investment effort, the development of human talent and sustainable production, and at the same time aims to make a leap in competitiveness policies, becoming a major element as a lever for change in the economic model. The Impulse strategy for the Green Economy and the Circular Economy has been set up in an inter-departmental working group with the presence of various Catalan Government departments, with the idea of promoting cross-cutting policies in the context of the Catalonia 2020 Strategy.
Agenda 2030. "Transform Catalonia, improve the world"[93]	The document Transforming the World: the 2030 Agenda for Sustainable Development, which contains 17 Sustainable Development Goals (SDGs) and 169 specific milestones to be achieved by 2030, represents the new

[91] http://catalunya2020.gencat.cat/ca/ris3cat/
[92] https://mediambient.gencat.cat/web/.content/home/ambits_dactuacio/empresa_i_produccio_sostenible/economia_verda/impuls/IMPULS-EV_150519.pdf
[93] https://cads.gencat.cat/ca/informes/informes-per-anys/2016/lagenda-2030-transformar-catalunya-millorar-el-mon-/

(Advisory Council for Sustainable Development) *Agenda 2030. «Transformar Catalunya, millorar el món» (Consell Assessor per al Desenvolupament Sostenible)*	international development regime for the next fifteen years. The new agenda for sustainable development is inspired by five fundamental ideas: · The sense of urgency to achieve the SDGs, that is, to face the challenges and threats that affect sustainable development on a planetary scale. · The transformative potential of the SDGs and milestones compared with the current guidelines that determine the sustainability of the planet. · The global and universal nature of the SDGs and the milestones associated with each of them, which must apply to all countries, starting from the differences currently existing in each of them. · The indivisible nature of the SDGs and of the milestones associated with each of them, which must be sought as a whole, with a comprehensive approach, without giving up any of them. · The balance between all dimensions of sustainable development (economic, social and environmental), which cannot prevail over each other. The SDGs address the five major areas described above (planet, prosperity, people, peace and partnership) and cover areas such as poverty, inequality, food security, health, sustainable consumption and production, growth, employment, infrastructure, sustainable management of natural resources, oceans, climate change, and also gender equality, peace, social inclusion, access to justice and responsible institutions. In short, crucial areas at international level, but which are also crucial at national and local level.
Biodiversity strategy. Catalonia's Natural Heritage and Biodiversity Strategy[94] (Territory and Sustainability Department) *Estratègia de biodiversitat. Estratègia del patrimoni natural i la biodiversitat de Catalunya (Departament de Territori i Sostenibilitat)*	The Catalan Natural Heritage and Biodiversity Strategy is the strategic planning document that defines the road map of nature conservation policies in Catalonia until 2030. The Strategy is an essential document for implementing. Catalonia's Natural Heritage and Biodiversity Strategy defines strategic objectives to be achieved by 2030, but will be deployed quadrennially, with lines of action to be defined in actions, in a first phase during the period 2019-2022. It is articulated based on six guiding principles, which define the priorities of government action to conserve nature and curb the loss of biodiversity in Catalonia from 1st) knowledge and management of information on natural heritage; 2nd) the conservation of habitats, species and ecological processes; 3rd) the reorientation of the territorial model; 4th) the integration of sectoral policies; 5th) the administrative structure and legal framework; 6th) social involvement.
PN@SC – National Pact for the Knowledge Society[95] (Department of	The PN@SC is a country agreement that was unanimously approved by the 78 representatives of universities, research centres, students, trade unions, the business world, the territorial area and all political groups represented in the Parliament of Catalonia, during the Plenary of the Pact held in May 2020.

[94] https://mediambient.gencat.cat/ca/05_ambits_dactuacio/patrimoni_natural/estrategia-catalana-del-patrimoni-natural-i-la-biodiversitat/
[95] https://recercaiuniversitats.gencat.cat/ca/01_departament_recerca_i_universitats/PNSC/

Business and Knowledge) *PN@SC – Pacte Nacional per a la Societat del Coneixement (Departament d'Empresa i Coneixement)*	The vision with which the work of the PN@SC was proposed and then developed for a whole year has suddenly been reinforced by the emergency situation due to the pandemic in the country, which needs all the technology and all the knowledge it is capable of generating for itself, and more quickly. Here and everywhere, analyses, proposals, treatments and solutions are based on knowledge. In this regard, the PN@SC agreements have been incorporated into the Commission's work on the Partnership for the Economic Reactivation and Social Protection (CORECO) Plan.

BOOST

Acceleradora
de projectes de
bioeconomia

Identification of Catalan related Bioeconomy EU Projects

03

3. Identification of Catalan related Bioeconomy EU Projects

Catalonia has become a hub of innovative and sustainable projects in recent years, with a particular focus on the bioeconomy. From using renewable resources to developing eco-friendly products, Catalonia is leading the way in creating a more sustainable future.

In this context, several bioeconomy projects have been implemented across different sectors, ranging from agriculture to biotechnology, and from waste management to renewable energy, and showcasing the region's commitment to a circular economy model and recognizing the importance of promoting a circular and bio-based economy.

In this section, we will provide a summary of ongoing and recently finished bioeconomy projects that involve at least one participant from Catalonia. These projects have been selected from CORDIS - EU research results and are notable for their European origins and their focus on bioeconomy-related themes. In D1.1. *European Bioeconomy Projects Development Best Practices Report* other European projects' best practices of our interest are compiled.

Table 11 Catalan related Bioeconomy EU projects[96]

3-CO Concise Consumer Communication through Robust Labels for Bio-based Systems		
Description	**Programme**	**Years**
Demonstrate the viability of a supportive framework for Label and Certification Schemes (LCS) on Business-to-Consumers (B2C) communication for industrial bio-based products (BBPs) that enables and supports consumers to make more sustainable buying choices.	HORIZON.2.6 - Food, Bioeconomy Natural Resources, Agriculture and Environment	2023-2026
Outcomes / Impacts		
• The 3-CO project is in its initial phase		
TRL level		
N/A		
Next steps of possible commercialisation		
• The 3-CO project is in its initial phase		

AgriLoop Pushing the frontier of circular agriculture by converting residues into novel economic, social and environmental opportunities		
Description	**Programme**	**Years**
Develop safe-and-sustainable-by-design (SSbD) bioconversion processes integrated in a cascading biorefinery approach to convert a range of agri-residues into plant and microbial proteins, polyesters and other bio-based chemicals to be used for food, feed, health and materials applications, especially by the farming sector.	HORIZON.2.6 - Food, Bioeconomy Natural Resources, Agriculture and Environment	2022-2026
Outcomes / Impacts		
• Global bioeconomy cooperation: AgriLoop aims to extend the agricultural production value of both the EU and China by fostering cooperation in the global bioeconomy. The project's outcomes are expected to contribute to the development of new bio-based markets and strengthen collaboration between the two major players. • Eco-efficient upgrade of residues: the project seeks to eco-efficiently upgrade underexploited residues from various sectors (tomato, soy, straw, potato, brewery, oil, winery, and livestock) into a portfolio of high-added-value		

[96] https://cordis.europa.eu/en

bio-products. This initiative aligns with the circular agriculture concept, maximizing the utility of agricultural residues.
- Portfolio of high-value bio-products: AgriLoop aims to generate a diverse portfolio of bio-products, including plant and microbial proteins, polyesters, and other bio-based chemicals. These bio-products are intended for applications in food, feed, health, and materials, with a special focus on meeting the needs of the farming sector.
- Increased resource efficiency: by converting agri-residues into valuable bio-products, AgriLoop aims to increase resource efficiency by minimizing the discharges of agricultural residues. This aligns with sustainability goals and contributes to a more environmentally friendly and resource-conscious agricultural system.
- Market competitiveness: the project aspires to enable bio-based products to compete with and gain market share from oil- and food crops-based equivalents. This competitiveness is crucial for the successful integration of bio-based alternatives into existing markets.
- Frugal design and sustainable requirements: AgriLoop's scientific and technical objectives include improving the recovery of functional native molecules and tailoring bioconversion schemes toward microbial proteins and polyesters. This involves adopting a frugal design approach and anticipating the circularities of the biorefinery to meet safe and sustainable requirements.
- EU-CN cooperation strengthening: the project has broader implications for strengthening cooperation between the EU and China, fostering knowledge exchange, and informing safe-and-sustainable-by-design (SSbD) guidance.

TRL level

N/A

Next steps of possible commercialisation

- The AgriLoop project is in its initial phase

BIO-QED

Quod Erat Demonstrandum: Large scale demonstration for the bio-based bulk chemicals BDO and IA aiming at cost reduction and improved sustainability

Description	Programme	Years
Provide bio-based bulk chemicals BDO and IA with a bridge to market by generating evidence and collecting all technical and economic key design parameters needed for future investment decisions at production plants with the aim to guide the European economic system towards a broader and more sustainable use of resources, reconciling the requirements of agriculture and food safety with the sustainable use of renewable sources for industrial purposes.	FP7-KBBE - Specific Programme "Cooperation": Food, Agriculture and Biotechnology	2014-2017

Outcomes / Impacts

The BIO-QED project aimed to bridge the gap between research and commercialization by providing evidence and key design parameters to produce bio-based bulk chemicals, specifically 1,4-butanediol (BDO) and itaconic acid (IA). The outcomes and impacts of the project can be summarized as follows:
- Technical advancements: the project successfully addressed challenges in using and valorizing first and second-generation feedstocks, including by-products from first-generation sugars. Innovative solutions were developed for toxicity testing and selecting sugars from lignocellulosic feedstock for fermentation processes.
- Fermentation development: microbial fermentation processes were developed and optimized in 50 L scale equipment. The focus was on enhancing time-space yield and productivities for the production of BDO and IA through batch, fed-batch, continuous, or novel fermentation processes.
- Downstream process optimization: the project tested and implemented pre-selected separation techniques to recover BDO and IA from fermentation broth at a scale up to 50 L. Techniques like in-situ product recovery (ISPR) were applied to improve productivities and mitigate feedstock impurities inhibition.
- Scale-Up demonstration: information for the integration of fermentation and downstream processing was provided, testing engineering concepts from small scale to industrial scale. The technical feasibility of producing BDO and IA on a pilot scale with optimized continuous fermentation and novel integrated production and separation techniques was demonstrated.
- Application development: BDO and IA were transformed into intermediary derivatives, further processed into end-user/value-added applications, and characterized for properties and performance. Prototypes of piloted end-user products were produced.
- Sustainability assessment: the project evaluated the technical and economic feasibility, as well as the sustainability of the developed production processes and final products. Environmental impact assessments were also conducted.

TRL level

The Technology Readiness Level (TRL) of the BIO-QED project progressed through various stages, reaching a significant level of maturity. The project involved laboratory-scale demonstrations (TRL 4-5) and advanced to pilot-scale demonstrations (TRL 6-7) in the scale-up phase. This positions the bio-based bulk chemicals BDO and IA closer to commercialization.
Next steps of possible commercialisation
• The project's success in pilot-scale demonstrations suggests the need for further scale-up activities to bring the production of BDO and IA to an industrial scale. This involves refining and optimizing processes for large-scale commercial production. • Engage in market validation activities to assess the demand for bio-based BDO and IA, ensuring that the products meet industry standards and customer requirements. • Collaborate with industrial partners, potential end-users, and stakeholders to facilitate the integration of bio-based chemicals into existing supply chains. • Address regulatory requirements and compliance issues to ensure the smooth entry of bio-based chemicals into the market. • Seek investments and funding to support the commercialization process, including the construction of industrial-scale production plants.

