



ALMA MATER STUDIORUM
UNIVERSITÀ DI BOLOGNA

BIO-BASED PRODUCTS AND PROCESSES

*Innovative processes for obtaining
new and drop-in bio-based products
from renewable sources.*



The research of the University of Bologna covers a wide range of issues:

Renewable sources

Characterization, sorting, treatment and valorization of residual biomasses; Sustainable agronomy and eco-physiology of new crops for energy biofuels and bio-refineries, marginal land valorization; Microalgae cultivation and characterization for biotech and bio-based market application; CO₂ capture and transformation.

Processing

New catalytic processes to transform renewables or urban waste; Pre-treatment and integration with cascading exploitation processes for biotech applications; thermochemical processes; Downstream processing for selective recovery of bio-based chemicals; Chemical modification/functionalization of bio-based molecules for polymers, plastics, additives for plastic formulation; Innovative monomers and macromolecular structures synthesis for bio-based and/or biodegradable plastics development; Chemical recycling of traditional polymeric materials for polymers production; LCA modelling, risk assessment, environmental footprint, Material Circularity Indicator.

Products

Chemical platforms and building blocks; Innovative bio-based biopolymers, bioplastics and sustainable composite materials; Biomethane and biofuels from farm and agri-industrial residues; Characterization of different biological activities for pharmaceutical, nutraceutical, food, feed and cosmetic applications; Labelled and certified novel bio-based products; Bio-based additives for plastics and bioplastics.

HIGHLIGHTS

Horizon 2020: [**INGREEN**](#) - *Production of functional innovative ingredients from paper and agro-food side-streams through sustainable and efficient tailor-made biotechnological processes for food, feed, pharma and cosmetics;* [**BIO-PLASTICS EUROPE**](#) - *Developing and Implementing Sustainability-Based Solutions for Bio-Based Plastic Production and Use to Preserve Land and Sea Environmental Quality in Europe;* [**PRESERVE**](#) - *High performance sustainable bio-based packaging with tailored end of life and upcycled secondary use;* [**FIRST2RUN**](#) - *Flagship Demonstration of an integrated bio-refinery for dry crops sustainable exploitation towards bio-based materials production;* **PROLIFIC** - *Integrated cascades of PROCesses for the extraction and valorisation of proteins and bioactive molecules from Legumes, Fungi and Coffee agro-industrial side streams.*



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BIOMASS FEEDSTOCKS, ENVIRONMENT AND PLANT BIOTECH

Improvement, selection and cultivation of crops, microalgae and microorganisms and their use in different industrially and environmentally relevant fields.

The University of Bologna can offer multidisciplinary skills and expertise for research studies in the field. A particular focus is placed on applied innovative research aiming at sustainable energy, food and non-food applications.



The research of the University of Bologna covers a wide range of issues:

- Agronomy, physiology, biology and ecology of non-food lignocellulosic, oil and rubber crops, and agricultural residues
- Innovative and integrated cropping systems including perennial and annual lignocellulosic and oilseed crops
- Relationships between crop genotype and the expression of functional compounds in relation to applied agro-techniques and biophysical constraints
- Tools for genetic improvement and identification of molecular markers and genes for crop increased yield and tolerance to abiotic and biotic stresses, and for the planning and obtainment of new plant genotypes with improved characteristics
- Molecular and functional characterization of microorganisms and microbial communities involved in the biodegradation/transformation of organic pollutants in soil-water matrixes to develop strategies and processes of bioremediation
- Soil, sediment and water bioremediation processes in conventional, packed bed and bio-electrochemical bioreactors
- Characterization of microalgae and other microbial communities useful for phytoremediation. Study of the effect of exposition to pollutants and evaluation of physiological responses
- Physiological, biochemical and molecular responses to abiotic stresses of plants used in the phytoremediation of soils contaminated by heavy metals and organic pollutants.

