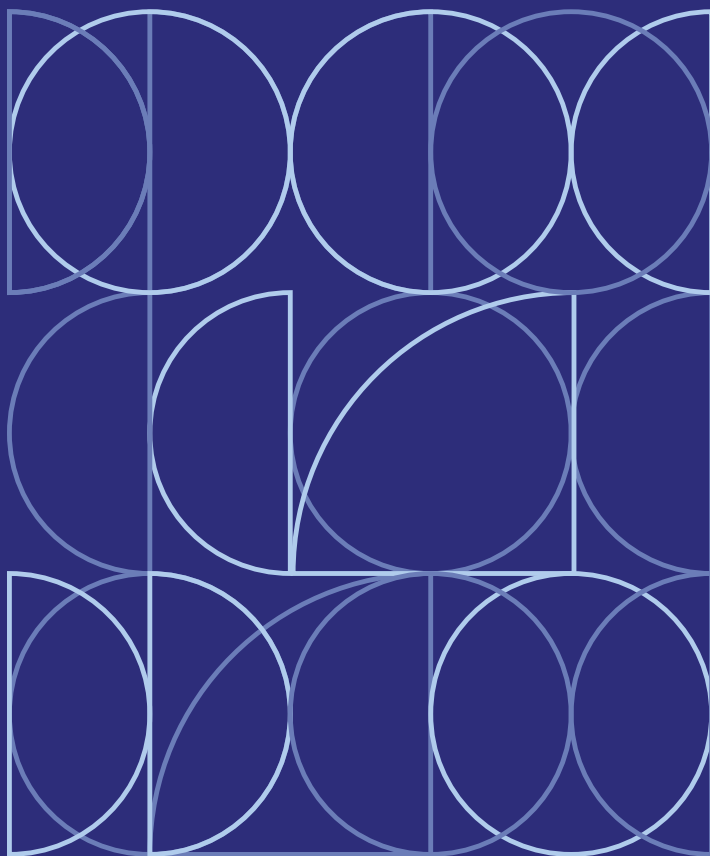




Circular
Bio-based
Europe
Joint Undertaking



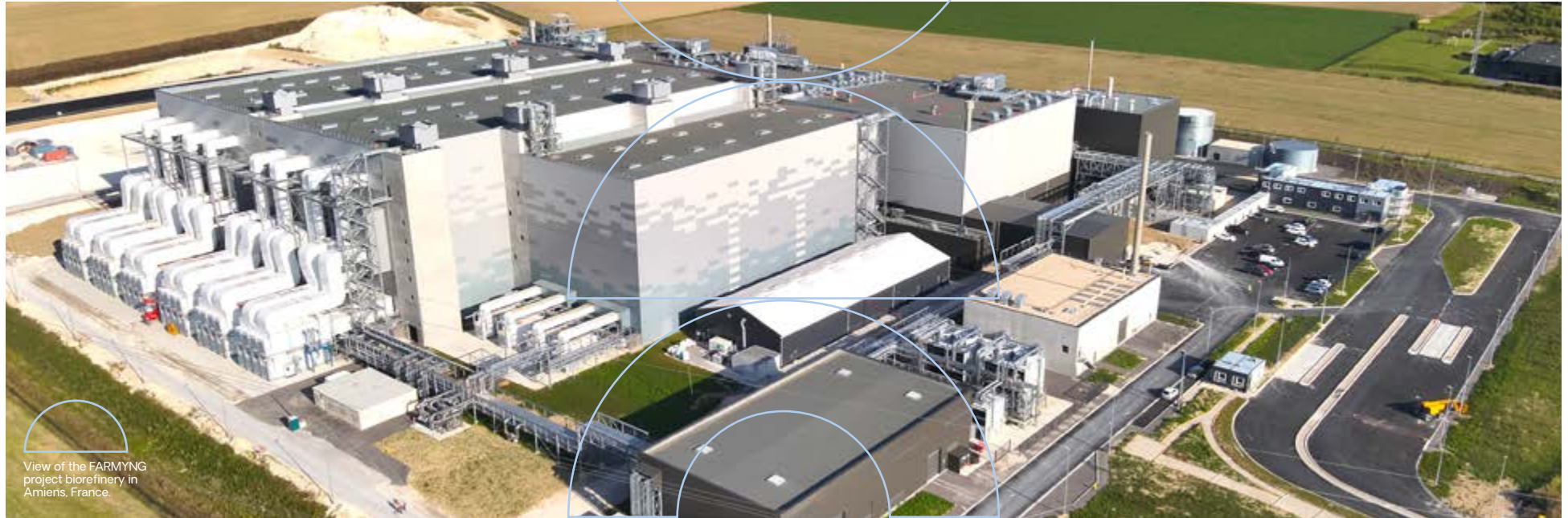
**A COMPETITIVE
BIOECONOMY**
FOR A SUSTAINABLE
FUTURE



UNLOCKING THE FUTURE OF THE CIRCULAR BIOECONOMY IN EUROPE

Climate change is an existential risk, and reliance on fossil resources is no longer an option. Simultaneously, the European economy has been affected by a pandemic and war. How can Europe transition to a low-carbon economy while continuing to ensure economic growth?