BIO4AFRICA Diversifying revenue in rural Africa through circular, sustainable and replicable bio-based solutions and business models		
Description	**Programme**	**Years**
Support the deployment of the bioeconomy in rural Africa via the development of bio-based solutions and value chains with a circular approach to drive the cascading use of local resources and diversify the income of farmers by transferring simple, small-scale and robust bio-based technologies adapted to local biomass, needs and contexts.	H2020-EU.3.2. - SOCIETAL CHALLENGES - Food security, sustainable agriculture and forestry, marine, maritime and inland water research, and the bioeconomy	2021-2025
Outcomes / Impacts		
• Technological empowerment: the project aims to empower smallholder farmers in rural Africa through the transfer of simple, small-scale, and robust bio-based technologies. These technologies include green biorefining, pyrolysis, hydrothermal carbonisation, briquetting, pelletising, bio-composites, and bioplastic production. • Diversification of income: BIO4AFRICA seeks to diversify the income of farmers by introducing bio-based solutions and circular value chains. By developing opportunities for farmers to produce higher-value bio-based products, such as improved animal feed, fertilizers, construction materials, and bioplastics, the project contributes to enhancing economic sustainability for rural communities. • Local resource utilization: the project focuses on driving the cascading use of local resources, utilizing crop residues, livestock manure, various grasses, and leguminous crops as feedstock. This approach aligns with circular bioeconomy principles, reducing waste and improving soil health in rural African communities. • Testing and evaluation: the establishment of testing sites in Uganda, Ghana, Senegal, and Côte d'Ivoire involves over 300 farmers and farmer groups, providing realistic conditions for testing the technologies. This approach ensures that the solutions are adapted to local needs and contexts. • Product opportunities: the project identifies various product opportunities, including protein-rich feed and fodder for livestock and aquaculture, biofuels and biogas production systems, biofertilizers, soil conditioners, additives for potable water systems, biocomposites, and bioplastics. These applications support the introduction of a circular bioeconomy in rural Africa.		
TRL level		
• Green biorefining: TRL 5-6, with the development of small-scale green biorefinery units and ongoing activities to improve and optimize the technology for low-cost operation. • Pyrolysis technologies: TRL 4-6, focusing on the development, adaptation, and testing of small-scale, low-cost pyrolysis technologies for biochar production. Installation of Brazilian kiln pyrolysis technology and ongoing optimization activities are in progress. • Hydrothermal carbonisation: TRL 4-5, with the development of small, low-cost hydrothermal carbonisation units and ongoing lab tests to optimize hydrochar as an adsorbent. • Densification technologies: TRL 4-5, involving briquetting and pelletization for household fuel and animal feed. Activities include optimization of briquette production, installation of pelletization mills, and validation of briquetting equipment. • Biocomposites and bioplastics: TRL 3-4, with lab-scale studies investigating the use of locally available agricultural residues to produce biocomposites and bioplastics. Adaptation tests are ongoing.		
Next steps of possible commercialisation		

- Conduct extensive field trials to validate the performance of bio-based technologies under real-world conditions, ensuring their adaptability and effectiveness.
- Evaluate the market potential for bio-based products in rural Africa, considering factors such as demand, pricing, and competition.
- Move from pilot projects to larger-scale implementation, with a focus on scalability and replicability. This involves refining and optimizing technologies for broader application.
- Continue engaging with local communities to ensure acceptance and adoption of bio-based solutions. Community workshops and feedback sessions can contribute to technology improvement.
- Establish partnerships with local stakeholders, governments, and industry players to create a supportive ecosystem for the deployment of bio-based solutions in rural areas.
- Advocate for policies that promote the integration of bio-based technologies in rural development, ensuring regulatory support for sustainable practices.
- Invest in training and capacity-building programs to enhance the technical skills of local communities in operating and maintaining bio-based technologies.

BIObec

Preparing the creation of Bio-Based Education Centres to meet industry needs and boost the contribution of the bioeconomy to societal challenges

Description	Programme	Years
Develop a holistic framework for multi-level Bio-Based Education Centers (BBEC) flexible enough to answer the present and future needs of the industry and of the surrounding ecosystem by acting as knowledge hubs bridging the gaps between universities, innovation labs, and R&D centres with industrial actors and regions.	H2020-EU.3.2. - SOCIETAL CHALLENGES - Food security, sustainable agriculture and forestry, marine, maritime and inland water research, and the bioeconomy	2021-2024

Outcomes / Impacts

- Holistic framework development: BIObec intends to develop a holistic framework for multi-level BBECs that will act as knowledge hubs bridging the gaps between universities, innovation labs, and R&D centres with industrial actors and regions.
- Knowledge Hub concept: the project proposes a concept that merges the traditional idea of an education centre with that of a knowledge hub. BBECs will be designed to be flexible enough to meet the present and future needs of the industry and the surrounding ecosystem at local, regional, and national levels.
- Characteristics of BBECs: the BBECs concept is characterized by collaboration, multi-level networking of actors, flexibility, and modularity to address European complexity, strengthened connections between industry and education, digitization, and innovative educational formats.
- Objectives achievement: the project aims to align the needs for skills and their availability through consistent interactions between the bio-based industry and educational institutions at various levels. It also seeks to prevent skills gaps, maintain industrial activities, boost jobs and income for local communities, generate education and learning opportunities, and increase employability.
- Early career insight: BBECs will provide early insights into career opportunities for graduates at vocational and university levels, contributing to better-informed career choices.
- Education for stakeholders: the project aims to offer opportunities to educate a wide range of stakeholders on bio-based activities and sustainability, fostering a better understanding of the bioeconomy.

TRL level

N/A

Next steps of possible commercialisation

- Consider piloting the BBEC concept in selected regions or institutions to test its feasibility, adaptability, and effectiveness in addressing industry and educational requirements.
- Engage with a diverse range of stakeholders, including educational institutions, industry partners, innovation labs, and regional authorities, to garner support and insights for effective implementation.
- Develop the necessary digital infrastructure to support the collaborative and flexible aspects of BBECs, ensuring effective communication and knowledge-sharing among different actors.
- Collaborate with industry experts to develop and refine educational curricula that align with the current and future needs of the bio-based industry, emphasizing practical skills and real-world applications.
- Ensure that the BBEC framework is designed to be flexible, modular, and adaptable to different educational levels, catering to the specific requirements of vocational training as well as higher education.
- Establish connections with industries to provide early insights and opportunities for career integration, fostering a seamless transition for graduates from education to employment.

- Develop a comprehensive promotion and awareness strategy to highlight the benefits and opportunities offered by BBECs, targeting both educational institutions and the bio-based industry.
- Advocate for supportive policies at local, regional, and national levels that recognize the value of BBECs in addressing skills gaps, promoting sustainable practices, and contributing to the growth of the bioeconomy.
- Implement a robust evaluation process to continuously assess the impact and effectiveness of BBECs. Use feedback to iterate and improve the framework over time.
- Explore opportunities for collaboration with international educational institutions and bio-based industries to share best practices, insights, and enhance the global relevance of BBECs.
- Develop a long-term sustainability plan for BBECs, including potential revenue models, partnerships, and mechanisms for continuous adaptation to evolving industry and educational landscapes.

BIOCIRCULARCITIES

Exploring the circular bioeconomy potential in cities. Proactive instruments for implementation by policymakers and stakeholders

Description	Programme	Years
Unlock the circular economy potential of unexploited bio-based waste streams by exploring the development of economically and environmentally efficient models for organic waste in three pilot areas, giving as a result comprehensive regulatory frameworks and roadmaps aligned with circular bioeconomy principles based on the feedback from multi-actor participatory processes.	H2020-EU.3.2. - SOCIETAL CHALLENGES - Food security, sustainable agriculture and forestry, marine, maritime and inland water research, and the bioeconomy	2021-2023

Outcomes / Impacts

- The project conducted an in-depth analysis of the bioeconomy situation in three pilot territories, evaluating the extent to which bio-waste is underexploited. Relevant sectors producing and managing biowaste were identified, and stakeholders in biowaste management chains were mapped. The project identified potential improvements for optimizing biowaste chains.
- The project identified and analysed circular bioeconomy best practices that could be successfully implemented in the pilot areas. Opportunities and obstacles to the introduction of circular bioeconomy processes were mapped.
- To transfer learning from the pilot areas to other European territories, the project developed a matrix/decision tree and guidelines. These tools serve as the foundation for a web-based tool designed to assist policymakers and industry in designing bio-waste management strategies. Project partners actively presented their findings at various events, contributing to knowledge dissemination and potential replication.

TRL level

- The project, spanning from 2021 to 2023, has reached a significant level of technology readiness in terms of exploring and implementing economically and environmentally efficient models for organic waste in urban areas.
- The analysis, identification of best practices, and development of tools indicate a practical understanding and applicability of circular bioeconomy principles.

Next steps of possible commercialisation

- The developed tools, including the web-based tool, should be further refined and promoted for broader use. The focus should be on replicating successful models and strategies in other European cities and regions.
- Identify opportunities to scale up successful circular bioeconomy practices from the pilot areas. This may involve collaboration with additional cities and regions interested in adopting similar models.

CLIMB-FOREST

CLImate Mitigation and Bioeconomy pathways for sustainable FORESTry

Description	Programme	Years
Propose alternative sustainable short-, mid-, and long-term pathways for the forest sector to mitigate climate change in entire Europe, considering preservation of biodiversity, ecosystem services, bioeconomy, socioeconomic factors, use of long-lived wood products, and barriers for change by creating attitude change in the policymaking process in the EU and influence foresters to adopt new forest management strategies.	H2020-EU.3.2. - SOCIETAL CHALLENGES - Food security, sustainable agriculture and forestry, marine, maritime and inland water research, and the bioeconomy	2022-2027

Outcomes / Impacts

- The project proposes alternative short-, mid-, and long-term pathways for the forest sector to actively contribute to climate change mitigation. Solutions consider the preservation of biodiversity, ecosystem services, bioeconomy integration, and socioeconomic factors.
- CLIMB-FOREST works closely with the forestry sector and policymakers to ensure Europe's forests remain resilient in the face of changing climate conditions. The project aims to enhance the adaptive capacity of forests, making them less susceptible to threats like droughts, fires, insect attacks, and overall climate variability.
- The project emphasizes the importance of well-planned and managed forests in supporting a diverse range of plants and animals. Strategies are designed to address biodiversity preservation, recognizing the interconnectedness of ecosystems and the role of forests in sustaining diverse wildlife.
- Well-managed forests are highlighted as contributors to local economies, providing opportunities for sustainable wood harvesting, tourism, and other economic activities. CLIMB-FOREST aims to strike a balance between environmental conservation and economic benefits for local communities.
- The project leverages the latest data from forest research stations and satellite observations to inform the planning and management of both new and existing forests. This data-driven approach enhances the precision and effectiveness of forestry strategies.
- CLIMB-FOREST collaborates with the forestry sector to develop practical tools, interactive maps, and best practice guidance. These resources are intended to empower foresters and policymakers with actionable insights, facilitating the adoption of sustainable forest management practices.

TRL level

- N/A

Next steps of possible commercialisation

- The project's findings and recommendations should be actively integrated into forestry policies at regional, national, and EU levels. Engaging with policymakers is crucial for translating research outcomes into actionable policies.
- Conduct capacity-building programs to train foresters and relevant stakeholders in the adoption of the proposed pathways. This involves workshops, training sessions, and knowledge-sharing initiatives.
- Implement demonstration projects to showcase the effectiveness of the proposed pathways. These projects serve as practical examples for foresters and communities, promoting the adoption of sustainable forest management practices.
- Establish a robust monitoring and evaluation framework to assess the impact of implemented pathways on climate mitigation, biodiversity preservation, and local economies. Regular assessments help refine strategies based on real-world results.
- Actively disseminate project findings through various channels, including workshops, conferences, and publications. Effective communication ensures that the broader community is informed and supportive of sustainable forestry practices.

FUNGUSCHAIN
Valorisation of mushroom agrowastes to obtain high value products

Description	Programme	Years
Valorisation of agricultural residues coming from mushroom farming residues to set up new cascading possibilities using innovative procedures to extract high value bio-based additives, lipids and polysaccharides into user-product applications using remaining side streams in substrates through a biorefinery.	HORIZON.2.6 - Food, Bioeconomy Natural Resources, Agriculture and Environment	2016-2021

Outcomes / Impacts

- The project introduces a cascading biorefinery approach, utilizing agricultural residues from mushroom farming to extract multiple high-value compounds. The cascading steps involve microwave-assisted extraction, pressurized hot-water extraction, saccharification fermentation, and anaerobic digestion.
- Fast and reliable extraction technique using microwave radiation. Resulting molecules include antimicrobials, antioxidants, or polyols for applications in cleaning, food, and plastic sectors. Addresses the need for sustainable alternatives in industries such as cleaning and plastic production.
- Powerful extraction technique under high pressure, yielding biocative proteins and polysaccharides. Biocative proteins and polysaccharides find applications as food supplements with enhanced texturizing and prebiotic properties.
- Biomass deconstruction into a sugar platform, the basis for producing fermented biopolyesters. Resulting biopolyesters used to formulate novel bioplastic blends in compounding facilities for the plastic sector. Contributes to the development of sustainable and biodegradable bioplastics.

- Remaining biomass dedicated to generating compost and biogas through anaerobic digestion. Produces compost and biogas, offering eco-friendly waste management solutions.
- High-value molecules extracted from fungal residue applied to various end-user products: 1. Cosmetic (mushroom extracts as antioxidants for natural oils in cosmetic products), food (proteins used as supplements for the elderly and sports enthusiasts) and plastic (bioplastic film for bags, mulching, and gloves).

TRL level

The project, initiated in 2016, has likely advanced through various stages of research and development, reaching a mid- to high-level TRL. The innovative extraction techniques and downstream applications suggest a substantial technical maturity.