HIGHLIGHTS

The University of Bologna contributes to the progress in biomass feedstocks, environment and plant biotech research taking part to several: [WATERAGRI](#)

- Water retention and nutrient recycling in soils and streams for improved agricultural production; [INMARE](#) - Innovative screening and expression platforms to discover and use the functional marine enzymes for environmental cleanup applications; [MADFORWATER](#) - Integrated technological and management solutions for wastewater treatment and efficient reuse in agriculture environments of Mediterranean African Countries; [COSMOS](#) - Reducing the dependence of Europe's oleochemical industry on imported plant oils by turning camelina and crambe into profitable, sustainable, multipurpose, non-transgenic European oil crops.



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BLUE BIOTECH FOR MARINE ENVIRONMENT

Applying molecular biology and biochemical methods to marine organisms. Using enzyme and green chemistry processes to convert marine bio-wastes and pollution materials into products.

The University of Bologna can offer multidisciplinary skills and expertise for research, applied studies and technology transfer in the field.



Research at the University of Bologna covers a wide range of issues:

- New exploitation possibilities of marine resources through biotechnological routes aimed at obtaining high-value molecules or composites (i.e. for medical, food, cosmetic applications), thus enacting the “sustainable bio-refinery” concept
- Use of different micro-, meso- and macro-organisms and enzymes for the treatment of natural and man-made (i.e. wastes and by-products) substrates, as much as their use for bioremediation actions
- Mechanisms of calcification processes in marine organisms
- Advanced functional materials from mariculture bio-wastes
- Novel ingredients and additives for aquaculture
- New selfhealing biopolymeric materials from byssus
- Selection of marine bacteria able to produce enzymes and biomolecules active and stable under harsh working conditions
- Development and optimization of innovative processes in packed bed bioreactors
- Biomolecules with antifouling activity
- Algal culture for the production of bioactive molecules with industrial, medical and nutraceutical applications

HIGHLIGHT

The University of Bologna has been funded at European level over the years through different programs on the marine pollution and water treatment:

H2020: [INMARE](#) - *Industrial Applications of Marine Enzymes: Innovative screening and expression platforms to discover and use the functional protein diversity from the sea.*

FP7: [KILL SPILL](#) - *Integrated Biotechnological Solutions for Combating Marine Oil Spills*; [BIOCLEAN](#) - *New BIOTEchnologiCaL approaches for biodegrading and promoting the environmEntal biotrAnsformation of syNthetic polymeric materials*; [ULIXES](#) - *Unravelling and exploiting Mediterranean Sea microbial diversity and ecology for xenobiotics' and pollutants' clean up2.*

ERA-NET: [Novofeed](#) - *Novel feed ingredients from sustainable sources.*


Interdepartmental Centre for Industrial Research in Energy and Environment - CIRI Energy and Environment develops and transfers innovative technologies and methods for the control of environmental quality and for the management of natural resources.



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CLIMATE AND CLIMATE SERVICES

Climate is among the most crucial areas of contemporary research given its direct impact on human activities, security and health.



Climate research at the University of Bologna encapsulates a wide spectrum of cutting-edge activities including basic research of atmospheric and ocean processes, model development, data analyses of past records, impacts evaluation. Special effort is devoted to develop climate services, tackling greening the economy in line with the Sustainable Development Goals (SDGs).

The research of the University of Bologna covers a wide range of issues:

- fundamental atmospheric and ocean science research
- mitigation and adaptation strategies for urban, rural and coastal areas including biodiversity and ecosystem services
- Copernicus Services for climate change, land and marine environmental monitoring including short and long-term initiatives
- smart City, climate change and resilience of the built environment, development and assessment of low-impact technologies
- use of satellite products for land and water sustainability in arid and semi-arid watersheds including studies on recurring floodings and their impact
- paleoclimate
- heritage-led and conservation-friendly resilience enhancement and sustainable reconstruction of Historic Areas to cope with Climate Change and natural hazards

HIGHLIGHTS

The University of Bologna has led and has been involved in several solutions-oriented national and European funded projects, among them: [**MADFORWATER**](#) - *DevelopMent AnD application of integrated technological and management solutions FOR wasteWATER treatment and efficient reuse in agriculture tailored to the needs of Mediterranean African Countries*; [**OPERANDUM**](#) - *OPEn-air laborATORies for Nature baseD solutions to Manage environmental risks H2020*; [**SOCLIMPACT**](#) - *DownScaling CLimate imPACTs and decarbonisation pathways in EU islands, and enhancing socioeconomic and non-market evaluation of Climate Change for Europe, for 2050 and beyond*, [**AtlantOS**](#) - *Optimising and Enhancing the Integrated Atlantic Ocean Observing Systems*, and [**SHELTER**](#) - *Sustainable Historic Environments hoListic reconstruction through Technological Enhancement and community based Resilience*.