A sustainable and circular bioeconomy contributes to addressing these challenges. Waste and leftovers of other production processes all offer the potential for conversion into chemicals, materials, food and feed ingredients, and other bio-based products. In the bioeconomy, these renewable biological resources, along with waste from households and industrial processes, replace the existing non-renewable sources of raw materials for energy and manufacturing.



WHY ARE BIO-BASED INDUSTRIES ESSENTIAL?

Circular bio-based industries produce sustainable bio-based materials, products and ingredients from renewable resources, including agriculture, the food industry, wood sidestreams and waste. This is an essential development for a sustainable future and a key element in addressing the world's current environmental and socio-economic challenges.

There are multiple benefits to establishing a viable bioeconomy in Europe:

- Reduce dependence on non-renewable, unsustainable fossil fuels
- Decrease our reliance on imported protein and cut food waste
- Increase competitiveness and create new jobs in Europe
- Manage natural resources sustainably
- Bring a positive impact on the environment
- Support the modernisation and strengthening of the EU industrial base against global competition

The circular nature of the bioeconomy represents a wide range of environmental, social, and economic benefits. A bioeconomy-based system

allows for minimal waste and CO₂ production, thus contributing to the EU's economic and climate targets and policies such as the European Green Deal. Investments in the bioeconomy also create new jobs and opportunities in remote rural and coastal areas suffering from economic emigration.

WHAT IS CBE JU?

The Circular Bio-based Europe Joint Undertaking (CBE JU) is a public-private partnership that funds projects deploying competitive, sustainable, and circular bio-based industries in Europe. By combining public

investment with the private perspective, CBE JU manages to simultaneously reduce the risk of investing in cutting-edge technologies while adding the skills and knowledge necessary to fulfil market demands.

CBE JU builds on the success of its predecessor, the Bio-based Industries Joint Undertaking (BBI JU), which helped position Europe as the world's bioeconomy leader. Continuing that legacy, CBE JU's goal is to help Europe become the world's first climate-neutral continent while increasing the sustainability and circularity of production and consumption systems.



Projects funded by CBE JU are expected to contribute to a more competitive and sustainable Europe. They help reduce pollution and Europe's

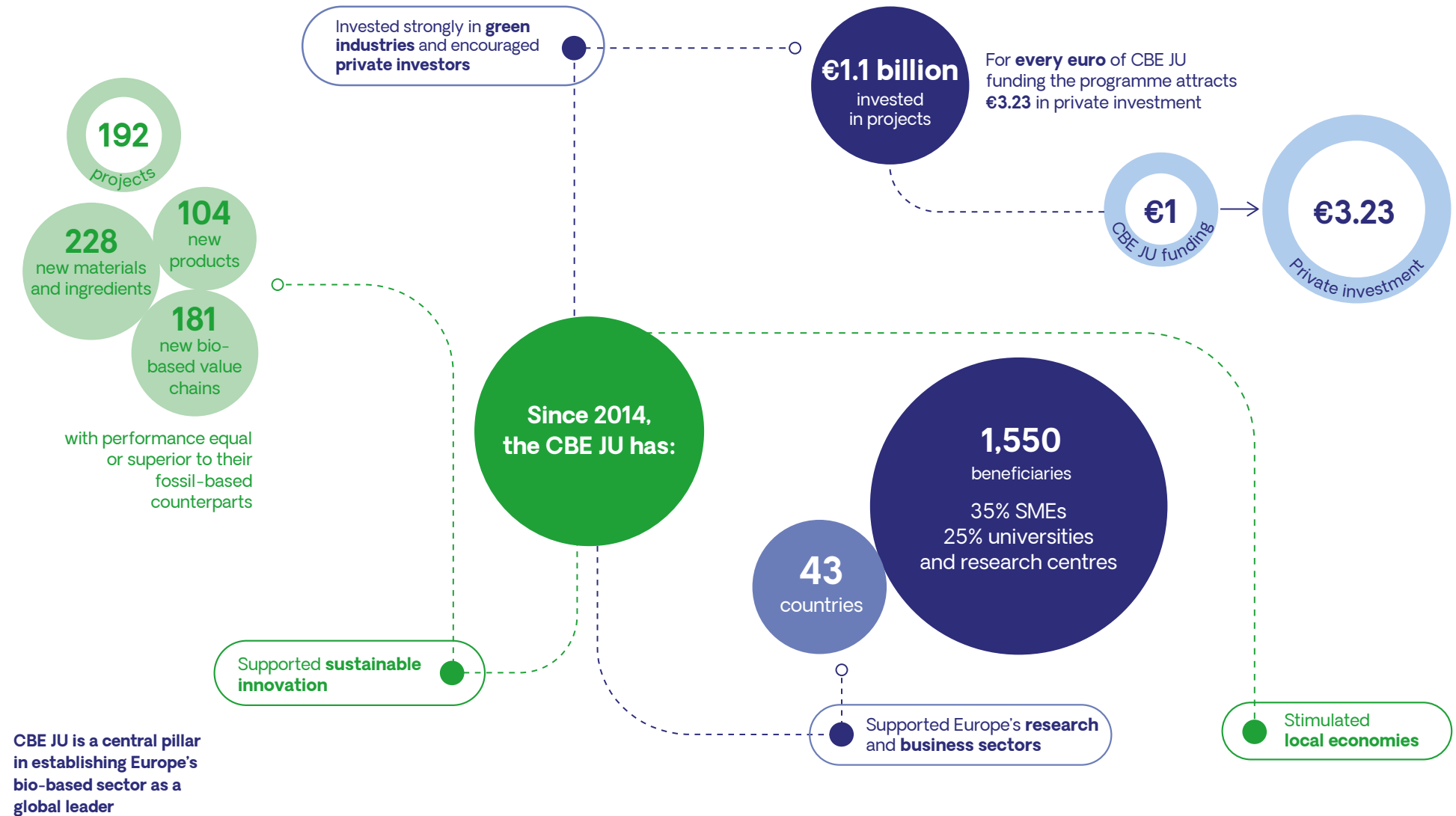
dependence on fossil resources and spur green investments and sustainable economic growth.

