CIRCULAR FOOD SYSTEM LAB

A new Living Lab for the Twin Transition of Food Systems at the Politecnico di Milano

CIRCULAR FOOD SYSTEM LAB
POLITECNICO MILANO 1863

POLITECNICO | DIPARTIMENTO
MILANO 1863 | DI DESIGN

POLITECNICO | DIPARTIMENTO DI ELETTRONICA,
MILANO 1863 | INFORMAZIONE E BIOINGEGNERIA

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CIRCULAR FOOD SYSTEM LAB

POLITECNICO MILANO 1863

Circular Food System Lab (CFS Lab) is a research laboratory at the Politecnico di Milano, multidisciplinary and modular, focused on the circular transition and digital transformation of Food Systems in metropolitan, urban, and peri-urban contexts. CFS Lab develops competitive research and consultancy activities for businesses and institutions. Created by the Department of Design in collaboration with the Departments of Mechanical Engineering and Electronics, Information, and Bioengineering, CFS Lab is structured as a **Living Lab** that collaborates with various external contexts and their circularity initiatives.

CFS Lab researches and develops product-service and process solutions for the **circular innovation of Food Systems**, with the main reference being the Farm to Fork Strategy (EU Green Deal 2020) and its objectives: the ecological transition of agri-food systems, the consumption of sustainable foods, the reduction of food waste, the adoption of healthy eating behaviors, and the enhancement of biodiversity in Agri-Food Systems.

The laboratory, active since the beginning of 2025, is funded through PNRR funds via MUSA (*Multilayered Urban Sustainability Action*), an innovation ecosystem for urban regeneration, born from the collaboration between the University of Milano-Bicocca, Politecnico di Milano, Bocconi University, and the University of Milan.
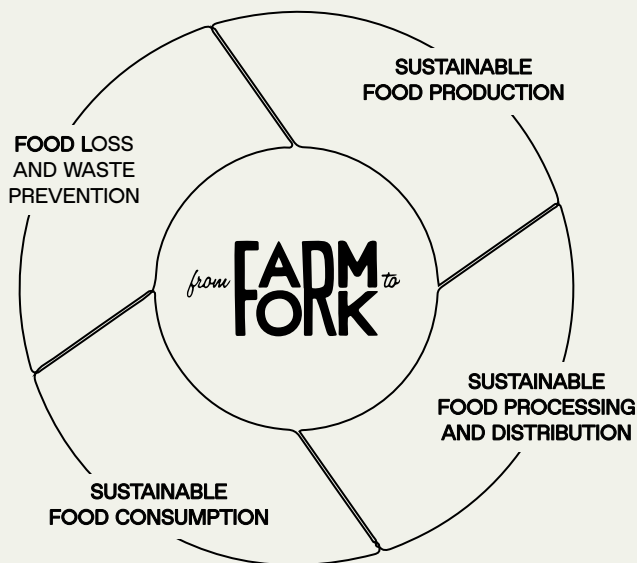
WHAT DO WE DO ✳

CFS Lab focuses on **competitive research** on Circular Food Systems, providing **consultancy** for circular innovation to businesses and organizations, developing **patents and start-ups** dedicated to food systems, and **public engagement** to promote circularity within agri-food systems.

CFS Lab adopts an action-research approach and practical experimentation, developing **pilot projects** and **proof of-concept** for Food Systems at the territorial scale. It combines design-driven and technological innovation, including open-source solutions, in the fields of mechanical engineering, computer science, electronics, and bioengineering, to create solutions applicable to products and services dedicated to Circular Food Systems.