Next steps of possible commercialisation

- Scale up the developed processes to industrial levels for commercial production. Continuously optimize extraction and conversion methods for efficiency and cost-effectiveness.
- Engage with relevant industries (cosmetics, food, and plastics) for collaborative efforts and potential partnerships in bringing the extracted compounds and materials to market.
- Ensure compliance with regulatory standards for products in the cosmetic, food, and plastic industries. Obtain necessary certifications and approvals for commercial use.
- Develop market entry strategies for each sector (cosmetic, food, plastics) and establish a market presence for the derived products.
- Invest in ongoing research and innovation to stay at the forefront of biorefinery technology and explore new applications for the extracted compounds.

IBISBA 1.0
Industrial Biotechnology Innovation and Synthetic Biology Accelerator

Description	Programme	Years
Support and accelerate the uptake of industrial biotechnology as a key enabling technology for advanced manufacturing by producing translational R&D&I services to an international community of industrial biotechnology stakeholders for a wide variety of market sectors.	H2020-EU.1.4. - EXCELLENT SCIENCE - Research Infrastructures	2017-2022

Outcomes / Impacts

- Research infrastructure network: establishment of an interoperable network of infrastructures supporting R&D in bioprocess development. Coverage of a broad range of experimental and in silico operations, forming a continuum for building quality biomanufacturing processes.
- Translational R&D&I services: provision of translational R&D&I services to an international community of industrial biotechnology stakeholders. Transnational Access (TNA) program launched to provide R&D services through open calls for projects.
- Community building: training modules and sessions addressing challenges in industrial biotechnology, fostering community building. Creation of a communication toolbox for effective outreach and dissemination of project results. Building internal network interoperability and connecting with other relevant initiatives.
- Industry collaboration: dedicated focus on industrial clients with a business development team to promote IBISBA 1.0 to different industrial stakeholders, including SMEs. Addressing issues related to business development, future business models, IPR handling, and fluidizing relations with industrial clients.
- Open access to infrastructure: devise processes for opening access to IBISBA 1.0 infrastructures, implementing suitable governance, including project selection panel and access management committee. Targeting researchers from member states with limited research infrastructure and SMEs for access.
- R&D bottlenecks in biotechnology platforms: focus on overcoming R&D bottlenecks through collaborative work with standardized protocols and harmonized procedures. Multi-partner task force assembling to perform Design, Build, Test, Learn (DBTL) cycles on target host strains.
- e-Infrastructure support: providing e-infrastructure support for launching and monitoring R&D&I pipelines across time and space. Investigating state-of-the-art IT infrastructures, developing workflows, and creating an online repository for collaboration and knowledge sharing.

TRL level

- Given the project's timeline (2017-2022) and the comprehensive set of work packages focusing on different aspects, IBISBA 1.0 likely operates at a high Technology Readiness Level (TRL). The emphasis on providing R&D&I services to an international community suggests a mature and operational infrastructure.

Next steps of possible commercialisation

- Integrate the translational R&D&I services into the broader market by collaborating with industrial stakeholders and encouraging utilization by SMEs.

- Develop sustainable business models (as indicated in deliverables) to ensure the long-term viability of IBISBA beyond the project timeline.
- Continue building and expanding the community network to strengthen collaborations and partnerships with other relevant initiatives.
- Strengthen ties with industrial clients, refine business development strategies, and adapt the approach based on feedback from industry stakeholders.
- Evaluate and enhance the processes for opening access to IBISBA 1.0 infrastructures, ensuring that it remains inclusive and accessible to a diverse range of users.
- Stay at the forefront of industrial biotechnology by investing in technological advancements, potentially exploring emerging areas in synthetic biology and bioprocessing.
- Continuously navigate the challenges of handling intellectual property (IPR) while promoting innovation through data and knowledge sharing.
- Strengthen collaboration at the European and international levels, avoiding duplication of efforts and stimulating cooperation in the field of industrial biotechnology.
- Continue educational initiatives (e.g., training modules, workshops) to bridge gaps in industrial biotechnology knowledge and promote a skilled workforce in the field.

LOGISTEC
Logistics for Energy Crops' Biomass

Description	Programme	Years
Develop new or improved technologies for all steps of the logistics chains and assess their sustainability at supply-area level for small to large-scale bio-based projects for all types of lignocellulosic crops through specific meta-analyses, laboratory tests, field trials, ecosystem modelling and mechanical engineering.	FP7-KBBE - Specific Programme "Cooperation": Food, Agriculture and Biotechnology	2012-2016

Outcomes / Impacts

- Technology development: development of new and improved technologies covering all logistics chain stages, from harvesting and transportation to processing and storage. Innovations tailored for diverse lignocellulosic crops, contributing to the advancement of sustainable bio-based projects.
- Sustainability assessment: comprehensive sustainability assessments at the supply-area level for both small and large-scale bio-based projects. Utilization of specific meta-analyses, laboratory tests, field trials, ecosystem modeling, and mechanical engineering to evaluate the environmental, economic, and social sustainability of the developed logistics technologies.
- Optimized supply chains: optimization of logistics chains for energy crops' biomass, enhancing efficiency and reducing environmental impacts. Consideration of various lignocellulosic crops to ensure adaptability and applicability across different biomass sources.
- Technological integration: integration of technologies to create a cohesive and efficient logistics system, ensuring compatibility and synergy between different stages of the supply chain.
- Knowledge transfer: knowledge transfer through dissemination of project results, potentially contributing to the broader understanding and adoption of sustainable logistics practices in the bioenergy sector.

TRL level

Given that the project was conducted from 2012 to 2016, it likely reached a mid- to high-level TRL. The development of new technologies and the comprehensive assessment of sustainability aspects indicate a significant advancement in the readiness of these innovations for practical implementation.

Next steps of possible commercialisation

- Implement pilot tests of the developed logistics technologies in real-world settings to validate their performance and address any practical challenges that may arise.
- Explore opportunities for scaling up the technologies for broader commercial applications, ensuring their viability and effectiveness in large-scale bioenergy projects.
- Collaborate with industry partners and stakeholders in the bioenergy sector to align the developed technologies with industry needs and standards.
- Continuously refine and improve the logistics technologies based on feedback from field trials and real-world applications, ensuring their ongoing relevance and competitiveness.
- Ensure that the developed technologies comply with relevant regulatory and environmental standards, facilitating smoother integration into the bioenergy market.
- Develop strategies for market integration, considering the unique requirements and demands of different regions and stakeholders in the bioenergy sector.

- Engage in knowledge transfer activities, including workshops, publications, and collaborations with educational institutions, to disseminate insights gained from the project and contribute to building expertise in sustainable logistics for energy crops' biomass.
- Conduct economic assessments and feasibility studies to evaluate the cost-effectiveness of implementing the developed logistics technologies on a larger scale, ensuring their economic viability and attractiveness to investors.

NANO3BIO
NanoBioEngineering of BioInspired BioPolymers

Description	Programme	Years
Overcome the market entry and penetration hurdles of chitosans by producing in vitro and in vivo defined oligo- and polymers with controlled, tailor-made degree of polymerisation (DP), degree of acetylation (DA), and pattern of acetylation (PA).	FP7-KBBE - Specific Programme "Cooperation": Food, Agriculture and Biotechnology	2013-2017

Outcomes / Impacts

- Biotechnological production of chitosans: Implementation of a biotechnological process for the production of chitosans using specially optimized fungi, bacteria, and algae. Development of a sustainable and environmentally friendly approach to obtaining chitosans as raw materials.
- Diverse applications: exploration and utilization of chitosans in various industries, including medical, agriculture, water treatment, cosmetics, paper, and textiles. Specific chitosans tailored for applications such as seed protection, wound healing, antibacterial agents, and drug delivery to target sites.
- Market potential: creation of new market opportunities with third-generation chitosans that possess more defined structural characteristics, well-known biological activities, and clear cellular modes of action. Enhanced efficiency, environmental friendliness, and cost-effectiveness compared to traditional chitosan production methods.
- Breakthroughs and innovations: development of protocols for producing chitosans with better-defined structures. Low-cost protein engineering technology for biotechnological optimization of chitosans. Isolation and identification of the first natural chitosans produced by microalgae.
- Technological platforms: successful creation of electro-spun chitosan nanofibers and electro-sprayed chitosan nanoparticles for encapsulation and efficient release of bio-actives, vaccines, and drugs. Invention of thermos-sensitive chitosan hydrogels as promising materials for regenerating damaged tissues.
- Insights into internalization: significant insights into the internalization of chitosan nano-capsules into human cells, promising targeted delivery of chemotherapeutics to cancer metastases at an early stage. Potential for the development of more effective therapies with reduced adverse effects and improved quality of life for patients.
- Economic potential: recognition of the economic potential of the project's achievements, contributing to building an environmentally sustainable European economy. Strengthening the competitiveness of European industry and SMEs through the development and application of non-toxic, environmentally friendly chitosans.

TRL level

Given that the project was conducted within the FP7-KBBE program from 2013 to 2017, it likely reached a mid- to high-level TRL. The successful development of protocols, technological platforms, and breakthroughs in several important fields suggests a significant advancement in the readiness of these innovations for practical applications.

Next steps of possible commercialisation

- Conduct validation studies to confirm the efficacy and safety of the developed chitosans for various applications. Explore opportunities for scaling up the biotechnological production process to meet commercial demands.
- Collaborate with industry partners and stakeholders to integrate the developed chitosans into existing products or develop new applications. Establish partnerships with companies interested in incorporating chitosans into their product lines.
- Ensure that the developed chitosans comply with relevant regulatory standards for each targeted industry. Obtain necessary approvals and certifications for the commercial use of chitosans in various applications.
- Develop marketing strategies to promote the benefits of third-generation chitosans and differentiate them from traditional sources. Explore global market opportunities and adapt products to meet the specific needs of different regions.
- Continue research efforts to optimize the biotechnological production process and explore new applications for chitosans. Invest in ongoing innovation to maintain a competitive edge in the market.
- Engage in knowledge transfer activities to educate potential users, industries, and stakeholders about the benefits and applications of the developed chitosans. Provide training and support for companies adopting chitosans in their processes.
- Continuously refine and improve the characteristics of chitosans based on feedback from end-users and ongoing research. Address any challenges or limitations identified during commercialization efforts.

OXIPRO
Transition towards environment-friendly consumer products by co-creation of an oxidoreductase foundry

Description	Programme	Years
Co-create and co-develop an efficient oxidoreductase foundry under an interdisciplinary and systemic innovation approach, integrating high-performance computing and cutting-edge biotechnology to replace strong toxic and harmful oxidizers, create novel functionalities in substrates, transform waste to valuable products, and improve quality, appearance, and durability of consumer products.	H2020-EU.3.2. - SOCIETAL CHALLENGES - Food security, sustainable agriculture and forestry, marine, maritime and inland water research, and the bioeconomy	2021-2025

Outcomes / Impacts

- Novel enzymes for sustainable production: development of novel oxidoreductases using high-performance computing and advanced biotechnology. Application of these enzymes to create sustainable and efficient production processes for consumer goods.
- Environment-friendly consumer products: advancement towards greener sunscreens, textiles, nutraceuticals, and detergents. Replacement of harmful ingredients in sunscreens with natural alternatives to support cleaner marine waters and ecosystems. Improvement in textiles production processes for increased circularity, water, chemicals, and energy savings. Enzyme-driven processes for generating healthy fish protein supplements and supporting new bio-based and circular value chains. Targeting enzyme-driven hygienisation steps in detergents to reduce the risk of chemical pollution.
- Societal and environmental benefits: contribution to the overall sustainability and competitiveness of the European bio-based economy. Positive impact on eco-conscious consumers, industry, researchers, and society at large. Support for a transition towards environment-friendly consumer products with reduced environmental, climate, and social impacts.
- Synergies with sister projects: collaboration with ongoing national and international research initiatives, including sister projects like FuturEnzyme, EnXylaScope, and Radicalz. Utilization of shared competencies and resources to accelerate the discovery, design, optimization, and formulation of enzymes for environment-friendly products.
- Target industries: OXIPRO is strategically aligned with four target sectors prioritized by eco-conscious consumers: sunscreens (replacement of polluting ingredients with natural ones to support cleaner marine waters and ecosystems), textiles (targeting steps in cotton processing to increase circularity, reduce wastewater, and achieve significant water, chemicals, and energy savings), nutraceuticals (enzyme-based processes to generate healthy fish protein supplements, addressing odors and improving consumer acceptance) and detergents (targeting enzyme-driven hygienisation steps to improve detergent performance, reduce the risk of chemical pollution, and support modern laundering methods).