BBI JU KPIs: 2023 results vs SIRA targets

SIRA was the BBI JU's Strategic Innovation and Research Agenda



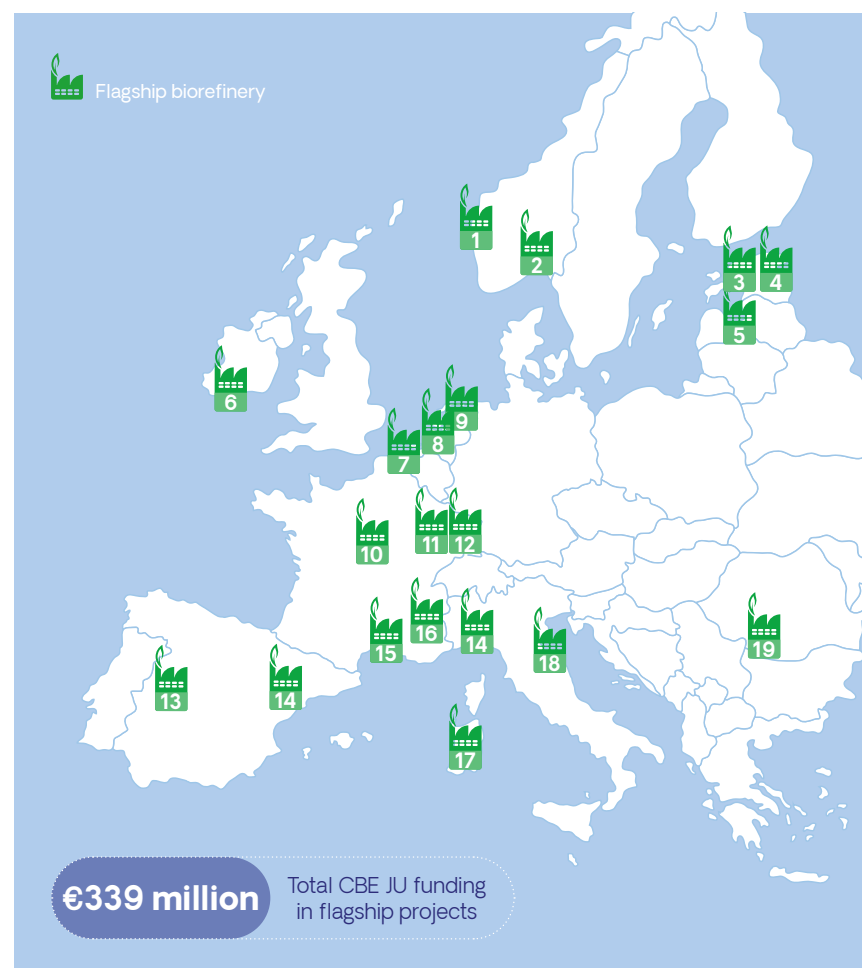
CBE JU-FUNDED PROJECTS IN NUMBERS



WHAT ARE THE CBE JU'S FLAGSHIP PROJECTS?

The flagship projects – first-of-their-kind large-scale production facilities in Europe – provide support for designing and constructing novel, commercial-scale biorefineries. The goal is to deliver technically mature facilities that are

ready for commercial operations by the completion of the project. Flagship projects seek to demonstrate the viability of processes with improved environmental and economic performance compared to existing fossil-based competitors.