SUSTAINABLE
FOOD PRODUCTION

FOOD LOSS
AND WASTE
PREVENTION

from FARM to FORK

SUSTAINABLE
FOOD PROCESSING
AND DISTRIBUTION

SUSTAINABLE
FOOD CONSUMPTION

From Farm to Fork: https://food.ec.europa.eu/horizontal-topics/farm-fork-strategy_en
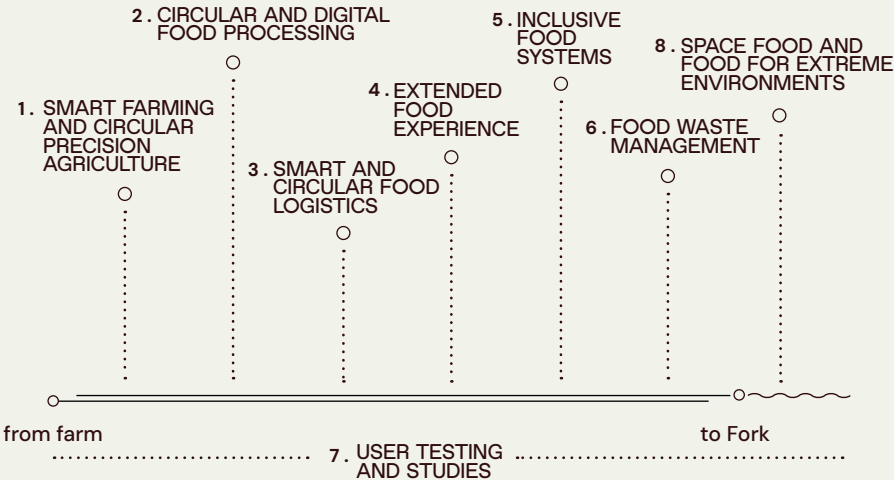
WHAT WE EXPLORE AND EXPERIMENT
Eight research ares to innovate from Farm to Fork.

1. **SMART FARMING AND CIRCULAR PRECISION AGRICULTURE**
   Solutions for vertical and urban farming, crop monitoring, biodiversity traceability, and waste valorization.

2. **CIRCULAR AND DIGITAL FOOD PROCESSING**
   Systems for alternative food processing, conservation, and tracking of material and energy flows.

3. **CIRCULAR AND SMART FOOD LOGISTICS**
   Solutions for transport, packaging, and tracking of goods, using circular materials and Digital Product Passport (DPP) for agri-food products.

4. **EXTENDED FOOD EXPERIENCE**
   Devices for extended reality (AR/VR) to enhance analysis and sensory experiences of Food Systems.

5. **INCLUSIVE FOOD SYSTEMS**
   Solutions for food redistribution, education, and access to Food Systems for vulnerable and disadvantaged communities.

6. **FOOD WASTE MANAGEMENT**
   Innovative systems for the collection, sorting, and recycling of food waste and post-consumer materials.

7. **USER TESTING E STUDIES**
   Innovative tools to test new product and service solutions with users in research and consultancy projects.

8. **SPACE FOOD AND FOOD FOR EXTREME ENVIRONMENTS**
   Solutions for producing and consuming food in space and in environments made extreme by climate change.

CFS Lab operates across the entire agri-food supply chain, following the objectives of the Farm to Fork Strategy. The area of user testing and studies is transversal to the research areas and vertical specializations, as CFS Lab operates as a Living Lab, adopting a user-centered and open innovation approach.

THEMATIC AREAS OF INTEREST OF CFS LAB

2. CIRCULAR AND DIGITAL FOOD PROCESSING

5. INCLUSIVE FOOD SYSTEMS

8. SPACE FOOD AND FOOD FOR EXTREME ENVIRONMENTS

1. SMART FARMING AND CIRCULAR PRECISION AGRICULTURE

4. EXTENDED FOOD EXPERIENCE

6. FOOD WASTE MANAGEMENT

3. SMART AND CIRCULAR FOOD LOGISTICS

from farm

to Fork

7. USER TESTING AND STUDIES

CFS LAB: MODULES AND COMPETENCES

A Living Lab with three physical spaces across the Bovisa campuses of the Politecnico di Milano.

CIRCULAR DESIGN FOR FOOD SYSTEMS is the module that coordinates CFS Lab. It is managed by **Polifactory**, the makerspace of the Politecnico di Milano active in the Department of Design. Physically integrated into the Fab Lab, this module specializes in research, circular design, and prototyping of interactive product–service systems for Food Systems. il modulo che coordina il CFS Lab.

CIRCULAR LOGISTICS FOR FOOD SYSTEMS is the module managed by the **IoT Lab** of the DEIB Department. It is physically located in MADE, the Competence Centre for Industry 4.0 at the Politecnico di Milano. This module specializes in the development of tech solutions (IoT and ICT) for logistics, traceability, monitoring, and control of circular agri–food supply chains.