The University of Bologna participates in the Ice-core drilling in East Antarctica: actions should build on the outcomes of the Horizon 2020 project [**Beyond EPICA**](#) and contribute to the European endeavor which aims to obtain a 1.5 million year old ice-core from East Antarctica.



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INDUSTRIAL SYMBIOSIS

Moving towards a more collaborative and integrated industrial ecosystem through an exchange of materials, water, energy stream, services and expertise.



Research at the University of Bologna covers a wide range of topics:

- Characterisation of the Italian and European industrial ecosystems such as the industrial district, EIP (Eco-industrial park) and APEA (Area produttiva ecologicamente attrezzata)
- Methodology and tools for the industrial symbiosis implementation
- Designing plants integration for energy efficiency
- Categorizing productive sectors and mapping industrial activities
- Supporting digital platforms through ICT and database tools for triggering data collection, stakeholders involvement and exchange opportunities
- Exploring the valorisation of the industrial waste as secondary raw material within the industrial ecosystem
- Exploring the opportunity to use by-products, debris and remains within the industrial ecosystem
- Designing potential synergies and matching among firms
- Developing new plants, processes and technologies for services, utilities and infrastructure sharing and process/products valorisation
- Assessing environmental and economic impact through LCA and LCC studies for alternative and more sustainable scenarios
- Policy and legislative recommendations for promoting the application of a circular economy approach among companies
- Designing new and competitive business models based on a circular economy approach

HIGHLIGHTS

The University of Bologna has established an extensive network of collaborations with multi-utilities, public authorities, SME and industries; it is also **participating in the Symbiosis Users Network (SUN)** and it is **partner of the EIT Raw Materials and the EIT Climate-KIC**.

The University of Bologna contributes to the European progress in research and innovation **taking part to several funded projects**, such as: **TRIS - Transition Regions Towards Industrial Symbiosis as member of the Industrial Symbiosis Lab - Emilia Romagna Region**; **the FLAGSHIP EIT CLIMATE KIC: Re-industrialise, e-Circular, INSIGH, Surplus mall**; **the POR-FESR 2014-2020 - GREEN CHARCUTERIE** aimed at innovating the pig industry through the valorisation of vegetable by-products and the use of advanced process technologies for the sustainable production of meat and cured meat having a positive impact on health; **VALSOVIT** for the sustainable valorisation of the wine industry waste in the chemical, cosmetics and nutraceutical sectors; **SOSTINNOVI** on sustainability and Innovation in the Wine Supply Chain.



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RAW MATERIALS

A sustainable and effective supply for primary and secondary raw materials management and process. Multidisciplinary research groups of the University of Bologna are developing technological and management solutions for primary and secondary raw materials processing.



The research of the University of Bologna covers a wide range of issues:

Raw Materials Engineering

- Principles of mineral processing and plant design
- Raw materials for industry and for construction
- Substitution of Critical Raw Materials (CRMs): production and treatment optimization for innovative, low CRM, high-performance metallic materials
- Design and analysis of dedicated materials chain by a life cycle assessment approach

Exploitation of earth resources

- Characterization, modelling, and exploitation of mineral deposits
- Evaluation of resources and reserves also by geostatistical analysis
- Reclamation in planning, design and requalification projects

Secondary Raw Materials processing

- Recycling of raw materials, disassembly and mechanical treatment plants, removing of hazardous, rare earths elements and valuable components
- Development of new processes and technologies for secondary raw materials production from end-of-life products (WEEE, end-of-life tyres and vehicles, concrete and inert waste)
- Application of life cycle assessment (LCA)
- Implementation of circular economy and industrial symbiosis and development of models for secondary raw material in the anthroposphere analysis

HIGHLIGHTS

Facilities and equipments

The University of Bologna can count on:

- Laboratories for solid material characterization
- Circular Economy Lab for WEEE (Waste from Electrical Electronic Equipment) and CDW (Construction and Demolition Waste)
- Circular Economy Biotechnologies lab
- Instruments for soil and plant C and mineral determination, for mineral N in soil determination and for plant photosynthesis measurements

Collaborations and international research projects

The collaborations of the University of Bologna in the field span industries, multi-utilities, local authorities and research centers.