Project's feedstock & final product



- 6 AgriChemWhey**
Dairy sidestreams
↳ Lactic acid, minerals for food & fertilisers
- 7 PLENITUDE**
Residues of cereal crops
↳ Mycoproteins
- 8 CIRCLE**
Food waste
↳ Lactic acid & polylactic acid
- 9 PEFerence**
Crop residues
↳ FDCA for bio-based materials
- 10 FARMYNG**
Mealworms & agri-food sidestreams
↳ Proteins for animal feed & organic fertiliser
- 11 AFTERBIOCHEM**
Sidestreams from sugar beet
↳ Flavourings, fragrances, hygiene products, pharmaceuticals, antimicrobials & polymers
- 13 SUSTAINEXT**
Crops & agro-industrial sidestreams
↳ Ingredients for food, feed, cosmetics & fertilisers
- 17 FIRST2RUN**
Underutilised oil crops
↳ Building blocks for polyester production
- 18 TERRIFIC**
Waste from agriculture and food industry
↳ Bio-based packaging
- 19 LIGNOFLAG**
Crop residues
↳ 2G bioethanol biofuel-building block



- 1 PROTEUS**
Brown algae
↳ Bio-based ingredients for food, feed, personal care products & industrial applications
- 15 SCALE**
Microalgae
↳ Nutritional ingredients for food, feed & cosmetics



- 2 EXILVA**
Cellulose
↳ MFC - MicroFibrillated Cellulose
- 3 SWEETWOODS**
Lignin & hardwood residues
↳ High-quality C5/C6 sugars & dried lignin
- 4 WOODCELL**
Locally sourced wood waste
↳ MCC - Microcrystalline Cellulose
- 5 VIOBOND**
Forest-based
↳ Bio-based resins
- 16 SYLPLANT**
Agri-based & wood based
↳ Alternative protein sources for food & feed ingredients
- 12 ReSolute**
Sidestreams from pulp & paper industry
↳ Biodegradable, harmless & bio-based solvent: Cyrene



- 14 CIRCULAR BIOCARBON**
Municipal solid waste
↳ High-value products from fertilisers to 5G technology



Project: **AFTERBIOCHEM**
 Biorefinery location: **Saint-Avoid, France**
 CBE JU funding: **€20 million**
 Coordinator: **AFYREN NEOXY, France**

The EU is the world's largest producer of sugar beet. The sector currently supports 140,000 sugar beet growers and around 27,000 direct jobs in sugar beet processing. The AFTERBIOCHEM project is building the first biorefinery for transforming the sugar industry's sidestreams – mainly pulp and non-food waste – into bio-based molecules of industrial interest, for the flavourings, fragrances, hygiene products, pharmaceuticals, antimicrobials and polymers sectors. This will increase the economic and environmental sustainability of the sugar beet industry. In addition, the process will be flexible enough to adapt to alternative feedstocks in the future.

CIRCLE



Project: **CIRCLE**
 Biorefinery location: **Amersfoort, The Netherlands**
 CBE JU funding: **€17 million**
 Coordinator: **TripleW, Israel**

The chemical industry in Europe is a crucial driver of the economy; however, it faces several challenges, such as high greenhouse gas emissions, energy costs and dependence on imported fossil sources. The CIRCLE project is working on an innovative biorefinery that will transform locally-sourced food waste and other biological residues into valuable bio-based chemicals like lactic acid to be used in cosmetics, cleaning products, the automotive industry and the food packaging sector. The project aims to upgrade the capacity of an existing biogas plant to demonstrate the wide application of these products on the market and promote its social acceptance.



Project: **CIRCULAR BIOCARBON**
 Biorefineries location: **Zaragoza, Spain & Sesto San Giovanni, Italy**
 CBE JU funding: **€15 million**
 Coordinator: **Urbaser, Spain**

Despite gigantic advances in waste recycling in recent decades, the organic fraction of municipal solid waste and sewage sludge are still not recovered efficiently. The CIRCULAR BIOCARBON flagship project is building two first-of-their-kind biorefineries converting this type of waste into four value-added products and a range of other intermediate products. The project's goal is to open new business frameworks based on an innovative circular approach to urban waste treatment. By doing so, the organic waste that currently goes to landfill and incineration will be reduced. It will also cut greenhouse gas emissions, notably methane and carbon dioxide.



Project: **EXILVA**
 Biorefinery location: **Sarpsborg, Norway**
 CBE JU funding: **€27.4 million**
 Coordinator: **Borregaard AS, Norway**

Why do we need to use fossil-based materials to absorb water when trees give us the most advanced water absorption technology? The EXILVA project was conceived to substitute fossil-based chemicals in personal care, coatings, and adhesives with advanced bio-based innovations. By using forestry waste, the EXILVA biorefinery enabled a significantly lower carbon footprint compared to existing technologies.



Project: **FARMYNG**
 Biorefinery location: **Poulainville, France**
 CBE JU funding: **€19.6 million**
 Coordinator: **YNSECT, France**

Alternative plant-based and sustainable proteins are needed for a meat-free future. At the same time, two-thirds of Europe's protein needs are imported. FARMYNG produces sustainable proteins with low environmental impact for animal feed by growing worms in the largest vertical farm in the world. On top of the outstanding environmental performance, producing alternative proteins in the EU will help reduce our dependence on protein imports. The project's appeal has propelled the French start-up leading the project, YNSECT, to raise the needed capitals for the commercial scale-up.