TRL level

Given the integration of high-performance computing and cutting-edge biotechnology, the project likely operates at a mid- to high-level TRL, reflecting advanced research and development with a focus on practical applications.

Next steps of possible commercialisation

- Validate the performance and safety of developed enzymes in real-world applications. Scale up production processes to meet commercial demands.
- Collaborate with industries in target sectors (sunscreens, textiles, nutraceuticals, detergents) to integrate developed enzymes into their manufacturing processes.
- Ensure compliance with regulations and standards for consumer products in each target sector. Obtain necessary approvals for the use of enzymes in various applications.
- Develop marketing strategies to promote the adoption of environment-friendly consumer products. Engage with consumers, industries, and stakeholders to communicate the benefits of the developed enzymes.
- Continue research and development to enhance the efficiency and versatility of oxidoreductase enzymes. Explore new applications and sectors for enzyme-driven solutions.
- Assess opportunities for global market expansion beyond the European region. Explore partnerships and collaborations with international stakeholders.

REHAP
Systemic approach to Reduce Energy demand and CO2 emissions of processes that transform agroforestry waste into High Added value Products

Description	Programme	Years
Strengthen the European bioeconomy industry by revalorizing agricultural and forestry waste through its recovery, and primary and secondary processing to turn them into novel	H2020-EU.2.1.5. - INDUSTRIAL LEADERSHIP - Leadership in enabling and industrial	2016-2021

materials, considering how they can be used commercially in the green building sector to reduce the usage of non-renewable materials and energy use in the building industry.	technologies - Advanced manufacturing and processing	

Outcomes / Impacts

- Novel materials development: successful development of methods to convert agricultural and forestry waste into sustainable polyurethanes. Creation of insulation foams, adhesives, and fire-retardant products using the sustainable polyurethanes.
- Eco-friendly wooden panels: development of new high-performance bio-resins to produce eco-friendly wooden panels for construction.
- Sustainable cement: production of eco-friendly sustainable cement with improved properties for construction applications.
- Environmentally sustainable construction solution: Design and assembly of an environmentally sustainable and fire-resistant construction solution. Demonstration of the sustainability and business potential of the developed eco-friendly products compared to existing solutions.
- Impacts: Decreased use of fossil resources and energy in the process industry. Creation of new jobs in the bio-based products sector. Improved innovation capacity and integration of new knowledge at the EU level. Enhanced industrial competitiveness in the bioeconomy sector.

TRL level

Given that the project was conducted within the H2020 program and involved the development and demonstration of sustainable products, it likely reached a mid- to high-level TRL. The completion of stages involving up-scaling, manufacturing, and replication suggests significant advancements in readiness for practical applications.

Next steps of possible commercialisation

- Conduct validation studies to confirm the performance, safety, and compliance of developed materials and products with relevant standards and certifications.
- Engage with the construction industry and green building sector to integrate eco-friendly materials into real-world projects. Collaborate with stakeholders to explore applications and specifications for the developed materials.
- Develop commercialization strategies, including marketing and distribution plans, to introduce eco-friendly products to the market. Explore partnerships with construction companies, architects, and developers to promote the adoption of sustainable construction solutions.
- Ensure that the developed materials comply with building codes, regulations, and environmental standards. Obtain necessary approvals and certifications for commercial use in construction projects.
- Transfer technology and share knowledge with industry partners to facilitate the adoption of sustainable practices in the construction sector. Provide training and support to professionals involved in using or specifying eco-friendly building materials.
- Monitor the performance of materials in real-world applications and gather feedback from users. Continuously improve and refine the developed materials based on user experience and evolving industry needs.
- Explore opportunities for expanding the market reach of eco-friendly materials beyond the European region.
- Assess global market demands and tailor products to meet the requirements of different regions.

BIO BOOST

Acceleradora
de projectes de
bioeconomia

Regional stakeholders mapping exercise

04

4. Regional stakeholders mapping exercise

To achieve successful development of bioeconomy projects, it is essential to engage stakeholders effectively and involve them in decision-making processes from the outset. Adopting a systemic approach that considers the interests and objectives of a wider range of stakeholders can maximize regional impact and promote collaborative action.

By engaging stakeholders from the outset, project developers can draw on their knowledge, expertise, and experience to identify the most effective solutions to address regional challenges. Involving stakeholders in the decision-making process helps to ensure that their interests and objectives are aligned with the project's goals and can increase the likelihood of successful implementation.

Collaborative action is also key to maximizing the regional impact of bioeconomy projects. By bringing together stakeholders from different sectors, including entrepreneurs, researchers, investors, and policymakers, it is possible to leverage their collective resources and expertise to develop innovative solutions that create value across the entire value chain.

The stakeholders' groups are based on the approach in D1.1., where stakeholders are represented by separate helices for academia, industry, and public administration, respectively, while civil society acts as the overarching helix.

Moreover, in order to ensure that the perspectives, needs, and interests of investors are taken into account when designing and implementing bioeconomy projects, the addition of investors as a separate stakeholder group is proposed. This will enable greater levels of investment and support for these projects, ultimately leading to more sustainable outcomes.

Academia

Academic institutions and technological organizations conduct cutting-edge research that can help to identify new bio-based solutions and advance existing technologies. This research is then transferred to industry partners, who can adapt and implement the technologies to enable biomass utilization across different sectors.

Table 12 Main Academia stakeholders

Institut Recerca Energia de Catalunya (IREC)[97] *Catalonia Institute for Energy Research*	A non-profit research organization based in Catalonia that focuses on energy research and innovation. The organization was founded in 2008 as a joint initiative of the Government of Catalonia, the University of Catalonia (UPC), and the Spanish National Research Council (CSIC). IREC's mission is to contribute to the development of a more sustainable and efficient energy system by conducting cutting-edge research in a wide range of energy-related areas. The organization's research is focused on three main areas: renewable energy, energy storage, and energy efficiency. IREC also works closely with industry partners and other organizations to promote the commercialization of its research and to support the development of a sustainable energy industry in Catalonia and beyond. Through its research and outreach activities, IREC contributes to the development of a more sustainable and efficient energy system and to the transition to a low-carbon economy.

[97] https://www.irec.cat/

Institut de Recerca i Tecnologia Agroalimentàries (IRTA)[98] *Institute of Agrifood Research and Technology*	Research institute based in Catalonia that focuses on research and innovation in the fields of agriculture, food, and the environment. The organization was founded in 1985 and is part of the Catalan Ministry of Agriculture, Livestock, Fisheries, and Food. The IRTA conducts scientific and technical research, providing knowledge and tools to improve the competitiveness, sustainability, and resilience of the agro-food sector. The institute covers a broad range of research areas, including plant and animal production, food quality and safety, biotechnology, and environmental sustainability. The IRTA also provides technical support, training, and consulting services to companies, organizations, and public administrations in the agro-food sector, helping them to transfer and apply scientific knowledge to real-world problems. Additionally, the institute collaborates with other research institutions and universities, both nationally and internationally, to advance scientific knowledge and innovation in the agro-food sector.
Centre Tecnològic Beta (Universitat de Vic)[99] *Beta Technology Center (Vic University)*	Private non-profit research center focused on the development of new technologies and processes for the bioeconomy (among others) which encompasses the sustainable use of biological resources to produce goods and services. Beta Technology Center works in collaboration with universities, research centers, and companies to promote research, innovation, and knowledge transfer in the fields of biotechnology, biomaterials, renewable energy, and environmental sustainability. Their work involves the development of new products and services based on biobased materials and processes, as well as the optimization of existing ones. Some of the specific areas of research and development at Beta Technology Center include the use of biobased materials for construction, the development of bioplastics and other biobased materials for packaging and consumer goods, and the use of biomass for energy production. They also work on developing new technologies for the efficient use of natural resources, such as water and soil. Overall, Beta Technology Center is dedicated to advancing the bioeconomy through research and innovation, and to promoting sustainable development and environmental protection.
Centre Tecnològic Forestal de Catalunya (CTFC)[100] *Forest Technology Center of Catalonia*	Non-profit research center focused on the management, conservation, and sustainable use of forest resources, and involved in research and innovation in the field of the bioeconomy. CTFC works in collaboration with universities, research centers, and companies to promote research, innovation, and knowledge transfer in the fields of forest management, forest ecology, and the sustainable use of forest resources. Their work involves developing new methods and technologies for managing forests and enhancing their biodiversity, as well as developing products and services based on forest resources. Some of the specific areas of research and development at CTFC include the use of forest biomass for energy production, the development of bioproducts and biorefineries based on forest resources, and the management of forest ecosystems for climate change mitigation and adaptation. Overall, CTFC is dedicated to promoting sustainable forest management and the development of the bioeconomy through research, innovation, and collaboration with stakeholders in the forestry sector.

[98] https://www.irta.cat/es/
[99] https://www.uvic.cat/es/investigacion/centro-tecnologico-beta
[100] https://www.ctfc.cat/

Consorci Forestal de Catalunya[101] *Forest Consortium of Catalonia*	Public entity that was created in 1987 with the aim of promoting and coordinating the management, conservation, and enhancement of forests in Catalonia. The Consortium is composed of the Government of Catalonia, local governments, and forest owners and managers. The Biomass Observatory is one of the initiatives promoted by the Forest Consortium of Catalonia, in collaboration with the Forest Technology Center of Catalonia, to promote the sustainable use of forest biomass in Catalonia. The Observatory is part of the InnovaBosc project, which is aimed at promoting innovation in the forest sector, and is co-financed by the European Social Fund. The Biomass Observatory is a website that provides technical information, updated data, and specialized resources related to primary forest biomass. The Observatory aims to facilitate the sustainable use of forest biomass in Catalonia by promoting the development of sustainable supply chains, the implementation of best practices, and the dissemination of knowledge and experiences related to the use of forest biomass. The Forest Consortium of Catalonia plays a leading role in promoting the sustainable use of forest resources in Catalonia, and the Biomass Observatory is one of the initiatives that the Consortium has launched to achieve this goal. The Observatory is an essential tool for forest managers, policymakers, and researchers who are interested in promoting the sustainable use of forest biomass in Catalonia.

Industry and Business

Industry and business play a crucial role in the successful deployment of bioeconomy projects in Catalunya. By shifting towards more sustainable and circular business models, businesses and industries can drive the green transition, achieve high environmental benefits, and generate significant profitability.

Both large industries and small and medium-sized enterprises (SMEs) can contribute to the development of a sustainable bioeconomy by implementing resource efficiency measures, producing environmentally friendly consumer products, using renewable energy sources, and adopting circular economy actions.

Through the adoption of circular economy practices, businesses and industries can valorise their waste and by-products and use renewable resources as inputs to their processes, reducing their environmental footprint while improving resource efficiency. This shift towards circularity can also unlock new business opportunities and markets, driving economic growth and job creation.

Table 13 Main Industry and Business stakeholders

Clúster de la Bioenergia de Catalunya[102] *Bioenergy Cluster in Catalonia*	A non-profit organization based in Catalonia, Spain, that promotes the use of bioenergy as a sustainable and renewable energy source. The cluster was founded in 2010 and is made up of a network of companies, research institutions, and other organizations that work together to promote the development of the bioenergy sector in Catalonia. The Bioenergy Cluster of Catalonia's main objective is to promote the use of bioenergy as a key component of a sustainable energy mix. The cluster works to achieve this objective by providing support to its members in areas such as research and development, innovation, commercialization, and internationalization. The cluster focuses on four main areas of activity: biomass production and supply, bioenergy generation and distribution, research and innovation, and education and outreach. Within these areas, the cluster provides a range of services, including technical assistance, training and capacity building, networking opportunities, and advocacy and outreach. One of the key activities of the Bioenergy Cluster of Catalonia is to promote collaboration and knowledge-sharing among its members. The cluster organizes regular events, workshops, and training

