European Commission

Research and Innovation

THE BIOECONOMY
Innovative Solutions for a Sustainable Future

THE BIOECONOMY: Innovative Solutions for a Sustainable Future

European Commission
Directorate-General for Research and Innovation
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Manuscript completed in November 2025
1st edition

PDF ISBN 978-92-68-33340-2 doi:10.2777/1719505 KI-01-25-223-EN-N

Luxembourg: Publications Office of the European Union, 2025

EUROPEAN COMMISSION

THE BIOECONOMY

Innovative Solutions for a Sustainable Future

2025

Directorate-General for Research and Innovation
Healthy Planet

CONTENTS

What is the bioeconomy and why is it important?

The bioeconomy delivers sustainable solutions based on biological resources. These solutions benefit sectors ranging from primary production to value chains of food, health, materials, and energy.

The bioeconomy **promotes circularity**, **contributes to climate change adaptation and mitigation**, **reduces fossil fuel dependency** and **cuts the use of polluting chemicals and materials** – all while creating quality jobs and income diversification, including for farmers and foresters. The bioeconomy supports a greener, more resilient future and increases Europe's strategic autonomy from imports.

The Commission has adopted the **new Bioeconomy Strategy in 2025**. Find more information about it on Europa.eu

The bioeconomy creates positive change

Through its Bioeconomy Strategy, the EU supports bioeconomy innovators and changemakers. EU research and innovation funding through Horizon Europe, in all fields of the bioeconomy, plays a central role and has resulted in many emerging solutions. **This booklet showcases 18 examples of such solutions that are already creating positive change for**:

- **Citizens:** who benefit from innovative biosolutions that improve quality of life by providing safer, eco-friendly products like enzyme-based detergents and algae-based cosmetics.

- **Industry:** innovations in bio-based materials enhance the sustainability of manufacturing processes. For example, using algae in cosmetics and packaging reduces reliance on petroleum-derived chemicals and fossil fuels, helping industries minimise their environmental footprint.

- **Farmers and foresters:** innovations such as biofertilisers help farmers grow crops more sustainably with less chemical input. Turning forestry side streams into high-value products such as construction material or bio-based textiles supports foresters' income by adding value to previously underutilised resources.

- **Rural communities:** innovations which turn agricultural side streams into valuable products, such as bio-based



styrofoam produced from straw for packaging, provide jobs and support local economies and skill development without additional pressure on farming land.

- **Climate and environment:** by reducing reliance on fossil fuels and materials, the bioeconomy contributes to climate goals, minimises waste and cuts pollutants. Bioeconomy innovations protect the environment and ecosystems, for example, by using microalgae in wastewater treatment, which prevents chemical runoff into rivers and lakes, safeguarding aquatic life.

The bioeconomy has a positive effect on **competitiveness** through new market creation with quality jobs (particularly from small and medium-sized companies and startups for scaling up innovations) while building **resilience and strategic autonomy** through reducing fossil dependency and securing EU leadership in sustainable bio-based global markets. The bioeconomy is the living proof that competitiveness, climate action, environmental protection and citizens' wellbeing go hand in hand.