Project: **FIRST2RUN**
 Biorefinery location: **Porto Torres, Italy**
 CBE JU funding: **€17 million**
 Coordinator: **Novamont SPA, Italy**

In Europe, many lands are not suited for agriculture due to their topography or uses of the past. However, these marginal lands could be used to produce renewable resources. The FIRST2RUN project involved local farmers to grow cardoons, an underutilised oil crop, in the Mediterranean landscape of Sardinia to make biodegradable and compostable bio-based products for the consumer market.



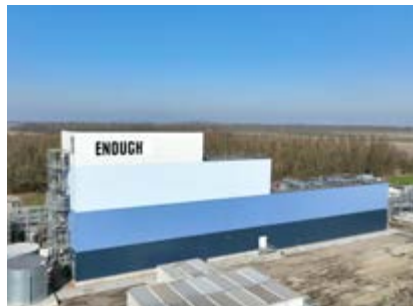
Project: **LIGNOFLAG**
 Biorefinery location: **Podari, Romania**
 CBE JU funding: **€24.7 million**
 Coordinator: **Clariant Produkte GmbH, Germany**

Straw is a common waste generated by agriculture. The LIGNOFLAG project developed technologies to produce bio-based ethanol from non food resources like leftover straw. The carbon footprint of such bioethanol production is much lower than that of fossil fuels, representing greenhouse gas savings that could reach up to 95%. In addition, the liquid by-product can be applied as a fertiliser for the crops used in the process.



Project: **PEference**
 Biorefinery location: **Delfzijl, the Netherlands**
 CBE JU funding: **€25 million**
 Coordinator: **Avantium Chemicals BV, the Netherlands**

Modern human societies need plastic for a wide range of uses. At the same time, plastics are polluting the environment at an alarming level. The PEference flagship project is establishing the first industrial-scale biorefinery producing FDCA, a bio-based chemical, to make high-value products. The goal is to replace a significant share of fossil-based plastics with 100% bio-based polyesters. These can compete with traditional packaging products in price and performance when produced at scale. The resulting bio-based material is sustainable and completely recyclable.



Project: **PLENITUDE**
 Biorefinery location: **Sas van Gent, the Netherlands**
 CBE JU funding: **€17 million**
 Coordinator: **3F BIO Ltd, United Kingdom**

Europe needs to increase alternative sources of homegrown sustainable proteins. The PLENITUDE project aims to produce affordable plant-based proteins for human consumption. When running at total capacity, the production of the mycoproteins will cut CO₂ emissions by 5 million tonnes a year compared with the production of meat proteins. The process consumes significantly less water compared to beef farming, and uses agriculture waste as the main resource.

PROTEUS



Project: **PROTEUS**
 Biorefinery location: **Avaldsnes, Norway**
 CBE JU funding: **€9.6 million**
 Coordinator: **Alginor, Norway**

Brown algae, particularly Laminaria hyperborea, offer abundant renewable resources in Europe, yet current harvesting methods limit their use. PROTEUS seeks to unlock the full potential of this type of seaweed by optimising its harvesting and extraction techniques. The project's biorefinery will transform 100% of the biomass into bio-based food and feed ingredients, personal care products and other industrial applications. This approach aims to sustainably boost Europe's blue economy by improving circularity and creating new business opportunities.



Project: **ReSolute**
 Biorefinery location: **Saint-Avoid, France**
 CBE JU funding: **€11.6 million**
 Coordinator: **Circa Group AS, Norway**

The goal of this project is to provide a biodegradable, safer, and bio-based solvent alternative to the fossil-based chemicals currently in use, all while using waste from pulp and paper industries as renewable raw material. The resulting bio-based solvent will have many application possibilities in pharmaceuticals, coatings, adhesives and electronics. This way, the European industry can use solvents which are safer for human health and the environment in many cutting-edge industries (like microchip production) whilst reindustrialising an old petrochemical site in France.



Project: **SCALE**
 Biorefinery location: **Baillargues, France**
 CBE JU funding: **€14.3 million**
 Coordinator: **Microphyt, France**

What if we could grow renewable resources in very reduced space to free land for agriculture and forestry? What if we could even capture CO₂ from the atmosphere to feed this resource? The SCALE project is building the world's first fully integrated microalgae biorefinery to produce natural active ingredients of high nutritional value for the food supplements, feed, and cosmetics sectors. Led by a French small business, this project aims to reduce the dependency on fossil-based resources, replacing them with bio-based alternatives.



Project: **SUSTAINEXT**

Biorefinery location: **Hervás, Spain**

CBE JU funding: **€14 million**

Coordinator: **Natac Biotech, Spain**

How to put in practice a zero-waste and circular-by-design industrial process in a rural region in Europe? SUSTAINEXT is up to the challenge in Extremadura, Spain. The project is turning an existing production plant into a digitalised circular biorefinery to produce healthy plant-based ingredients from local medicinal and aromatic plants, and agricultural sidestreams. This will generate value and new jobs for the region, showing the positive impact of pursuing the European Green Deal objectives. The project's model is easily adaptable and replicable and can run on renewable energy.