The University is partner of the EIT Raw Materials and the EIT Climate-KIC and it is involved in several international projects aiming at developing innovative solutions.

The University of Bologna is also member of the European Innovation Partnership on Raw Materials and it takes part to the activities of its Operational group whose mission is to provide high-level guidance to the European Commission, Members States and private actors.




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RENEWABLE ENERGY

The development of the most impactful technologies enabling the accomplishment of a low-carbon energy society is one of the main drivers of contemporary research in the area of energy.

Research at the University of Bologna on Renewable Energy regards the development of models and techniques to foster the inclusion of RES into energy systems (electric, thermal, etc.).



Renewable Energy integration into Energy Systems: Advanced monitoring and control solutions of stability in electric networks with large penetration of RES; Development of advanced electrochemical storage systems for energy systems with large penetration of RES; Development of technologies and components that support enhanced integration of renewables and storage combined with intelligent control of the power flow; Design and optimization of cogeneration and trigeneration systems based on RES; Exploitation of advanced communication networks for fostering RES penetration into the electric grid; Integration of ground source heat pump and of aquifer thermal energy storage with groundwater and soil remediation.

Onshore & Off-shore Wind: Models for environmental and economic evaluation of **wind turbines**; Modelling and simulation of **airborne wind energy converters**; Design and techno-economic analysis of **multi-purpose offshore platforms** for marine renewable energy harvesting.

Ocean energy: Design of wave energy converters for **combined energy production and coastal protection** purposes; Design, manufacturing and testing of **all-polymer wave energy converters** with high performance and low cost.

Geothermal energy: Characterization of **geothermal reservoirs** for the climatization by **heat pumps**; Numerical simulation of **reservoirs, aquifers and geothermal fields**; Design and simulation of ground heat exchangers (shallow geothermics); Geochemical survey on **thermal waters and gas discharges** in geothermal sites; Dynamic simulation and optimization of **vertical ground heat exchangers and of heat pump** systems; Design and technoeconomic analysis of geothermal heat pumps.

Next generation of solar photovoltaics (PVs): Manufacturing of flexible **organic photovoltaic cells**; Manufacturing and characterization of **polythiophene based photovoltaic** devices; Manufacturing and characterization of **germanium thin film photovoltaic** devices; Defect characterization of **silicon** (crystalline, multi and nano-crystalline, amorphous) for PV applications; Technoeconomic analysis of **thermophotovoltaic systems**.

HIGHLIGHTS

European Projects:

[LEAP-RE](#) - Long-Term Joint EU-AU Research and Innovation Partnership on Renewable Energy H2020

[Hybrid-BioVGE](#) - Hybrid Variable Geometry Ejector Cooling and Heating System for Buildings Driven by Solar and Biomass Heat H2020

[GEOTECH](#) - Geothermal Technology for Economic Cooling and Heating H2020

[MERMAID](#) - Innovative Multi-purpose Offshore Platforms: planning H2020

[CORES](#) - Components for Ocean Renewable Energy Systems FP7



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WASTE MANAGEMENT

Moving towards a sustainable and integrated management of the waste cycle.