FOOD

Animal-free egg white for food industry change

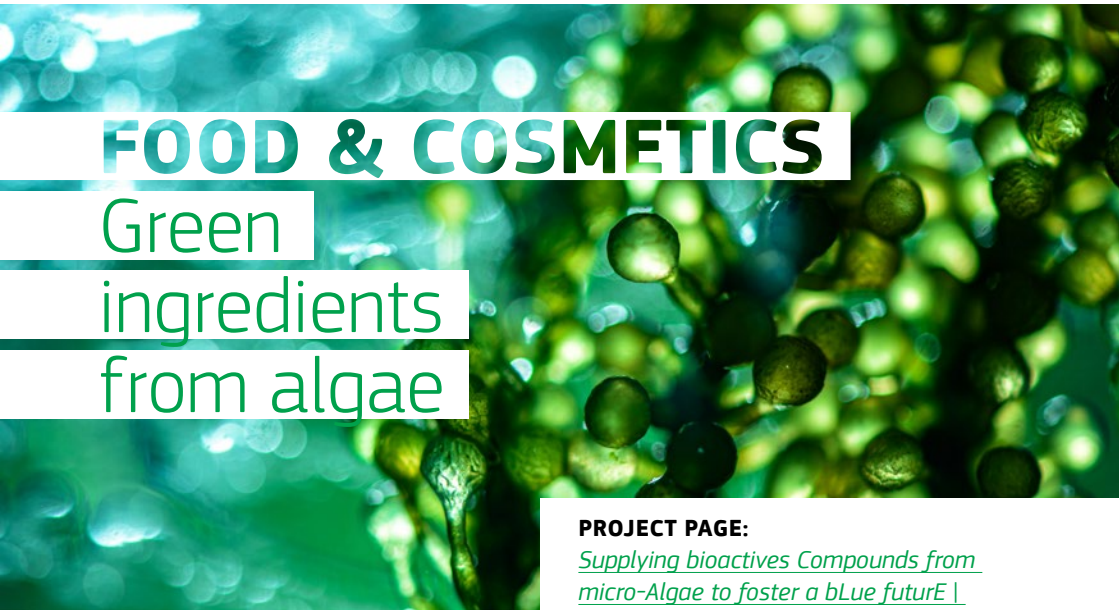
PROJECT PAGE:
Novel precision fermentation process to produce animal-free bioidentical ovalbumin | Bioalbumen

The food industry relies heavily on eggs for their functional properties in baking, cooking, and food manufacturing. However, traditional egg production requires vast amounts of land, water, and feed, while contributing significantly to greenhouse gas emissions. It also faces challenges such as supply chain volatility, price fluctuations, and ethical concerns related to animal welfare and avian flu outbreaks.

Onego Bio, a Finland-based food ingredient company, has developed Bioalbumen®, an egg white protein produced through precision fermentation without the need for animals. Bioalbumen® matches the nutritional and functional properties of conventional egg whites while offering superior foaming, gelling, and emulsification. It is ideal for baked goods, snacks and sauces, while conventional eggs continue to be important for direct consumer consumption.

Compared to traditional egg production, Bioalbumen® reduces greenhouse gas emissions by 89%, land use by 95%, and water consumption by 87%. By lowering the need for poultry farming, it mitigates risks associated with zoonotic diseases and improves supply chain stability. This innovation supports a more resilient and ethical food system, enhances food security, and contributes to achieving global sustainability goals.

The EU has supported Onego Bio through the EIC and EIT Food (Horizon Europe).



FOOD & COSMETICS

Green ingredients from algae

PROJECT PAGE:
Supplying bioactives Compounds from micro-Algae to foster a bLue futurE | SCALE

Microalgae offer a rich and diverse natural material that can be grown in tanks using minimal land and water. Packed with proteins, omega-3 fatty acids, vitamins, and minerals, algae serve as functional ingredients for the food industry and a sustainable source of plant-based protein. In cosmetics, algae-derived compounds provide natural alternatives to synthetic additives. In packaging, biodegradable films for food wrappers and containers can be made from algae biopolymers, replacing petroleum-based plastics.

With microalgae production through biorefineries, a complete value chain is created (from cultivation to extraction and product development), reducing the use of land, water, and fossil fuels. Microalgae act as a carbon sink, lowering greenhouse gas emissions while supporting marine conservation and diversifying Europe's supply of sustainable ingredients.

Microphyt, a French SME in microalgae-based solutions for nutrition and well-being, has developed and patented a cutting-edge photobioreactor technology. Thanks to the EU-funded SCALE project, this technology was transferred from the demo plant to an industrial plant which can produce large-scale volumes of high-value ingredients from unique microalgae species that cannot be supplied through other production technologies.

The EU has supported the SCALE project with funding from CBE JU (Horizon 2020).

FOOD
Capture carbon to produce food

PROJECT PAGE:
Inspiring CO2 circularity by introducing carbon transformation to our plates | C - 2C - Protein

As the global population grows, the demand for protein surges. However, conventional farming uses a lot of land, water, and energy, while climate change is challenging our food production. Innovative and sustainable food production methods are needed to meet our nutritional needs while preserving the environment.