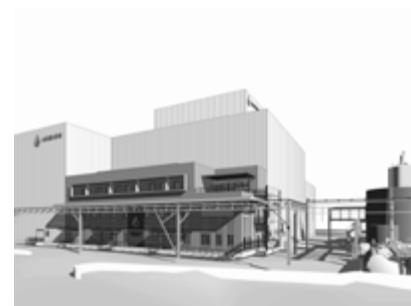
Project: **SWEETWOODS**

Biorefinery location: **Imavere, Estonia**

CBE JU funding: **€21 million**

Coordinator: **Fibinol OU, Estonia**

Lubricants, adhesives, and plastics are extremely useful materials, but when they are made of fossil-based raw materials, they contribute to global warming and pollution. SWEETWOODS is building a first-of-its-kind, highly efficient, reduced environmental impact industrial biorefinery to obtain high-value compounds using hardwood waste as a raw material. The biorefinery is part of a new industry that is advancing an innovation hub in Estonia focused on forestry-based chemicals and materials.



Project: **SYLPLANT**

Biorefinery location: **Roussillon, France**

CBE JU funding: **€14 million**

Coordinator: **Arbiom, France**

The world faces the challenge of feeding a growing population sustainably. Additionally, the EU ought to reduce the large protein imports. The SYLPLANT project will produce protein-rich ingredients from underutilised resources, like agricultural and forestry residues. The success of the SYLFEED demonstration project paved the way for SYLPLANT, which is building a commercial biorefinery to produce 10,000 tons of protein-rich ingredients for food and feed per year.



Project: **TERRIFIC**

Biorefinery location: **Bottrighe, Italy**

CBE JU funding: **€16.8 million**

Coordinator: **Novamont, Italy**

The goal of the TERRIFIC project is to decarbonise the packaging sector and make it circular with bio-based materials for recyclable, compostable and high performing packaging. The project will build a first-of-its-kind biorefinery to produce bio-based and biodegradable film laminated on pulp or paper, as well as rigid and flexible thermoplastic bio-based materials for packaging solutions.



Project: **VIOBOND**
 Biorefinery location: **Riga, Latvia**
 CBE JU funding: **€15.9 million**
 Coordinator: **Latvijas Finieris A/S, Latvia**

Wood panels require glues whose components – phenol and formaldehyde – may pose risks to human health. By transforming hardwood residues, the VIOBOND project demonstrates the feasibility of an effective and efficient business model for lignin transformation into harmless and sustainable bio-based resins for wood panels and construction materials. This technology has high market potential, as the current sales of phenolic resins in Europe are around €1 billion.

WOODCELL



Project: **WOODCELL**
 Biorefinery location: **Imavere, Estonia**
 CBE JU funding: **€17 million**
 Coordinator: **Fibinol, Estonia**

Bio-based materials, like lignin and wood sugars, offer a sustainable alternative to fossil-based materials. WOODCELL aims to produce micro-scale microcrystalline cellulose (MCC) from hardwood residues by building on Fibinol's unique SWEETWOODS production. The project will promote industrial competitiveness, reduce dependency on imports by using wood residues as feedstock, and offer a wider range of bio-based applications for the chemical and materials industry. Additionally, it aims to improve the environmental sustainability of the production process and create new job opportunities in the region.

WHAT IS THE REAL ECONOMIC AND SOCIAL IMPACT OF THESE PROJECTS IN EUROPE?

Currently, the EU's bioeconomy has a turnover of €2.5 billion and employs nearly 18 million people.

The bio-based economy has also **encouraged investments and created new employment opportunities**. Many of these are new, highly skilled jobs in remote, rural, and coastal areas, where many resources and biomass are located. Moreover, the **bio-based sector creates alternative income sources** and sustainable production opportunities for the primary producers in the agriculture, aquaculture and forestry sectors. Therefore, there is the potential to revitalise areas of Europe affected by young people's economic migration to search for jobs and opportunities.

Moving forward, the CBE JU-funded flagship projects are boosting the tangible impact of these green sectors, as the funded biorefineries are built across Europe. The industrial-scale biorefineries demonstrated a **high replicability potential** in other regions and countries.



DEMONSTRATION ACTIONS

Innovation actions are designed to demonstrate the technical and financial feasibility of new or improved bio-based processes.

By the end of their activities, these projects are expected to reach TRLs (Technology Readiness Levels) 6 or 7 and be large enough to allow proving the business model and testing of products at pre-industrial scale.

61
projects

€405 million
in CBE JU funding

PULP2VALUE Capturing more than sugar from sugar beet

The PULP2VALUE consortium has realised the potential of sugar beet.

Sugar beet is one of Europe's major crops and its pulp is primarily used as low-value animal feed. However, treated correctly, this pulp has great potential as a source of other higher value products, such as microcellulose fibres, arabinose, and galacturonic acid. These substances can be used for a wide variety of applications such as chemical building blocks, in food and flavour applications, and in detergents and personal care products.