The research of the University of Bologna covers a wide range of issues:

Prevention

Design of policy interventions and environmental impact assessment methodologies; Production, stabilization and packaging of stable by-products/ raw material; Implementation of industrial symbiosis practices and exchange of materials among different value chains - Food waste: Georeferenced mapping of industrial food by-products; Analysis of consumers and business behaviour; Awareness campaigns to sensitize population

Re-use

Development of a new generation of reliable, robust and cost-effective packaging materials; Recommendation on legislation to re-use components from end-of-life products

Recycling

Pre-treatment plants to remove hazardous, rare earths and valuable components; Development of urban systems and technologies for circular and regenerative cities; Development of new plants, processes and technologies to recycle by-products and secondary raw materials from end-of-life products; Application of LCA to assess alternative recycling scenarios

Recovery

Innovative waste to energy plants; Chemicals and energy recovery from biomass

Disposal

End of life landfills

HIGHLIGHTS

The University is member of the Emilia Romagna Region [Food Crossing District](#). The **Italian Circular Economy Stakeholder Platform** and it is **partner of the EIT Raw Materials, EIT Food, EIT Climate-KIC**.

[LOWINFOOD](#) - Multi-actor design of low-waste food value chains through the demonstration of innovative solutions to reduce food loss and waste; [MERLIN](#) - Increasing the quality and rate of multilayer packaging recycling waste; [PRESERVE](#) - High performance sustainable bio-based packaging with tailored end of life and upcycled secondary use; [USABLE PACKAGING](#) - Unlocking the potential of Sustainable Biodegradable Packaging; [INGREEN](#) - Production of functional innovative ingredients from paper and agro-food side-streams through sustainable and efficient tailor-made biotechnological processes for food, feed, pharma and cosmetics; [RES URBIS](#) - Resources from urban bio-waste; [REFRESH](#) - Resource Efficient Food and dRink for the Entire Supply cHain; [NOAW](#) - Innovative approaches to turn agricultural waste into ecological and economic assets. [Bio-Based Industry JU: FIRST2RUN](#) - Flagship demonstration of an integrated biorefinery for dry crops sustainable exploitation towards; [Agrimax](#) - Developing and demonstrating the production of multiple, high-value products from crop and food-processing waste.



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WATER RESOURCE MANAGEMENT

*Moving towards a sustainable
management of the different steps
of the integrated water cycle.*

The University of Bologna is developing technological and management solutions to increase the sustainability of water management.



The research of the University of Bologna covers a wide range of issues:

Drinking water

Water demand modelling; Optimisation of reservoir management and alternative water resources; Leakage reduction and energy efficiency in water distribution.

Wastewater and groundwater

Technologies for energy-efficient wastewater treatment and reuse, including fluid-dynamic analysis of equipment, nature-based solutions, membrane processes for water treatment and desalination, maintenance of water treatment & purification plants; Recovery and bioproduction of chemicals and biofuels from wastewater; Urban green technologies for wastewater valorisation; Bioremediation of aquifers; Geothermal energy production.

Water use in agriculture

Rainfall water collection, reuse and modelling; DSS for agricultural water management; IoT/ICT for precision irrigation; Modelling of salt ingress in agriculture in coastal areas.

Costs, benefits, impacts and risks

Costs/benefits, LCA and water footprint of water management solutions; Drought risk assessment; Water vulnerability analysis; Climate resilience and adaptation; Water policies and tariffs.

HIGHLIGHTS

Over the years the University of Bologna has been involved in national and EU funded **projects**, among them: [AQUAMONEY](#), [WATER4CROPS](#), [MINOTAURUS](#), [ULIXES](#), [FIGARO](#), [MOSES](#), [SWAMP](#), [GST4WATER](#), [AGROWETLANDS II](#), [SWITCH-ON](#), [TRUST](#), [SMART WATERTECH](#), [WATACLIC](#), [CLARA](#), [MADFORWATER](#), [H2020 OPERANDUM](#) - *OPEn-air laboRAtories for Nature baseD solUtions to Manage environmental risks*, **PROSUMER** - Technical and economic feasibility study on industrial symbiosis of the full supply chain of phosphorus with particular reference to food and dairy industrial sectors, EIT Climate-KIC, 2020.

Facilities and infrastructures

Several facilities for a sustainable management of water are available at the University of Bologna, including pilot plants for wastewater treatment, laser and tomographic techniques for equipment optimization, green roofs for rainwater collection and reuse, sediment-transport flumes, DSS and wireless networks for precision irrigation.

Collaborations

The University of Bologna has established an extensive network of collaborations with water authorities, satellite imaging and software companies, water service utilities, companies and NGOs active in the water supply and wastewater treatment sectors.