The Greek company Solmeyea has created a smart way to produce food-grade proteins using algae fed with CO_2, which is directly captured from the air or from industrial sources. This process turns harmful emissions into useful, nutritious proteins. It also reduces the pressure on farmland and fresh water, making protein production cleaner, more efficient and more secure.

The EU has supported Solmeyea through the EIC (Horizon Europe) as well as through the European Regional Development Fund (ERDF), the European Social Fund (ESF) and NextGenerationEU.

SPACE
Food for space and crisis areas

PROJECT PAGE: *Hydrogen oxidizing bacteria engineered to valorize CO2 for whey protein production | HYDROCOW*
Solar-driven synthesis of proteins and lipids via photoelectrochemistry of living organisms | SOLARSPOON

Space missions and crisis zones share a critical challenge: the lack of reliable food supply. In space, traditional agriculture is impossible, and sending food to space is costly. In crisis situations, food supply chains are often disrupted. Both environments need solutions that are independent of climate, land, and logistics.

Solein® is a protein developed by Solar Foods, and produced in a bioreactor by using carbon dioxide, hydrogen, and renewable electricity. The bioreactor functions as a closed-loop life support system, where waste is recycled and resources are conserved. In this process, a natural microbe converts air and energy into a complete protein – without agriculture, animals, or sunlight.

Solein® protein is versatile, nutritious, and can be integrated into a wide range of food products. The system enables sustainable food production also in space habitats, supporting long-duration missions. On Earth, it offers a lifeline in deserts and emergency zones – from refugee camps to regions affected by climate disasters – where conventional food systems might fail.

The EU is supporting Solar Foods by granting it the status of Important Project of Common European Interest (IPCEI). In addition, Solar Foods receives funding from the EU through the EIC (Horizon Europe) for its participation in projects such as HYDROCOW and SOLARSPOON.

FARMING

Specialised bio-fertilisers using upcycled waste

PROJECT PAGE:
Bio-based FERtilising products as the best practice for agricultural management SusTainability | B-FERST

Increasing land productivity in a sustainable way is the main challenge in the farming sector. Conventional, chemical fertilisers can harm animal and human health and pollute the environment, and their production consumes high amounts of energy. Bio-waste can be used to replace imported, non-renewable and energy-intensive fertilisers while reversing the loss of soil nutrients.

The B-FERST project is applying a circular system whereby waste from agriculture and cities is converted into useful fertilisers. These fertilisers are custom-made to match the specific needs of each farm, allowing for more precise nutrient use and better crop growth. This approach encourages stronger collaboration between farmers and fertiliser producers, making the whole process more efficient, environmentally friendly and better adapted to local farming practices.

The EU has contributed through CBE JU (Horizon Europe) to the B-FERST project.

MATERIAL
Products with less environmental impact

PROJECT PAGE:
Wood residues derived microcrystalline cellulose for sustainable materials | WOODCELL

Microcrystalline cellulose (MCC) is used in many everyday products – like tablets in medicine, sauces and snacks in food, creams in cosmetics, and paints and glues in industry. Traditional production methods use cotton or fresh wood pulp and involve strong chemicals and lots of energy. This harms the environment and is expensive.

Fibenol, a company based in Estonia, has found another way: making MCC from wood side-streams – leftover materials from forestry – instead of fresh trees. Their process uses less energy, fewer chemicals, and follows circular economy principles. The result is a high-performing MCC that works even better in industrial products.

Fibenol's MCC helps make supply chains in medicine, food, and cosmetics more sustainable. It reduces waste, lowers pollution, and supports Europe's move toward eco-friendly materials. It is a smart step toward a cleaner, greener future.

The EU has supported Fibenol through several CBE JU (Horizon Europe) projects, including WOODCELL.

PERSONAL CARE

From farm waste into everyday products

AFYREN NEOXY biorefinery

PROJECT PAGE:
Anaerobic FermenTation & EsteRification of BIOmass for producing fine CHEmicals | AFTERBIOCHEM

Everyday products such as cosmetics, foods and pet feed all need ingredients from the chemical industry, which is heavily dependent on petrochemical processes. These processes contribute to climate change, resource depletion, and environmental pollution.