RECOVERY AND RECYCLING FOR FOOD SYSTEMS is the module managed by **The Manufacturing Lab** of the Department of Mechanical Engineering. Physically located in the Bovisa La Masa Campus, it develops high–tech solutions (mechanics–automation) for the recovery, recognition, sorting, and treatment of waste and post–consumer materials related to Food Systems.

CAMPUS LA MASA

Module 1
B3, c/o Polifactory

Module 2
B8, c/o MADE

CAMPUS DURANDO

Module 3
B23, c/o The
Manufacturing Lab

CFS Lab across the Bovisa campuses

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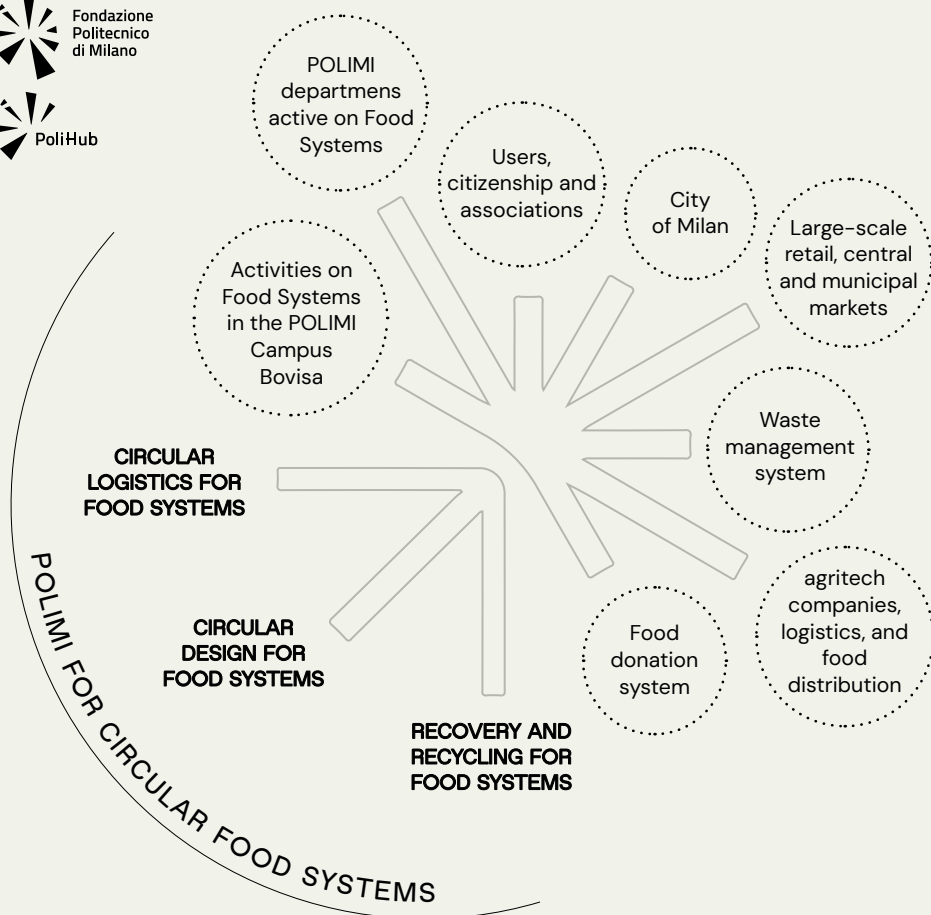MILANO 1863 | INFORMAZIONE E BIOINGEGNERIA

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Fondazione
Politecnico
di Milano

PoliHub

POLIMI departmens active on Food Systems

Users, citizenship and associations

City of Milan

Large-scale retail, central and municipal markets

Activities on Food Systems in the POLIMI Campus Bovisa

Waste management system

CIRCULAR LOGISTICS FOR FOOD SYSTEMS

agritech companies, logistics, and food distribution

CIRCULAR DESIGN FOR FOOD SYSTEMS

Food donation system

RECOVERY AND RECYCLING FOR FOOD SYSTEMS

POLIMI FOR CIRCULAR FOOD SYSTEMS

The three modules of CFS Lab create a Living Lab for Food Systems that experiments with design and technologies in real-world contexts and conditions, with actors from the production world, public and private entities and institutions, citizens, and their associations. The Lab promotes synergies with social innovation initiatives on Food Systems active at the Politecnico di Milano, with the city of Milan and its Food Policy, with agritech companies and food distribution, and with food waste management and food donation networks.