PULP2VALUE has constructed demonstration plants and developed positive business cases for microcellulose fibres and galacturonic acid, and confirmed the health benefits of arabinose.

Currently, these microcellulose fibres are being used as new structurants for particles in solution in **detergents, adhesives, paints and coatings, and drilling muds**. Arabinose is being used to develop **foods** with a low glycaemic index, and galacturonic acid is finding applications in **personal care** and as an environmentally friendly corrosion inhibitor.

RESEARCH AND INNOVATION ACTIONS

Research and innovation actions fund the development and testing of new technologies and solutions, to fill the gaps in existing bio-based value chains or innovate.

BARBARA Advanced automotive components from biowaste

The **BARBARA project** was established to **address the need for plastic in automotive applications**.

The project is **developing a range of bio-based plastics from food waste**.

These can replace the plastics derived from the unsustainable fossil-based resources, and have all the required properties – mechanical, thermal, aesthetical, optical, and antimicrobial – for this demanding application area.

The project has **produced materials suitable for manufacturing bio-based plastics** for a range of applications such as filaments for 3D printing. With the carmaker FIAT, these were used to print

car door trims and a dashboard fascia, and with the building infrastructure company ACCIONA they were used to fabricate truss joints.

There is a high potential for BARBARA technologies in other areas, including in biotechnology, nanotechnology, advanced materials and advanced manufacturing technologies.

90
projects

€346 million
in CBE JU funding

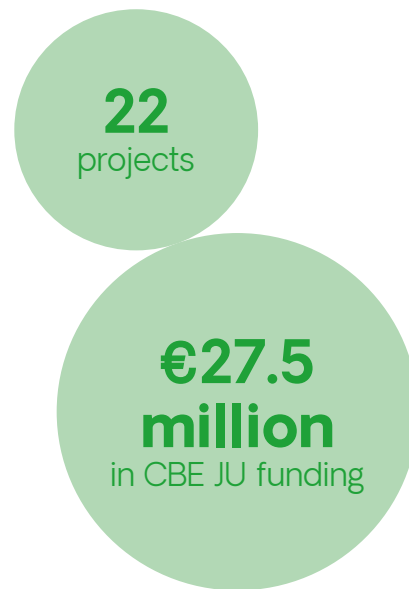


COORDINATION AND SUPPORT ACTIONS

The long-term success of Europe's bio-based sector relies on bringing new, innovative solutions to the market and, once there, boosting their uptake and building share of use. This is the role of the CBE JU coordination and support actions, which address the cross-sectoral challenges of the bioeconomy including developing skills, identifying regulatory barriers and promoting user acceptance.

PILOTS4U Multipurpose pilot and demo infrastructures database

The PILOTS4U project provides an easily accessible database of relevant demonstration facilities for the bioeconomy available to all companies and research institutes. Any user can search for multipurpose demo infrastructures in the open-access database, which would be difficult to find otherwise. This addresses the challenge of

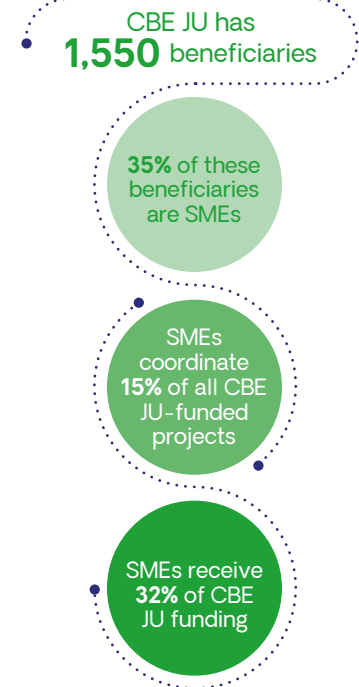


locating and accessing the facilities needed to scale up to pilot and demonstration size before commercial production.

The database can be searched according to specific requirements of each project. This way, PILOTS4U helps new bio-based products and technologies stepping from the laboratory bench to the market.

ENCOURAGING BUSINESSES AND RESEARCHERS

CBE JU-funded projects offer opportunities for small and medium-sized enterprises (SMEs), industry, primary producers, trade associations, and end users, to develop technologies and business models that can drive Europe's green economy while helping companies scale up their own technologies and improve their market access.