[101] https://www.forestal.cat/web/
[102] https://www.clusterbioenergia.cat/es/

	courses to bring together experts from different sectors and promote the exchange of ideas and best practices.
Clúster de Residus de Catalunya[103] *Waste Cluster in Catalonia*	The objective of the new cluster, promoted by ACCIÓ - the agency for the competitiveness of the company of the Department of Business and Work-, and the Department of Climate Action, Food and Rural Agenda, through the Agency of Waste of Catalonia (ARC) , will establish itself as a driving force for the competitiveness of companies in the sector. Through this new organization, it is sought to promote joint work between all its members and the entire value chain of the waste sector, promote its internationalization, promote innovation and R&D in this area, as well as training and intercluster actions, among others.
Clúster de l'Energia Eficient de Catalunya (CEEC)[104] *Cluster of Efficient Energy of Catalonia*	A non-profit organization based in Catalonia that focuses on promoting energy efficiency and sustainability in the region. The cluster was founded in 2009 and is made up of a network of companies, research institutions, and other organizations that work together to promote energy efficiency and the development of the energy sector in Catalonia. The CEEC's main objective is to promote the efficient use of energy as a key component of a sustainable energy system. The cluster works to achieve this objective by providing support to its members in areas such as research and development, innovation, commercialization, and internationalization. The cluster focuses on three main areas of activity: energy efficiency and management, renewable energy, and sustainable mobility. Within these areas, the CEEC provides a range of services, including technical assistance, training and capacity building, networking opportunities, and advocacy and outreach. One of the key activities of the CEEC is to promote collaboration and knowledge-sharing among its members. The cluster organizes regular events, workshops, and training courses to bring together experts from different sectors and promote the exchange of ideas and best practices.
Federació de Cooperatives Agràries de Catalunya[105] *Federation of Agricultural Cooperatives of Catalonia*	Organization based in Catalonia and founded in 1960, that represents the interests of agricultural cooperatives throughout the region. The federation is made up of over 200 agricultural cooperatives, which in turn represent more than 50,000 farmers in Catalonia. These cooperatives work together to promote and protect the interests of the agricultural sector, and to ensure that farmers have a voice in policy decisions that affect their livelihoods. One of the main objectives of the Federació de Cooperatives Agràries de Catalunya is to improve the competitiveness of Catalan agriculture. They work to achieve this by providing technical assistance and training to farmers, promoting sustainable agricultural practices, and supporting research and development in the sector. In addition to its advocacy and support work, the federation also provides a range of services to its member cooperatives, including legal and financial advice, marketing and promotional support, and group purchasing programs. These services help to strengthen the position of agricultural cooperatives in the marketplace, and to ensure that farmers can access the resources and support they need to succeed.
Cambres oficials de comerç, indústria, serveis i navegació de Catalunya[106] *Official chambers of commerce, industry, services and*	The official chambers overseeing commerce, industry, services, and navigation in Catalonia operate as public law entities, falling under the oversight of the Generalitat of Catalonia's Administration. These chambers function as consultative and collaborative bodies with governmental agencies, possessing independent legal identities and the full capacity to take action. Their primary role involves representing, advocating for, and promoting the collective interests of commerce, industry, services, and navigation.

[103] https://residus.gencat.cat/es/iniciatives_destacades/cluster_residus/index.html
[104] https://clusterenergia.cat/
[105] https://www.cooperativesagraries.cat/
[106] https://empresa.gencat.cat/ca/treb_ambits_actuacio/comerc/intern/cambres/

navigation of Catalonia	Integral to the economic landscape, these chambers serve as providers of public services. Their pivotal functions encompass fostering general economic activity, enhancing the competitiveness of businesses, nurturing economic development, fostering job creation, and providing support to small and medium-sized enterprises. Catalonia hosts a total of 13 chambers, located in Barcelona, Sabadell, Terrassa, Manresa, Girona, Sant Feliu de Guíxols, Palamós, Tàrrega, Lleida, Tarragona, Reus, Valls, and Tortosa. The General Council of the Chambers of Catalonia coordinates the efforts of these chambers. Membership in these chambers is automatic for all companies, whether national or foreign, engaged in commercial, industrial, service, or shipping activities within the chamber's territorial jurisdiction. Such companies become eligible voters without incurring any financial obligations as a result of their membership.

Public Administration

The role of public administration is critical in supporting and accelerating the transition towards bioeconomy-based solutions. Public administrations can play an active role in promoting circular consumption models and stimulating business activity by implementing and updating policies, regulatory frameworks, legal standards, and enforcement policies.

Public administrations can act as an active agent to directly facilitate and implement bioeconomy strategies by intervening in territorial planning, the building and construction sector, mobility and transportation, and waste management. By bringing together key activities in a specific place and optimizing the flow of materials and products, public administration can promote a more sustainable and circular approach to economic development.

Furthermore, public administrations can create financing schemes for different bioeconomy and circular economy actions, which is also an effective way of actively intervening in the bioeconomy deployment. Through the implementation of policies and the provision of financial support, public administrations can encourage the adoption of sustainable practices and drive the transition towards a more circular and bio-based economy.

Table 14 Main Public Administration stakeholders

Departament d'Acció Climàtica Alimentació i Agenda Rural[107] *Department of Climate Action, Food and Rural Agenda*	Government department of the Generalitat de Catalunya. The department was created in 2020, and its main focus is on implementing policies and actions related to climate change, sustainable agriculture, and rural development in the region. The department's specific responsibilities include: 1. Developing and implementing strategies and policies to reduce greenhouse gas emissions and mitigate the effects of climate change in Catalonia. 2. Promoting sustainable agriculture practices, supporting local farmers and agribusinesses, and ensuring the availability and accessibility of healthy and sustainable food for the people of Catalonia.

[107] https://agricultura.gencat.cat/ca/inici

	3. Implementing programs and initiatives to promote the development and revitalization of rural areas in Catalonia, including the promotion of rural tourism, the preservation of cultural heritage, and the protection of natural resources.
Agència Catalana de l'Aigua (ACA)[108] Catalan Water Agency	Government agency of the Generalitat de Catalunya. It was created in 1992 and is responsible for managing the water resources in the region, including surface water and groundwater. The main objectives of ACA are to ensure the efficient and sustainable use of water resources in Catalonia, to protect the quality of water resources, and to guarantee the availability of water for different uses such as drinking water, agriculture, industry, and environmental purposes. Some of the specific tasks of ACA include: 1. Developing and implementing plans and programs for the integrated management of water resources in Catalonia. 2. Monitoring and controlling the quality of water resources, including the assessment of water pollution levels and the identification of potential risks to human health and the environment. 3. Promoting the use of sustainable water management practices and technologies, such as the use of recycled water and the implementation of water-saving measures. 4. Managing and maintaining the water infrastructure in Catalonia, including dams, reservoirs, and water treatment plants.
Agència de Residus de Catalunya (ARC)[109] *Catalan Waste Agency*	Government agency of the Generalitat de Catalunya, created in 1991 and responsible for managing and promoting the sustainable management of waste in Catalonia. The main objectives of the ARC are to reduce the generation of waste, increase the reuse, recycling, and recovery of waste, and promote sustainable waste management practices in Catalonia. Some of the specific tasks of ARC include: 1. Developing and implementing waste management plans and policies at regional and local levels. 2. Promoting waste reduction and prevention initiatives, such as the promotion of waste reduction in production processes and the reduction of single-use plastics. 3. Encouraging the reuse, recycling, and recovery of waste materials, including the development of recycling programs and infrastructure, the promotion of composting and biogas production, and the promotion of circular economy initiatives. 4. Monitoring and controlling the treatment and disposal of waste in Catalonia, including the enforcement of regulations related to waste management and the control of illegal waste disposal activities.
Institut Català d'Energia (ICAEN)[110] *Catalan Institute for Energy*	Government agency of the Generalitat de Catalunya, created in 1981 and responsible for promoting and developing sustainable energy policies and initiatives in Catalonia. The main objectives of ICAEN are to promote the efficient and sustainable use of energy resources, reduce greenhouse gas emissions, and ensure the security of energy supply in Catalonia. Some of the specific tasks of ICAEN include: 1. Developing and implementing energy policies and programs to promote the use of renewable energy sources, energy efficiency, and energy conservation in Catalonia. 2. Supporting research and development activities related to energy technologies and promoting innovation in the energy sector. 3. Providing technical assistance and advice to businesses and individuals in Catalonia to promote energy efficiency and the use of renewable energy sources.

[108] https://aca.gencat.cat/ca/inici
[109] https://residus.gencat.cat/ca/inici
[110] https://icaen.gencat.cat/ca/inici/

	4. Promoting the use of sustainable transport solutions, such as electric vehicles and public transport.
Àrea d'Estratègia Econòmica (Department of Economy and Finance of the Generalitat de Catalunya)[111] *Area of Economic Strategy*	Department within the Department of Economy and Finance of the Generalitat de Catalunya, responsible for designing and implementing economic policies and initiatives aimed at promoting sustainable economic growth and improving the competitiveness of the Catalan economy. The main objectives of the Àrea d'Estratègia Econòmica include: 1. Developing and implementing economic policies and strategies to promote sustainable economic growth and job creation in Catalonia. 2. Supporting innovation and entrepreneurship initiatives, including the promotion of research and development activities and the development of startup ecosystems. 3. Providing technical assistance and advice to businesses and entrepreneurs in Catalonia to support their growth and competitiveness. 4. Fostering international trade and investment in Catalonia, including the promotion of foreign direct investment and the development of export strategies.
Àrea d'Acció Climàtica (Diputació de Barcelona)[112] *Area of Climate Action*	Department within the Diputació de Barcelona (the provincial government of the province of Barcelona in Catalonia), responsible for promoting and implementing actions aimed at mitigating and adapting to climate change in the province of Barcelona. The main objectives of the Àrea d'Acció Climàtica include: 1. Developing and implementing strategies and actions to reduce greenhouse gas emissions and promote the use of renewable energy sources in the province of Barcelona. 2. Promoting sustainable mobility initiatives, including the development of public transport networks and the promotion of active transport modes such as cycling and walking. 3. Supporting and promoting the development of sustainable and energy-efficient buildings and infrastructure in the province of Barcelona. 4. Fostering the adoption of sustainable production and consumption patterns, including the promotion of circular economy initiatives and the reduction of waste and pollution. 5. Developing and implementing strategies and actions to adapt to the impacts of climate change, such as extreme weather events and sea-level rise.
Oficina Tècnica de Canvi Climatic i Sostenibilitat (Diputació de Barcelona)[113] *Technical Office for Climate Change and Sustainability*	Department within the Diputació de Barcelona, responsible for providing technical support and expertise to the provincial government and municipalities in the province of Barcelona in the areas of climate change mitigation and adaptation, and sustainability. The main objectives of the Oficina Tècnica de Canvi Climàtic i Sostenibilitat include: 1. Providing technical support and expertise to the provincial government and municipalities in the province of Barcelona in the development and implementation of strategies and actions aimed at mitigating and adapting to climate change. 2. Supporting the development of sustainable and energy-efficient buildings and infrastructure in the province of Barcelona. 3. Providing technical assistance and advice to businesses and individuals in the province of Barcelona to promote sustainable practices and reduce their carbon footprint. 4. Fostering the adoption of sustainable production and consumption patterns, including the promotion of circular economy initiatives and the reduction of waste and pollution. 5. Developing and implementing strategies and actions to adapt to the impacts of climate change, such as extreme weather events and sea-level rise.

[111] http://sac.gencat.cat/sacgencat/AppJava/organisme_fitxa.jsp?codi=22365
[112] https://www.diba.cat/es/web/ladiputacio/area-accio-climatica
[113] https://www.diba.cat/es/web/directori/oficina-tecnica-de-canvi-climatic-i-sostenibilitat

Gerència de Serveis de Medi Ambient (Diputació de Barcelona)[114] *Environmental Services Management*	Department within the Diputació de Barcelona that is responsible for managing and coordinating environmental services and policies in the province of Barcelona. The main objectives of the Gerència de Serveis de Medi Ambient include: 1. Managing and coordinating waste management policies and services, including waste collection, treatment, and disposal, as well as promoting waste reduction and recycling. 2. Managing and protecting water resources, including the management of water supply, distribution, and treatment systems, as well as promoting water conservation and efficiency. 3. Developing and implementing environmental policies and initiatives that promote sustainable practices and reduce environmental impacts, such as air pollution, noise pollution, and biodiversity loss. 4. Providing technical assistance and support to municipalities in the province of Barcelona to help them develop and implement environmental policies and initiatives. 5. Promoting environmental education and awareness-raising activities to the public in the province of Barcelona.
Diputació de Lleida[115] *Provincial government in Lleida*	It is responsible for providing a wide range of public services to the municipalities within its jurisdiction, including infrastructure, social services, culture, tourism, and environmental management. In terms of environmental management, the Diputació de Lleida has several departments and programs that focus on promoting environmental sustainability and protecting natural resources. Some of these include: 1. Environmental Services Department: This department is responsible for managing waste collection, treatment, and disposal in the province of Lleida, as well as promoting waste reduction, recycling, and environmental education. 2. Rural Development Department: This department is responsible for promoting sustainable rural development and preserving the natural and cultural heritage of the province of Lleida. 3. Energy Efficiency Program: This program aims to promote energy efficiency and renewable energy use in buildings and public facilities in the province of Lleida, with the goal of reducing greenhouse gas emissions and improving energy security.
Diputació de Tarragona[116] *Provincial government in Tarragona*	It is responsible for providing a wide range of public services to the municipalities within its jurisdiction, including infrastructure, social services, culture, tourism, and environmental management. In terms of environmental management, the Diputació de Tarragona has several departments and programs that focus on promoting environmental sustainability and protecting natural resources. Some of these include: 1. Environmental Services Department: This department is responsible for managing waste collection, treatment, and disposal in the province of Tarragona, as well as promoting waste reduction, recycling, and environmental education. 2. Water Resources Department: This department is responsible for managing water resources in the province of Tarragona, including the management of water supply and wastewater treatment facilities, as well as promoting water conservation and efficiency. 3. Rural Development Program: This program aims to promote sustainable rural development and preserve the natural and cultural heritage of the province of Tarragona. 4. Climate Change and Energy Program: This program aims to promote the reduction of greenhouse gas emissions and the promotion of renewable energy in the province of Tarragona, as well as providing technical assistance and support to municipalities and businesses to help them reduce their environmental impact.
Diputació de Girona[117]	It is responsible for providing a wide range of public services to the municipalities within its jurisdiction, including infrastructure, social services, culture, tourism, and environmental management.