MODULE 1
CIRCULAR DESIGN FOR FOOD SYSTEMS

Design solutions – strategies, product–service systems, processes, and tools for the circularity of Food Systems.

POLIFACTORY
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c/o Polifactory,
Via Candiani 72, Politecnico di Milano,
Campus Bovisa–Durando,
Building B3, Milano, 20158

https://www.polifactory.polimi.it/

STAFF

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Coordinator of the Specializing Master in Design for
Food Systems, POLI.design

SPECIALIZED EQUIPMENT AND TOOLS

Smart Farming e Circular Precision Agriculture	System for vertical and indoor farming with aeroponic systems and growing boxes.
	IoT devices and drones for precision agriculture.
	Garden equipped for smart and collaborative farming (project under development)
Extended Food Experience	Workstations equipped with fluorescent light sets for sensory analysis of food.
	Instruments for the analysis of the chemical and organoleptic properties of food (spectrophotometer, colorimeter, hygrometer, pH meter, refractometer, probe thermometer, electronic nose, dynamometer)
Smart & circular food logistics, inclusive food systems e circular food waste	Set of readers and terminals for traceability and identification (RFID systems, antennas, and smart gates)
Circular food processing	Catering equipment: • Professional kitchen furniture system • Smart refrigerator with AI food recognition • Combination convection and steam oven • Softcooker for low-temperature cooking • Set of professional appliances (microwave oven, blast chiller-freezer, proofing chamber, multifunction kitchen robot, slow-speed juicer, dehydrator) Food processing equipment: • Electric grain mill and flaker • Freeze dryer (lyophilizer) • Rotovapor (rotary evaporator) • Essential oil distiller • Molecular gastronomy kit Laboratory and Precision Instruments: • Ultrasonic food treatment tank • Bench and laboratory weighing instruments • Food incubator

MULTIPURPOSE EQUIPMENT AND TOOLS

Digital Fabrication	3D Printers: • FELIX Switch Head Food 3D Printer • MSLA Formlabs Form 4B compatible with medical-grade materials • LDM Wasp 40100 for high-viscosity materials • FDM Original Prusa XL with 5 extruders • FDM Bambu Lab X1 Carbon with AMS
Physical Computing	Workstation equipped with tools for electronics, microcontrollers, microprocessors, and sensors for IoT prototypes
Robotics and automation	Universal Robot UR5e Cobot with a 5 kg payload, Robotiq 2F-140 grippers, and a Cobot Station Mini workstation
Extended Reality	Workstation for interactive simulations in virtual reality with Meta Quest Pro headsets and standalone 3D scanner

MODULO 2
CIRCULAR LOGISTICS FOR FOOD SYSTEMS

Tech solutions (IoT and ICT) for logistics, traceability, monitoring, and control of agri–food supply chains

IoT Lab

c/o IoT Lab / Centro MADE,
Via Candiani 72, Politecnico di Milano,
Campus Bovisa–Durando,
Building B8, Milan, 20158

www.iotlab.polimi.it

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Full Professor, Department of DEIB,
Scientific Director ANTLab

Team

Mattia Cerutti
Researcher, Department of DIG,
Operative Director IoT Lab

Sanders Batista
Research Fellow, Department of DEIB

SPECIALIZED EQUIPMENT AND TOOLS

Smart Farming Sensoristics	Sensors: • Acidity sensors (pH) • Nitrogen, Phosphorus, Potassium (NPK) sensors • Water hardness sensors (TDS) • Wind speed sensors
General Sensoristics	Sensors: • Thermal camera (infrared) • Camera • Temperature, Pressure, Humidity, Presence sensors • Volumetric sensors