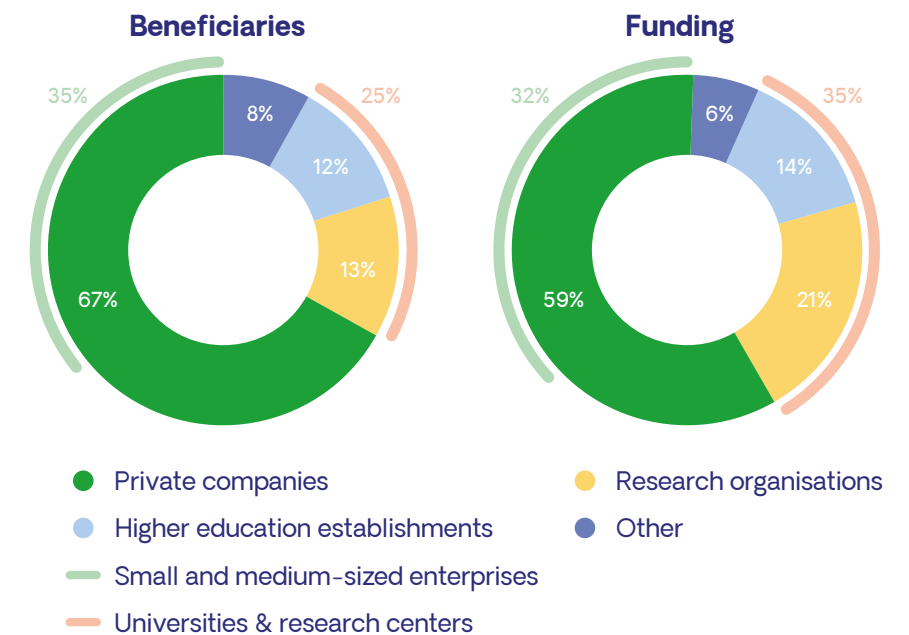


Circular Bio-based Europe Joint Undertaking

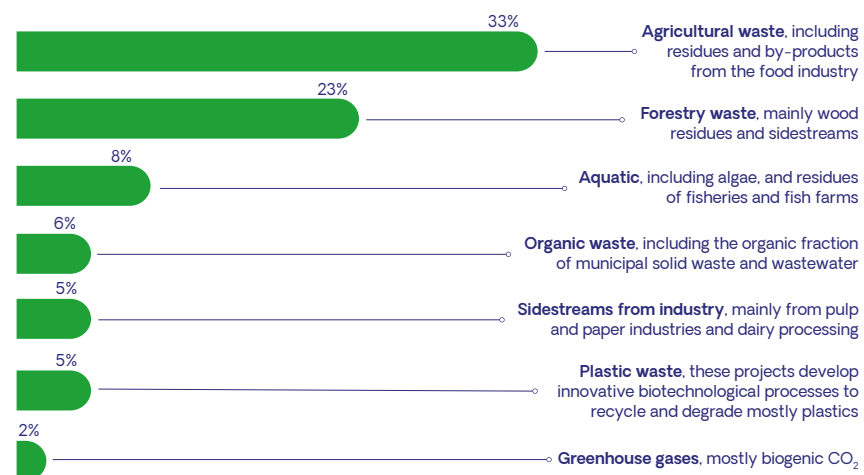
With a CBE JU funding share of one-third, industrial biotechnology SMEs are important technology providers in CBE JU-funded projects.

Other small businesses are involved in a variety of sectors, such as chemicals, food, feed, materials, engineering, construction, waste processing, recycling, plastics packaging, agriculture and aquaculture.

Accelerating the innovation process for bio-based solutions and fostering technology transfer are part of CBE JU's core objectives. Universities and research centres, representing one-quarter of all CBE JU beneficiaries and one-third of all funding, are key providers of innovative bio-based solutions for the projects.



Main source of feedstock used in CBE JU projects



18% of projects use more than one source of feedstock.

Application areas of the bio-based products and solutions

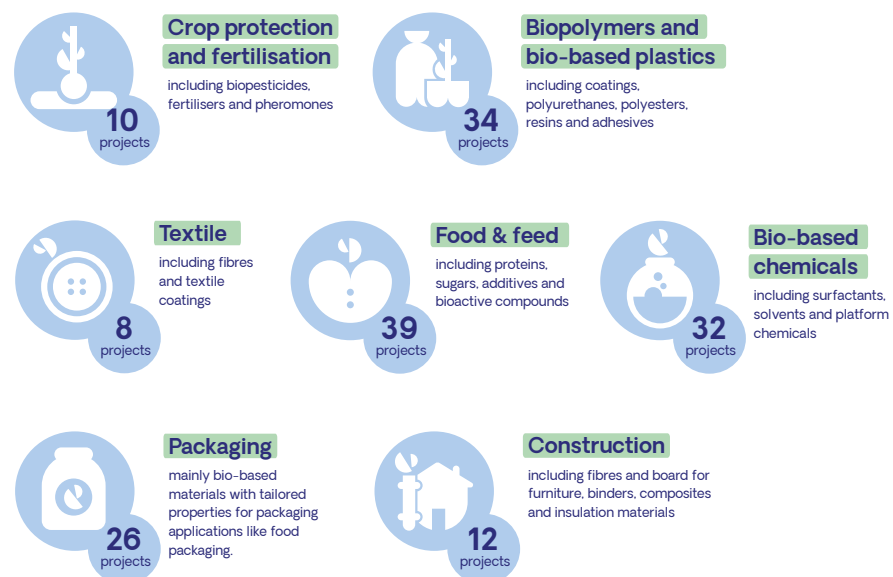


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