The AFTERBIOCHEM project has developed an innovative biorefinery that transforms agricultural side-streams – such as sugar beet pulp, molasses, and other non-food biomass – into organic acids and esters. These molecules can replace petrochemical ingredients across multiple industries, including:

- Fragrances and flavours for perfumes, air fresheners, and food.
- Cosmetics and hygiene products, offering biodegradable alternatives to synthetic additives.
- Pharmaceuticals, as intermediates in cleaner drug production.
- Food and feed additives, such as preservatives and nutritional enhancers.
- Polymers, including bioplastics, coatings, and solvents for industrial use.

AFTERBIOCHEM enables a low-carbon, circular chemical industry by turning agricultural waste into high-value, sustainable products. It reduces CO_2 emissions, petroleum dependency, and supports the creation of new value chains and green jobs.

The EU has contributed through the BBI JU (Horizon 2020) to the AFTERBIOCHEM project.

PERSONAL CARE

Smarter enzymes for everyday products

PROJECT PAGE:
Technologies of the Future for Low-Cost Enzymes for Environment-Friendly Products | FuturEnzyme

Resource-intensive chemical processes are also used for other everyday consumer products like detergents, personal care products, and textiles. These traditional methods consume large amounts of water and energy, emit high levels of CO_2, and rely on synthetic ingredients that can harm both people and the environment.

The FuturEnzyme project is developing eco-friendly, low-cost enzymes (small, active protein molecules speeding up chemical reactions) that replace harmful chemical processes. These high-performance enzymes work efficiently at lower temperatures, reducing energy and water use. They offer a chemical-free, biodegradable alternative, making everyday items safer and more sustainable.

FuturEnzyme's innovation supports a cleaner, low-carbon future for the consumer goods industry.

The EU has contributed through Pillar 3 of Horizon 2020 to the FuturEnzyme project.

PACKAGING
Keeping vegetables fresh without plastic

PROJECT PAGE:
ALOe vera Edible Coating: effective, safe and sustainable post-harvest treatment to enhance shelf-life of vegetables | ALOEco

The demand for fresh fruits and vegetables is rising, but these products are difficult to preserve throughout the supply chain. Post-harvest losses contribute significantly to food waste, while producers face increasing pressure to reduce chemical use and comply with stricter regulations.

Edible coatings are a promising way to preserve freshness and reduce vegetable spoilage. However, most current solutions contain synthetic additives and are not suitable for organic markets. The ALOeco's aloe vera edible coating is a natural, organic, and safe alternative to plastic packaging or post-harvest fungicides. Applied directly to vegetables, it forms a protective layer that slows spoilage and maintains quality.

This innovation replaces fossil-based plastic packaging with a fully biodegradable, edible solution, which extends the shelf life of vegetables by up to 40%. The coating is especially valuable for organic producers and retailers seeking sustainable ways to meet consumer demand for clean and circular food systems.

The EU has contributed through the EIC (Horizon Europe) to the ALOEco project.

PACKAGING
Plastic-free material that disappears naturally

Traceless materials mix

PROJECT PAGE:
Market Entry traceless materials | MaEtra

Single-use fossil-based plastics – like straws, bags, bottles, and food wrappers – are used for minutes but persist in the environment for centuries. They can pollute land and oceans, harm wildlife, and contribute to microplastic pollution and greenhouse gas emissions. Despite growing awareness, alternatives often fall short in performance or sustainability.

The Traceless® materials company offers a fully compostable, plastic-free alternative made from agricultural residues such as starch and brewery by-products. The material is safe, versatile, and breaks down naturally without leaving microplastics or toxic residues in nature. This bio-based circular production model can be used across industries to replace conventional plastics in packaging, consumer goods, and more – without compromising functionality.

By turning waste into value, Traceless® contributes to a future where materials return safely to nature.

The EU has contributed through the EIC (Horizon Europe) to the MaEtra project.