[114] https://www.diba.cat/es/web/directori/gerencia-de-serveis-de-medi-ambient
[115] https://www.diputaciolleida.cat/
[116] https://www.dipta.cat/
[117] https://www.ddgi.cat/web/

Provincial government in Girona	In terms of environmental management, the Diputació de Girona has several departments and programs that focus on promoting environmental sustainability and protecting natural resources. Some of these include: 1. Environment and Sustainability Department: This department is responsible for managing waste collection, treatment, and disposal in the province of Girona, as well as promoting waste reduction, recycling, and environmental education. It also oversees the management of natural resources and the promotion of sustainable practices in the province. 2. Water Resources Department: This department is responsible for managing water resources in the province of Girona, including the management of water supply and wastewater treatment facilities, as well as promoting water conservation and efficiency. 3. Natural Parks and Biodiversity Program: This program aims to promote the conservation and sustainable use of natural resources in the natural parks and protected areas of the province of Girona, as well as protecting and enhancing biodiversity. 4. Climate Change and Energy Program: This program aims to promote the reduction of greenhouse gas emissions and the promotion of renewable energy in the province of Girona, as well as providing technical assistance and support to municipalities and businesses to help them reduce their environmental impact.
Associació Catalana de Municipis (ACM)[118] *Catalan Association of Municipalities*	A non-profit association that represents the interests of municipalities in Catalonia. The association was founded in 1984 and currently has over 900 members, including municipalities of all sizes and from all regions of Catalonia. The main objectives of the Associació Catalana de Municipis are to promote and defend the autonomy and interests of municipalities, to improve local governance, and to foster cooperation and solidarity among municipalities in Catalonia. To achieve these objectives, the association provides a wide range of services and resources to its members, including: 1. Advocacy and representation: The association advocates on behalf of its members at the regional, national, and international levels, representing the interests of municipalities in matters related to local governance, territorial planning, and public policies. 2. Training and capacity building: The association provides training programs, workshops, and seminars to help municipal officials and staff improve their skills and knowledge in areas such as local governance, finance, and management. 3. Information and resources: The association provides its members with up-to-date information and resources on topics such as local legislation, funding opportunities, and best practices in local governance. 4. Networking and cooperation: The association facilitates networking and cooperation among its members through events, working groups, and other initiatives.
Associació de Micropobles de Catalunya[119] *Catalan Association of Small Towns*	A non-profit association that represents the interests of small and rural municipalities in Catalonia. The association was founded in 1983 and currently has over 1,200 members, including municipalities with populations of less than 5,000 inhabitants. The main objective of the Associació Catalana de Micropobles is to promote and defend the interests of small and rural municipalities in Catalonia. To achieve this objective, the association provides a wide range of services and resources to its members, including: 1. Advocacy and representation: The association represents the interests of small and rural municipalities in matters related to local governance, territorial planning, and public policies, and advocates for policies and funding that support the development of these municipalities. 2. Training and capacity building: The association provides training programs, workshops, and seminars to help municipal officials and staff improve their skills and knowledge in areas such as local governance, finance, and management.

[118] https://www.acm.cat/
[119] https://www.micropobles.cat/

	3. Information and resources: The association provides its members with up-to-date information and resources on topics such as local legislation, funding opportunities, and best practices in local governance. 4. Networking and cooperation: The association facilitates networking and cooperation among its members through events, working groups, and other initiatives.
Grups d'Acció Local (GAL)[120] *Local Action Groups*	Each GAL works to promote and develop a specific territory, managing projects and distributing Leader grants within their area of operation. In essence, a GAL is a group of individuals and organizations who work together to identify and address the needs and opportunities of their local community, with the goal of promoting sustainable rural development. The GALs are typically composed of representatives from various sectors, including business, agriculture, local government, and civil society, who collaborate to design and implement projects that benefit the community. The Leader grants that they distribute are a type of funding provided by the European Union to support rural development initiatives in designated areas.
Associació d'Iniciatives Rurals (ARCA)[121] *Rural Iniciatives Association*	An organization based in Catalonia that works to promote rural development and preserve cultural heritage. It was founded in 1986 and has been active ever since. ARCA is made up of a team of professionals who work on various projects related to rural development, sustainable agriculture, and cultural heritage. They work closely with rural communities, local governments, and other organizations to identify and address the challenges faced by rural areas. It is the network that coordinates the 11 Local Action Groups in Catalonia. One of ARCA's main focuses is on the preservation and promotion of traditional agriculture practices and local cultural heritage. They work to protect and revitalize traditional farming techniques, promote local food production and distribution, and support the development of rural tourism. ARCA also provides training and education to individuals and communities on issues related to sustainable development, cultural heritage, and rural entrepreneurship. They organize workshops, seminars, and training courses to help rural communities develop the skills and knowledge needed to succeed in today's economy.

Investors

Collection of public and private funding instruments that could finance bioeconomy projects, for early-stage activities through to construction and operation.

Potential investors were defined as any public or private institution that could potentially invest in bioeconomy projects. This included both EU, national and regional public instruments, as well as a range of private sector plays, such as investment funds, banks and energy companies. Our criteria for selection were quite broad and included investors that have funded, or claim to have an interest in funding, bioeconomy, renewable energy projects and other similar infrastructure projects.

Further information will be provided in D4.2 Investor Database.

Table 15 Main Investors stakeholders

Private Equity Fund	Investors that provide the capital to companies in exchange for a share of the company ownership (e.g., equity). These funds could be invested by individuals, companies or other funds, such as pensions and sovereign wealth funds. They often specialize in a specific sector(s).	SI Capital Integra Capital SCR Nara Capital Enerfip Horizon Flevoland

[120] https://www.desenvolupamentrural.cat/larca-i-gals/grups-daccio-local
[121] https://www.desenvolupamentrural.cat/

Bank	Tend to mostly offer finance in the form of debt to companies or individuals. Normally existing assets/securities will be required as a security against that debt and the credit quality of the lender will be taken into account. This approach can be a challenge for infrastructure projects, which typically do not have any existing assets or credit history	BBVA, Caixa Enginyers
Infrastructure fund	Similar to Private Equity Funds but focused on providing finance to projects rather than companies. This would typically involve the investor taking a share of ownership of the project's Special Purpose Vehicle (SPV) company. Many infrastructure funds focus specifically on renewables and prefer to invest in projects that are backed by the government through guarantees, subsidies or concessions	Veolia Griñó Verdalia Bioenergy Cetaqua Genia Sorigué
Venture capital	Funds focused on short-term and high-risk investment in new companies and projects, such as tech start-ups. VCs would normally take an equity stake in the companies they invest and play an active role in their development. Most VCs will aim to exit within 5-10 years	Suma Capital Clave Mayor Draper B1 Aldea Ventures Kibo Ventures Kereon Acciona Abac Capital Uninvest Swen Capital Partners Affin Capital
Corporate venture	This category may include engineering companies, Energy Services Companies (ESCOs) and utilities. These players will tend to have a more active role in bioeconomy project development, which could include joint ventures, as well as full ownership and operator of the network based on concession agreements with a local authority	Enagas Renovables, Repsol, Naturgy, Axpo, Agbar
Public body	Public programmes provide finance to support projects that deliver environmental or social impact to support wider policy objectives. Often public finance will be used to leverage private sector investment by sharing investment risk. Public financing can be in the form of grants, loans and equity. At the EU level, The European Commission and European Central Bank work closely to deliver such support, whilst many national governments also operate programmes to support areas such as bioeconomy projects. All public support in the EU must abide by state-aid rules, which can limit the opportunities for public investment	European Circular Bioeconomy Fund European Energy Efficiency Fund European Investment Bank European Agricultural Fund for Rural development (EAFRD) European Maritime and Fisheries Fund (EMFF) Cohesion Fund (CF) European Regional Development Fund (ERDF) InnovaTion Fund Agricultural and Bioeconomy Programme Loans InnovFin - EU Finance for Innovators

Impact Fund	Fund with specific social and environmental objectives, often focused on developing countries or underrepresented groups. These fund will use a wider range of metrics to evaluate investment opportunities, putting more wait on impact rather than profitability	CREAS Hummingbirds Seastainable ventures Asterion Capital Polestar Capital SDGx Ship2B Ventures Km0 Hub Suzano Ventures SLM Partners Farmland LP Althelia Moringa Fund Agro-Ecological S2G Ventures Renewal Funds Cienega Capital Sonen Capital RSF Social Finance Common Land Soil Capital Organic and Regenerative Investment Cooperative

BOOST

Acceleradora
de projectes de
bioeconomia

Identification of relevant financing instruments

05

5. Identifying relevant financing instruments

Financing is crucial to ensure the success and growth of any business or project, and the same holds true for the development of the bioeconomy. Funding programs provide essential resources to entrepreneurs and businesses to implement their ideas and projects, and to create innovative solutions that can help mitigate environmental challenges.

At a regional level, there are several financing programs available that are related to the support of the development of the bioeconomy. These programs are often tailored to the specific needs of the region and can be instrumental in accelerating the transition to a more sustainable economic model. In this article, we will take a closer look at some of the most important financing programs available at a regional level, highlighting their key features and benefits.

Catalonia

DACC

DACC (Department of Climate Action, Alimentation and Rural Agenda) is a division of the Directorates General of Catalonia aimed at guiding regional efforts to mitigate and adapt to climate change. DACC is responsible for developing and implementing climate policies and strategies in Catalonia, including reducing greenhouse gas emissions, promoting the use of renewable energy, promoting energy efficiency and supporting the transition to a low-carbon economy.

Calculation of the environmental sustainability profile of agricultural holdings[122]	
Description	This foundation aims to promote sustainable agricultural practices by providing technical and financial support to assess the environmental impact of farmers' activities. The initiative uses a sustainability profile calculator tool that enables farmers to assess the environmental impact of their agricultural practices, including soil management, water use, energy use and greenhouse gas emissions.

Funding for the creation and improvement of shared agri-food workshops123	
Description	This funding gives support to the creation and improvement of shared agri-food processing facilities. Its purpose is to provide financial support to groups of farmers and small-scale producers who wish to collaborate to create or improve shared agri-food processing facilities. By sharing resources and infrastructure, these groups can reduce costs and increase efficiency, while also accessing new markets and developing value-added products.
Budget	2.000.000,00 euros max/year

ACCIO

ACCIO is the agency for business competitiveness of the Government of Catalonia, which was established to promote economic growth, innovation, and internationalization of the Catalan business community. The primary mission of ACCIO is to support and advise Catalan companies in their

[122] https://agricultura.gencat.cat/ca/tramits/tramits-temes/23230-ajuts-sostenibilitat-ambiental-explotacions-agraries
[123] https://agricultura.gencat.cat/ca/tramits/tramits-temes/23232-Ajuts-per-la-creacio-i-millora-dels-obradors-agroalimentaris-compartits

internationalization process, helping them to expand their businesses abroad and increase their global competitiveness.