TEXTILE

Fungi fibres, a natural alternative to plastic

PROJECT PAGE:
Reinventing a smart, circular and competitive textile industry with advanced myco-fibres | MY-FI

The textile industry contributes to microplastic pollution and consumes vast amounts of water and energy. Additionally, textile waste is rarely recycled, leading to growing environmental and landfill concerns.

Innovative nonwoven fabrics made from mycelium fibres – grown through fungal fermentation of textile industry waste – offer a sustainable alternative. These materials are fully bio-based, customisable, and high-performing, with properties that make them suitable for replacing both synthetic textiles and animal-based leather. They are waterproof, soft, and versatile, ideal for use in fashion items like belts, bags, and footwear, as well as in automotive interiors such as headrests and steering wheels.

Replacing synthetic and animal-based textiles with mycelium-based materials contributes to a greener, more resilient textile industry. It reduces reliance on fossil fuels and animal products, cuts down on water and energy use, and supports EU goals for circularity and bioeconomy. These materials also help reduce microplastic pollution and promote textile waste valorisation.

The EU has contributed through Pilar 3 of Horizon 2020 to the MY-FI project.

TEXTILE
Making clothes from captured CO_2

PROJECT PAGE:
Novel business model enabled by a patented fermentation technology to produce 100% biodegradable textile fibres from CO_2-emissions | CO2TEXTILE

The textile industry is a major contributor to pollution, relying heavily on synthetic fibres made from fossil fuels. Energy-intensive industries such as chemicals also emit vast amounts of CO_2, accelerating climate change.

CO2BioClean bridges these industries with a disruptive business model: capturing harmful industrial CO_2 emissions and converting them into 100% biodegradable biopolymers using a patented fermentation technology, which can transform 2.5 tonnes of CO_2 into 1 tonne of PHA (trichloroethylene, an industrial solvent pollutant) biopolymer. This polymer is then spun into textile fibres that match market standards and can be used for several years – yet fully decompose within one year in compost or marine environments.

Germany-based CO2BioClean creates a closed-loop, climate-positive textile solution. It reduces industrial CO_2 emissions, replaces fossil-based synthetic fibres, and prevents plastic waste. By connecting CO_2-emitting sectors with textile manufacturing, it supports a circular economy and offers a scalable path to sustainable fashion and materials.

The EU supports CO2BioClean through the EIC (Horizon Europe).

CONSTRUCTION

Wood-based alternative to ceramics

PROJECT PAGE:
Wood composite set to eliminate CO_2 emissions of the ceramics industry | WOODRY

Ceramics production has high environmental impacts due to its energy consumption and raw-material extraction. It emits high levels of CO_2 and dust particles and generates large volumes of polluted water. The energy-intensive firing process and reliance on non-renewable materials make ceramic bathroom products environmentally costly. As demand for sustainable construction and interior design grows, the need for cleaner alternatives becomes urgent.

Woodio® offers a unique solution: bathroom products made from a wood composite material that replaces traditional ceramics. Made from wood chips sourced from forest industry side-streams, the material is 100% waterproof, durable, and has a significantly lower carbon footprint. Unlike ceramics, Woodio® products require no high-temperature firing, making the production process cleaner and more energy-efficient.

By offering stylish, functional, and sustainable alternatives for washbasins, bathtubs, and toilets, Woodio® contributes to a greener built environment without compromising quality or aesthetics.

The EU has supported Woodio® through the EIC (Horizon Europe).

CONSTRUCTION
Self-healing buildings

PROJECT PAGE:
Bioinspired living skin for architecture | ARCHI-SKIN

In construction and engineering, coatings and surface treatments are widely used to protect materials from environmental damage. However, many of these treatments rely on harsh chemicals, energy-intensive processes, and consume large volumes of precious water.

The ARCHI-SKIN project pioneers the use of Engineered Living Materials (ELMs) to protect building surfaces. Inspired by nature, the team develops fungal biofilms that act as "living skins" – protective layers that can grow, adapt to environmental changes, and even self-heal. These biofilms replace chemical coatings with a low-cost, bio-based solution that is scalable and environmentally responsive.