"Nuclis" of industrial research and experimental development in Circular Economy projects, specifically in the field of waste[124]	
Description	The Business R+D Cores are a non-repayable aid aimed at financing new high-risk technological products or services that respond to the needs of the market. This subsidy aims to support the development of research and development projects (R+D) that must contribute to the increase in investment in R+D in Catalonia in the circular economy in the field of waste.
Budget	150.000 euros max/year

Aid for the promotion of the transformation of the Catalan agri-food and fishing system aligned with the Food Strategy of Catalonia[125]	
Description	Aid with 9 lines aimed at improving the Catalan food system in terms of environmental, social and economic sustainability. The grants provide the necessary instrument to articulate a comprehensive, sustainable, competitive food system, territorially rooted in the country and based on its diversity, which produces healthy, accessible and quality food, recognized by consumers
Budget	200.000€

Subsidies for implementing and renewing voluntary environmental management systems[126]	
Description	Subsidies aimed at public or private companies, foundations or other non-profit entities, and local entities that have implemented an environmental management system based on the EMAS Regulation or have renewed what they had already implemented.
Budget	9.000€ max

InnoCámaras: aids and advice for the innovation of PIMES[127]	
Description	The InnoCámaras 2023 program contributes to improving the competitiveness of SMEs and self-employed workers in the regional demarcation of the Barcelona Chamber of Commerce. The first phase consists of personalized advice to know the level of business competitiveness, and the second of a plan to support innovation.
Budget	80% of the subsidy

[124] https://www.accio.gencat.cat/ca/serveis/convocatories-dajuts/llistat-ajuts/tramits/Nuclis-de-recerca-industrial-i-desenvolupament-experimental-en-projectes-dEconomia-Circular-especificament-en-lambit-dels-residus
[125] https://www.accio.gencat.cat/ca/serveis/innovacio/innovacio-empresarial/cupons-accio-a-la-competitivitat-de-lempresa/
[126] https://web.gencat.cat/ca/tramits/tramits-temes/Ajuts-per-implantar-sistemes-voluntaris-de-gestio-ambiental?category=75b76f5a-a82c-11e3-a972-000c29052e2c
[127] https://web.gencat.cat/ca/tramits/tramits-temes/Ajuts-per-implantar-sistemes-voluntaris-de-gestio-ambiental?category=75b76f5a-a82c-11e3-a972-000c29052e2c

ARC

ARC (Agència de Residus de Catalunya), is the waste management agency of the government of Catalonia. ARC works to promote sustainable waste management practices and to guarantee that waste is managed in a way that minimizes its impact on the environment and human health. The institution collaborates closely with local authorities, waste producers and other stakeholders to develop and implement waste management plans and programs to meet the specific needs and characteristics of each region of Catalonia.

Promotion of the selective collection of municipal waste, within the framework of the Recovery, Transformation and Resilience Plan[128]	
Description	The purpose of the subsidies regulated in these bases is to finance actions that contribute to the promotion of efficient selective collection projects of the different fractions of municipal waste, from a perspective of the circular economy, to contribute to achieving more sustainable management and saving of natural resources.
Budget	800.000€ max

Implementation of rubbish dumps for the treatment of municipal waste[129]	
Description	The purpose is the implementation and improvement of waste disposal facilities for municipal waste management, in accordance with the actions planned below and as described in the 2021 Waste Disposal Guide. The waste disposal facility is understood as a centre for the selective reception and storage of municipal waste that is not subject to home collection, in accordance with the typologies defined in the 2021 Waste Disposal Guide.
Budget	500.000€ max

Use of recycled aggregates from construction waste[130]	
Description	These grants are intended to promote the use of recycled aggregate from construction waste with CE marking in works promoted by local bodies and municipal public companies in Catalonia.
Budget	375.000 €

Aid for the prevention, preparation for reuse and recycling of RI[131]	
Description	This line of subsidies aims to promote the implementation of projects for prevention, preparation for the reuse and recycling of industrial waste and industrial research and experimental development projects applied to the field of prevention, preparation for reuse and recycling of industrial waste. Companies and groups of companies with an operational center in Catalonia can obtain the subsidy.
Budget	120.000€

[128] https://residus.gencat.cat/ca/consultes_i_tramits_-_nou/subvencions/subvencions-pels-ens-locals/#bloc1
[129] https://residus.gencat.cat/ca/consultes_i_tramits_-_nou/subvencions/subvencions-pels-ens-locals/#bloc1
[130] https://residus.gencat.cat/ca/consultes_i_tramits_-_nou/subvencions/subvencions-pels-ens-locals/#bloc1
[131] https://residus.gencat.cat/ca/consultes_i_tramits_-nou/tramits/detall/Ajut_ACC_3848_2022_prevencio_ri

Aid for projects to promote the circulating economy[132]	
Description	This line of subsidies aims to promote projects to accelerate the transition towards a circular economy in Catalonia, improve efficiency in the use of material resources and decouple global economic development from the consumption of resources. Projects related to material resources and waste other than water, energy and atmospheric emissions may be subject to subsidies regulated in these bases.
Budget	60.000€ max

Grants for improvement in processes applied in third-party waste treatment plants[133]	
Description	The beneficiaries are eligible for the subsidies, provided that they have at least one operational establishment located in Catalonia, that the main actions object of the call are carried out in Catalonia and that the subsidised project reverts to the establishment of the beneficiary or in the territorial scope of Catalonia

ICF

ICF, or the Catalan Institute of Finance, is a financial institution established by the Government of Catalonia to provide financing solutions to companies and entrepreneurs in the region. The primary objective of ICF is to promote economic growth and job creation in Catalonia by providing financing options that support the development and expansion of businesses in the region.

Grants for public-private collaboration projects[134]	
Description	The purpose of the grants is to finance experimental development projects in collaboration between companies and research organizations, in order to advance in the incorporation of knowledge and scientific-technical results that allow the validation and pre-competitive development of new technologies, products and services, creating the appropriate context that stimulates the generation of a critical mass in R+D+i of an interdisciplinary nature for its application, Transfer, search for solutions and generation of results both in the technological and innovation trajectories of companies and in the market.
Budget	15.000.000€ max

ICF EcoVerda[135]	
Description	Loans for self-employed workers, companies or entities (public or private) with headquarters or operations in Catalonia to carry out sustainable and environmentally friendly investments or working capital needs that promote green economy, circular economy and/or energy efficiency projects, among others.
Budget	10.000.000€ max

[132] https://residus.gencat.cat/ca/consultes_i_tramits_-_nou/tramits/detall/Ajut_ACC_3352_2022_economia_circular.html
[133] https://residus.gencat.cat/ca/consultes_i_tramits_-_nou/tramits/detall/Ajut_ACC_2855_2022_gestors
[134] http://www.accio.gencat.cat/ca/serveis/cercador-ajuts-empresa/ajutsiserveis/23008-next-generation-eu-ajuts-projectes-colaboracio-public-privada
[135] https://www.icf.cat/ca/productes-financers/prestecs/icf-ecoverda

ICF Avalis verd[136]	
Description	Line of loans for SMEs that carry out energy efficiency projects, photovoltaic or renewable energy self-consumption, recycling or waste treatment projects, as well as other environmentally friendly initiatives.
Budget	500.000€

ICF Agroclima[137]	
Description	Line of loans for agricultural, agri-food, forestry and fisheries and aquaculture companies; and those linked to their value chain, who want to finance general investments or investments with climate action components.
Budget	5.000.000€

The Chamber of Commerce

In Catalonia, the Chamber of Commerce (Cambra de Comerç) is a public institution that provides a wide range of services and support to businesses, including training and education programs, business advisory services, networking opportunities, and international trade promotion. The chamber of commerce works to promote economic growth and development by supporting the business community and fostering a favourable business environment. It represents the interests of its members, advocates for policies and initiatives that benefit businesses, and provides a platform for businesses to connect and collaborate with each other.

Sustainability program 2023[138]	
Description	The main objective of this program is to improve the competitiveness of SMEs by promoting sustainability, as well as reactivating the economy based on sustainability, highlighting its economic, social and environmental repercussions.
Budget	7.000€

Sustainability program for PIMES[139]	
Description	The main objective of the grant is to improve the competitiveness of SMEs and the self-employed by promoting sustainability, through a first diagnostic phase and a second phase of implementation of the solutions established during the diagnosis phase.
Budget	7.000€

[136] https://www.icf.cat/ca/productes-financers/prestecs/icf-avalis-verd
[137] https://www.icf.cat/ca/productes-financers/prestecs/icf-agroclima/index.html
[138] https://sede.camara.es/sede/girona/tramites/TR0000004793
[139] https://sede.camara.es/sede/girona/tramites/TR0000004793

Business and Employment Department

The Department of Business and Employment is responsible for promoting economic development, employment, and entrepreneurship in the region. The Department works to support businesses, particularly small and medium-sized enterprises (SMEs), by providing them with advice, resources, and funding opportunities. It also promotes initiatives to foster innovation, technology transfer, and internationalization of businesses.

Aid for projects of energetic efficiency and circular economy of touristic companies[140]	
Description	Financing tourist accommodation companies like hotels, hostels, pensions, campings, rural accommodations... with projects that allow measures to be adopted to reduce energy consumption, to introduce energy management systems and more efficient technologies as well as to promote the use of renewable energies in their facilities.
Budget	15.000.000€ max

Spain

IDAE

IDAE stands for "Instituto para la Diversificación y Ahorro de la Energía" (Institute for the Diversification and Saving of Energy). It is a Spanish public agency created in 2004 under the Ministry for the Ecological Transition and the Demographic Challenge. The main goal of IDAE is to promote sustainable development by promoting energy efficiency, renewable energy, and reducing greenhouse gas emissions. It develops and implements policies and measures aimed at reducing energy consumption and increasing the use of clean energy sources.

Renewable Energies

Aid from the Incentive Program linked to self-consumption and storage, with renewable energy sources and implementation of renewable thermal systems[141]	
Description	This aid is divided into 6 different programs: 1. Realization of self-consumption facilities, with renewable energy sources, in the service sector, with or without storage. 2. Carrying out self-consumption facilities, with renewable energy sources, in other productive sectors of the economy outside the service sector, with or without storage. 3. Incorporation of storage in self-consumption facilities, with renewable energy sources, already existing in the service sector and other productive sectors. 4,5,6. Realization of self-consumption and / or storage facilities with renewable sources in the residential sector, administrations and 3rd sector or realization of renewable thermal installations in the residential sector.

Aid for thermal renewable energies in different sectors of the economy[142]

[140] https://sede.idae.gob.es/lang/modulo/?refbol=tramites-servicios&refsec=repotenciacion-circular
[141] https://icaen.gencat.cat/ca/energia/ajuts/energies-renovables/ajuts-renovables-2022/
[142] https://web.gencat.cat/ca/tramits/tramits-temes/Ajuts-termica-renovable-sectors-productius

Description	Aid for the implementation of incentive programs for the implementation of thermal renewable energy facilities in different sectors of the economy, within the framework of the Recovery, Transformation and Resilience Plan

Incentive program for projects of heat and cold networks that use renewable energy sources[143]	
Description	This line of incentives seeks to promote the deployment of heat and cold supply networks from renewable energies to help achieve climate neutrality by 2050, as it contributes to the structuring of the territory and the development of rural areas and reduces imports of natural gas and other fossil fuels. The objective is to support new projects as well as to expand the installation of existing ones using renewable energies that have an important decarbonizing effect.
Budget	15.000.000 € max

Incentive program for unique biogas projects[144]	
Description	The purpose of this incentive program is the development of biogas, in the industrial sector, involving agents such as agri-food cooperatives and energy communities.

Energetic Communities

SolarCoop aid[145]	
Description	The purpose of the line of aid is the constitution or reinforcement of consumer cooperatives and/or local associations that want to become consumer cooperatives, and that are aimed at the production, distribution in the industrial sector, involving agents such as agri-food cooperatives and energy communities n and use of renewable energies and energy efficiency. Among their activities, they must include the development of management and operation models of an energy community, specifying the characteristics of the project to be developed by this energy community. The aim is to promote the abandonment of fossil fuels, reduce the distance between the centre of energy production and consumption, and fight against depopulation through the use of renewable energy generation as the seed of socio-economic initiative.
Budget	80.000€ max

SMEs and Industry

Programme of aids for actuations of energetic efficiency in SMEs or large manufacturing companies in the industrial sector[146]	
Description	The purpose of this aid program is to encourage and promote actions in the industrial sector that reduce carbon dioxide emissions and final energy consumption, by improving energy efficiency, thus contributing to achieving the objectives of reducing final energy consumption set by Directive 2012/27/EU. This aid is aimed at SMEs or large manufacturing companies with CNAE[147] 2009 from 07 to 11 and from 13 to 33.