ARCHI-SKIN's innovation reduces pollution, lowers water and energy use, and extends the lifespan of construction materials. This project supports sustainable architecture and, by training architects and engineers in nature-based materials, promotes a shift towards greener construction practices across Europe.

The EU has contributed through the ERC (Horizon Europe) to the ARCHI-SKIN project.

PAPER

Paper from fallen leaves, not trees

PROJECT PAGE:
Releaf Paper - breakthrough technology for sustainable production of leaves-based fibre disrupting paper production and eco packaging industries | Releaf Paper

The production of paper predominantly involves cutting down trees and using a substantial amount of chemicals, water and energy, with significant pressure on nature. Traditional paper production also releases big amounts of CO_2 into the air, contributing to climate change.

Releaf Paper is the world's first company to make cellulose – the main ingredient in paper – from fallen leaves. The leaves are gathered from urban areas instead of forests. Using a patented process that combines mechanical, chemical and thermal steps with a special drying method, Releaf Paper creates strong, high-quality paper without cutting trees. The process uses standard equipment and is easy to scale.

Paper made via this process uses no harmful chemicals like sulphates or sulphites, reduces CO_2 emissions by 78% compared to traditional paper, needs 15 times less water and 3 times less electricity and can be recycled up to 5 times (or naturally decomposes in 30–60 days), all with a lower cost thanks to easy access to raw materials, therefore offering a smart, sustainable alternative to traditional paper.

The EU has contributed through the EIC (Horizon Europe) to the Releaf Paper project.

BATTERIES
Storing clean energy with bacteria

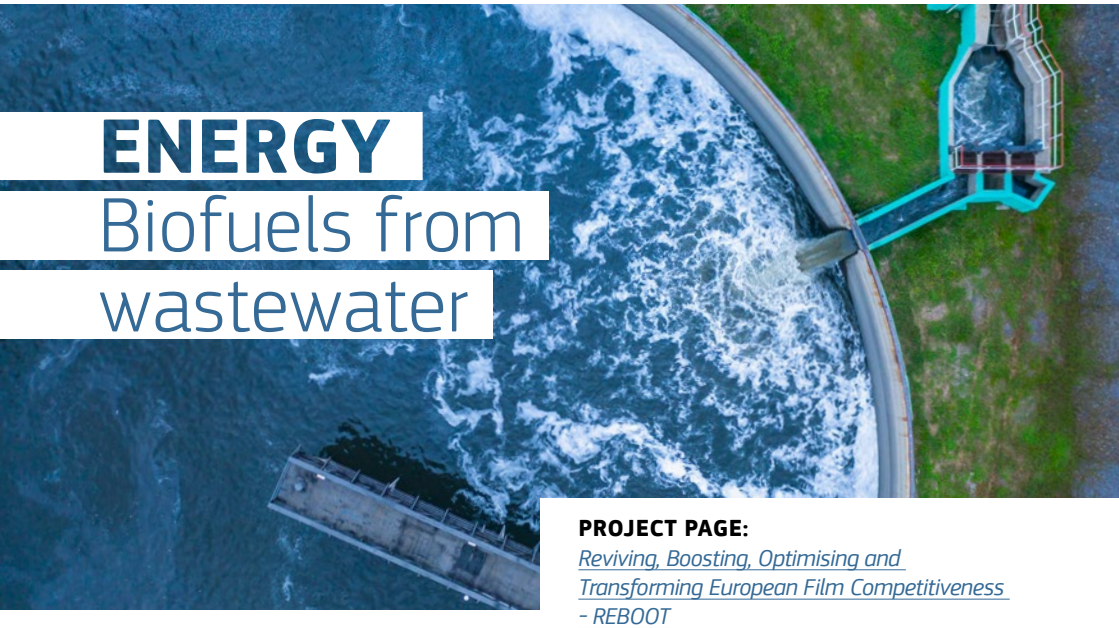
PROJECT PAGE:
Acetogenic bacteria: from basic physiology via gene regulation to application in industrial biotechnology | ACETOGENS

Renewable energy sources like solar and wind are clean – but we need better ways to store it for later use, when production power is low. Hydrogen is a clean energy carrier but storing it safely and efficiently with traditional storage methods can be expensive, complex, or harmful to the environment.