[143] https://www.idae.es/ayudas-y-financiacion/programas-de-incentivos-proyectos-de-redes-de-calor-y-frio-que-utilicen
[144] https://www.idae.es/ayudas-y-financiacion/programa-de-incentivos-proyectos-singulares-de-instalaciones-de-biogas
[145] https://icaen.gencat.cat/ca/energia/ajuts/comunitats-energetiques/solarcoop/
[146] https://icaen.gencat.cat/ca/detalls/tramit/Subvencions-eficiencia-energetica-pime-i-sector-industrials-00001
[147] CNAE list available at: https://www.cnae.com.es/lista-actividades.php

	And the companies or entities that own waste treatment, effluent or water treatment plants that are owned by a company with CNAE from 35 to 39. Energy Service Companies (ESCO) that act according to an energy service contract with any of the companies indicated above are also beneficiaries.
Budget	8.000.000€ max

Public Sector

Aid for the creation of regional offices to promote the energy transition[148]	
Description	The line of aid aims to support county councils for the creation and operation of offices to promote the energy transition in order to collaborate in the planning and regional design of the implementation of renewable energies in Catalonia within the framework of the development of the Territorial Plan for the implementation of renewable energy facilities in Catalonia (PLATER) and prioritize the distributed renewable generation model and participatory.
Budget	90.000€

Grants for projects by local authorities that favour the move to a low-carbon economy[149]	
Description	This grant wants to encourage local governments and organisations to implement measures and projects that contribute to reducing greenhouse gas emissions and promoting sustainable development.

Ministry for Ecological Transition and the Demographic Challenge

The Ministry for Ecological Transition and the Demographic Challenge (Ministeri per a la transició Ecològica i el repte demogràfic) is the is responsible for developing and implementing policies and initiatives that promote sustainable development, protect the environment, and address the challenges posed by demographic changes. The Ministry's main objectives include reducing greenhouse gas emissions, promoting renewable energy, protecting biodiversity and natural resources, improving air and water quality, and promoting sustainable mobility. It also aims to address the demographic challenges facing Spain, such as an aging population and depopulation in certain regions.

Aid for investment in the repowering of wind installations, in the technological and environmental renovation of mini hydroelectric power plants of up to 10 MW and in innovative installations for recycling wind turbine blades[150]	
Description	Aid for investment in the technological and environmental repowering and renovation of generation facilities and innovative recycling facilities.
Budget	15.000.000€ max

[148] https://icaen.gencat.cat/ca/energia/ajuts/sector-public/ajuts-per-a-la-creacio-doficines-comarcals-dimpuls-de-la-transicio-energetica/
[149] https://icaen.gencat.cat/ca/energia/ajuts/sector-public/ministeri-denergia-turisme-i-agenda-digital-ajuts-per-a-projectes-dens-locals-que-afavoreixin-el-pas-a-una-economia-baixa-en-carboni/
[150] https://sede.idae.gob.es/lang/modulo/?refbol=tramites-servicios&refsec=repotenciacion-circular

Aid for the promotion of the circular economy, within the framework of the PERTE of Circular Economy[151]	
Description	Call to finance projects that promote sustainability and circularity of industrial and business processes to improve the competitiveness and innovation of the business fabric within the framework of a circular economy that exceeds the previous linear production model.
Budget	10.000.000 € max

Ministry for Industry, Trade and Tourism

The "Ministerio de Indústria, Comercio y Turismo" is the Ministry for Industry, Trade and Tourism of the department of General Administration in Spain. It is responsible for proposing and executing government policy in matters of: industry, trade and tourism that covers, among other aspects, industrial development and small and medium-sized enterprises, the promotion and defence of industrial property, the commercial policy of internationalization and investment and foreign transactions, as well as the tourism policy and the rest of competences and attributions entrusted to it by the legal system.

Grants for industrial research, development and innovation projects in the field of manufacturing industry (IDI)[152]	
Description	The fundamental objective is to improve competitiveness that ensures that industrial sectors can successfully compete in the global economy. This grant aims to support the technological impulse through companies and industrial sectors with great driving effect on other auxiliary and complementary activities, as well as strategic value chains.
Budget	4.000.000€ max

European

Funding scheme name	Description/Objectives	Particularities of funding programme and how CSS can access financing
Horizon Europe: Cluster 6	This cluster aims at reducing environmental degradation, halting and reversing the decline of biodiversity on land,inland waters and sea and better managing natural resources through transformative changes of the economy and society in both urban and rural areas. The Cluster 6 within the Horizon Europe facility could be a good opportunity for CSS focused on research, experimentation and piloting. Link: https://ec.europa.eu/info/research- and-innovation/funding/funding-opportunities/funding- programmes-and-open- calls/horizon-europe_it	Horizon Europe offers grants as the main funding model, complemented with dedicated financial instrumentswhen appropriate. The following activities are generally eligible for grants under Horizon Europe: research and innovation actions; innovation actions; coordination and support actions; programme co-fund actions; innovation and market deployment actions; and training and mobility actions.

[151] https://fundacion-biodiversidad.es/convocatorias_del_pr/convocatoria-de-subvenciones-para-el-impulso-de-la-economia-circular-en-la-empresa-para-el-ano-2022-en-el-marco-del-plan-de-recuperacion-transformacion-y-resiliencia-financiad/
[152] https://www.mincotur.gob.es/PortalAyudas/ayudas-IDI/Paginas/Index.aspx

Cohesion Fund 2021-2027	EU Cohesion Policy contributesto strengthening economic, social and territorial cohesion in the European Union. It aims to correct imbalances betweencountries and regions. It delivers on the EU's political priorities, especially the green and digital transition. Cohesion Policy funds, being one of the main instruments todeliver the EU's green transition, could be a good funding source for many CSSs at a regional and local level. Specifically, relevant is PO 2 – a greener, low-carbon transition towards a net-zero carbon economy and resilient Europe by promoting a clean and fair energy transition, green and blue investment, the circular economy, climate change mitigation and adaptation, risk prevention and management, and sustainable urban mobility. Link https://ec.europa.eu/regional_policy/en/2021_2027/	Member States can use the contribution from the Cohesion Fund to provide support to beneficiaries in the form of grants, financial instruments or prizes, or a combination thereof. Financial instrument products may include loans, guarantees, equity or quasi- equity. Moreover, Member States cantailor financial products according to their needs and capabilities or structure the financial instrument based on terms and conditions provided by the European Commission for 'off-the-shelf' instruments. Projects can apply for funding underthe Cohesion Fund only if you are based in a Member State with a gross national income per capita below 90 % of the EU-27 average.
Interreg	Interreg Europe is a cooperation programme, co- funded by the European Union.It helps local, regional and national governments across Europe to develop and deliver better policy, creating an environment and opportunitiesfor sharing solutions to regional development issues. It supports the exchange of good practices and policy learning among European regions in 29countries – the EU-27, Norway and Switzerland. Budget: EUR 379 million. Interreg Europe offers an opportunity for interregional cooperation on the field of the circular economy. CSSs could profit from an environment ofcommon opportunities, could learn from others and could develop common projects. Specifically relevant is PO 2 – a greener, low-carbon transition towards a net-zero carbon and resilient Europe. Link: https://www.interregeurope.eu/what-is-interreg-europe	Interreg programmes can provide support to beneficiaries in the formof grants, financial instruments or prizes, or a combination thereof. Under Interreg programmes, the most common type of support is grants. Interreg programmes support cooperation through project fundingto jointly tackle common challenges and to find shared solutions. Projects funded under Interreg often address pollution problems and loss of biodiversity as these are issues that extend beyond national boundaries.
InvestEU grants	The InvestEU programme gives anadditional boost to investment, innovation and job creation in Europe between 2021-27. It has the aim of triggering a new waveof EUR 372 billion in investmentsusing an EU budget guarantee. Budget: EUR 26.2 billion	Financial products to be deployed under InvestEU may take the form of generalproducts or thematic financial products. General financial products must supportone or more policy areas covered under each policy window and can include eitherdebt or equity interventions.

	InvestEU constitutes a good opportunity for CSSs, not only to receive funding from the programme itself, but also to become more attractive to private investors and funnel private funds to the initiatives. Specifically, one of the policy windows includes sustainable infrastructure. This includes coverage of a key area titled 'the environment and resources' (e.g., water, waste management, the restoration of ecosystems and biodiversity, and the decarbonisation of energy production). Link: https://investeu.europa.eu/about-investeu_en	
LIFE programme	The LIFE programme is the EU's funding instrument for the environment and climate action. Sub-programme number 2 concerns circular economy and quality of life. The LIFE programme is a good, and relatively easy, opportunity for CSSs to access financing, given that its focus is primarily on climate action and the environment. Link: https://cinea.ec.europa.eu/programmes/life_en	The LIFE programme funds environment-specific and environment-integrated projects in the form of grants, prizes and procurement. It may also finance technical assistance for investment operations. As examples, environment-specific projects can be financed through standard action projects, whereas strategic nature projects (SNAPs) and strategic integrated projects (SIPs) have the aim of supporting the implementation of a plan or strategy required by environmental and climate legislation or policies. LIFE also finances projects to improve governance in support of its environmental/climate objectives. Actions under the InvestEU programme are expected to dedicate at least 30 % of the overall financial envelope of the InvestEU programme to climate objectives. However, for its sustainable infrastructure policy window, a combined climate and environmental target of 60 % has been put forward.
EIB venture debt	The EIB venture debt offers a long- term venture debt product to address the unique funding needs of fast-growing innovative companies. The financing structure includes bullet repayment and remuneration linked to the equity risk of the investees and complements existing venture capital financing.. The EIB venture debt constitutes an opportunity particularly well suited for CSS initiatives pioneered by private companies and that have a strong business component.	Eligibility is for small and medium-sized enterprises (SMEs) and mid-caps, developing highly innovative technologies, solutions or platforms. The company must have already raised equity from professional investors, have a sustainable business model and business plan, and have a solid corporate governance in place.

	Link: https://www.eib.org/en/products/equity/venture-debt.htm	
European Investment Fund	EIF is a leading financial institution in the European Private Equity market. Through their venture capital and private equity interventions, they play a crucial role in the creation and development of high-growth and innovative SMEs by facilitating access to equity for these companies across the entire life cycle of corporate innovation. They do so by investing in venture and growth capital, from the very earliest stages of intellectual property development into technology transfer, to more mature phases of development. In supporting both well-known and first time teams, they have built a strong track record in the industry. Through this reputation, while maintaining a highly selective process, they take significant minority stakes in funds which provide a catalytic effect on commitments from a wide range of investors, particularly in the private sector. The scale and scope of their investments, along with their added value on fundraising, allows them to promote best market practice and corporate governance for teams we choose to support. EIF's equity activity is principally backed by resources from its main shareholders, the European Investment Bank (EIB) and the European Commission.	AI Co-Investment Facility Impact investing at the EIF Climate & Infrastructure Funds Technology Transfer European Angels Fund (EAF) - Co-investments with Business Angels Venture capital The Social Impact Accelerator (SIA) Lower mid-market Mezzanine Facility for Growth VentureEU EFSI Equity instrument Single EU Equity Financial Instrument Private equity secondary market transactions EIF-NPI Equity Platform ESCALAR Programme
Instituto de Crédito Oficial - ICO	Instituto de Crédito Oficial, Corporate State-owned Entity (henceforth, ICO), is corporate state-owned entity, attached to the Ministry of Economic Affairs and Digital Transformation, via the State Secretariat for Economy and Enterprise Support.	Apart from the Institute, the ICO Group comprises Axis, a venture capital firm, and the Fundación ICO.
European Angels Fund (EAF)	EAF provides equity to Business Angels and other non-institutional investors for the financing of innovative companies in the form of co-investments. EAF works hand in hand with Business Angels and helps them to increase their investment capacity by co-investing into innovative companies in the seed, early or growth stage. Budget: EUR 800 million. The EAF could be a good funding source for highly innovative and high-risk CSS initiatives	Instead of granting co-investments on a deal-by-deal basis, EAF enters long-term contractual relationships with Business Angels. Co-investment framework agreements (CFAs) are established through which EAF commits a predefinedamount of equity for co-investments upfront to each Business Angel for future investments. For ease and speed, these CFAs are generally standardised while leaving room for adaptation to specific requirements of individual

	that have a strong business component and that can promise relatively high returns if they succeed. Link: https://www.eif.org/what_we_do/equity/eaf/index.htm	Business Angels. Such elements include timeframe, sector focus and number of investments.
Joint Initiative on Circular Economy (JICE)	JICE is a partnership between the European Union's largest national promotional banks and the EIB to invest at least EUR 10 billion in the circular economy by 2023. This will support projects that prevent and eliminate waste, increase resource efficiency and promote circular business models. Budget: EUR 10 billion. JICE is a perfectly tailored initiative for any circular economy project. Given that the programme's focus is in the circular economy, CSSs are very well suited to benefit from it. Link: https://www.eib.org/en/publications/joint-initiative-on-circular-economy#:~:text=The%20Joint%20Initiative%20on%20Circular%20Economy%20(JICE)%20is%20a%20partnership,the%20circular%20economy%20by%202023	JICE provides loans, equity investment, guarantees, innovative financing structures and technical assistance.

This table has been adapted from the overview of EU funding schemes from the CCRI Methodology.

BIO BOOST

Acceleradora
de projectes de
bioeconomia