Researchers of the ACETOGENS project explored how special bacteria – called acetogenic bacteria – can help store hydrogen in a new way. These bacteria naturally convert hydrogen and carbon dioxide into useful compounds. The ACETOGENS team used this knowledge to create a battery that stores hydrogen biologically, offering a promising alternative for clean energy storage.

This biobattery innovation could make hydrogen energy safer, cheaper, and more sustainable. It supports the shift to renewable energy and reduces our dependence on fossil fuels.

The EU has contributed through the ERC (Horizon Europe) to the ACETOGENS project.



ENERGY
Biofuels from wastewater

PROJECT PAGE:
Reviving, Boosting, Optimising and Transforming European Film Competitiveness - REBOOT

Energy is essential for modern life – it powers industries, transportation, homes, and infrastructure, making it a backbone of economic growth and societal well-being. For the EU, energy security and sustainability are strategic priorities in a more volatile and geopolitical global context. The EU is reducing energy consumption, diversifying energy sources, but also investing in renewables, including biofuels.

Biofuels can be an alternative in hard-to-abate sectors such as aviation and marine transport, but their production – often land-intensive – can have negative impacts on biodiversity and food production.

The REBOOT project proposes an advanced technology that recovers precious materials from wastewater, treats them and generates carbon-neutral fuels.

This process can convert sewage waste or manure into renewable bio-crude that could be refined into sustainable aviation and marine fuels. Great advancements have been made under this project, bringing this process closer to industrial implementation.

The EU has contributed through the ERC (Horizon Europe) to the REBOOT project.

SOIL
Removing pollutants with microorganisms

PROJECT PAGE:
Enhanced In Situ Bioremediation for Contaminated Land Remediation | EiCLaR

Contaminated areas in industrial sites are detrimental to the environment and pose risks to human health, but cleaning them up is costly. Through a process called bioremediation, microorganisms can be used to break down toxic substances into harmless components.

The EiCLaR project has developed four technologies that leverage bioremediation in novel ways, combining biological processes with physical processes. These technologies include electro-nano-bioremediation, bioelectrical remediation, aerobic metabolic TCE degradation and enhanced phytoremediation.The solutions target a range of industrial pollutants that impact soil and groundwater. These pollutants include PFASs (per- and polyfluoroalkyl substances, also called 'forever chemicals'), petroleum hydrocarbons and heavy metals.

The EiCLaR project has put these technologies on track for rapid market adoption, and two of them (electro-nano-bioremediation and bioelectrical remediation technologies) are already entering commercial use.

The EU has contributed through Pillar 2 of Horizon 2020 to the EiCLaR project.

EU funding terminology

BBI JU – Bio-based Industries Joint Undertaking (predecessor of CBE JU).
CBE JU – Circular Bio-based Europe Joint Undertaking.
EIC – European Innovation Council.
EIT – European Institute of Innovation and Technology.
ERC – European Research Council.
Horizon 2020 – EU Framework Programme for Research and Innovation (2014–2020).
Horizon Europe – EU Framework Programme for Research and Innovation (2021–2027).
NextGenerationEU – temporary recovery instrument to support Europe's economic recovery from the coronavirus pandemic.

More about the bioeconomy

The European Commission provides information and scientific support to policymaking in its Knowledge Centre for Bioeconomy (KCB). Find more about it on the KCB website.

To discover more about the activities of the European Commission with regard to research and innovation on the bioeconomy, visit DG RTD's Bioeconomy website.

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The bioeconomy delivers sustainable solutions based on biological resources. These solutions benefit sectors ranging from primary production to value chains of food, health, materials and energy. The EU-funded bioeconomy innovations presented in this booklet show the bioeconomy's role in fostering circularity, adapting to and mitigating climate change, reducing reliance on fossil fuels and decreasing pollutants. They create jobs and income opportunities, particularly for farmers and foresters, and support a greener, more resilient future. The bioeconomy is the living proof that competitiveness, climate action, environmental protection and citizens' wellbeing go hand in hand.

Project information

Publications Office
of the European Union