MULTIPURPOSE EQUIPMENT AND TOOLS

Hardware Platforms	• Raspberry PI 5 8GB • Jetson Orin Nano Dev. Kit • Impinj IPJ R700 RFID Reader • Kathrein WRA 3070 Antenna
Connectivity	• Development boards for Wireless Short-Range • Development boards for Wireless Long-Range

MODULE 3

RECOVERY AND RECYCLING FOR FOOD SYSTEMS

Tech solutions (mechanical and auto-mation) for the recovery, sorting, and treatment of post-consumption mate-rials from Food Systems

c/o The Manufacturing Lab, Via Giuseppe La Masa 1, Politecnico di Milano, Campus Bovisa – La Masa, Building B23, Milan, 20158

https://tecnologie.mecc.polimi.it/labora-tory_en.htm

STAFF

Coordinator

Giorgio Colombo
Full Professor, Department of Mechanical Engineering, Scientific Director The Manufacturing Lab

Team

Marco Rossoni
Researcher, Department of Mechanical Engineering

SPECIALIZED EQUIPMENT AND TOOLS

Food Waste Depackaging	Station for the study and simulation of (de-)packaging of food packaging, consisting of a collaborative robot and a tracking system integrated with immersive visualization solutions
Artificial Olfactory System	AI-based system for recognizing and classifying odors in a controlled environment

MULTIPURPOSE EQUIPMENT AND TOOLS

Robotics and automation	Universal Robot UR5e Cobot with a 5 kg payload, equipped with end-effectors such as grippers and vision systems
Extended Reality	Workstation for interactive simulations in virtual reality equipped with Meta Quest headset
Physical Computing	• Nvidia Jetson Nano • Raspberry Pi 4 8 GB • Sensori Bosch BME688
Tracking System	8-camera Vicon tracking system

PORTFOLIO
Research and innovation projects developed by the modules of the CFS LAB.

SMART FARMING AND CIRCULAR PRECISION AGRICULTURE

HERBULA

Polifactory
Department of Design

Prototype and proof-of-concept developed in the T-Factor project (Horizon2020, 2020–2024). The Herbula system enables the exploration of urban biodiversity through experimental and educational activities that enhance the knowledge and care of local natural resources.

IoT system for mapping biodiversity within urban ecosystems.

www.polifactory.polimi.it/portfolio/t-factor/

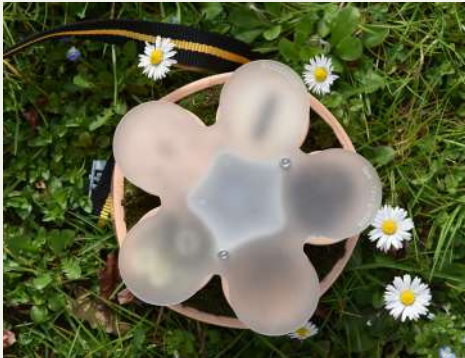## DISTRIBUTED FOOD FACTORY - DISTRIBUTED DESIGN

Polifactory
Department of Design

Initiative conceived and developed by Polifactory within the 2023–2024 edition of the Creative Europe Distributed Design project, dedicated to designing open-source solutions for studying Food Systems at both macro and micro levels.

Open Farmer Kit is a semi-automated system for mapping and monitoring urban and social farming contexts.

Circle Fermenter is a semi-professional modular fermenter for experimenting with plant-based food transformations and supporting forms of small-scale self-production.

3ee is an open-source system based on acoustic technologies, designed to identify, classify, and monitor pollinator species in urban contexts.

www.polifactory.polimi.it/portfolio/distributed-food-factory/

https://distributeddesign.eu/

Distributed Design

Co-funded by the European Union

OPEN FOOD FACTORY DISTRIBUTED DESIGN

Polifactory
Department of Design

Initiative conceived and developed by Polifactory within the 2022–2023 edition of the Creative Europe Distributed Design project, dedicated to designing open-source solutions for plant-based nutrition.

Hacko uses distributed design to make Nukazuke, an ancient Japanese fermentation technique, an accessible and reproducible process across different cultures.

Breath is a system with 3D-printed valves for lacto-fermentation, a domestic food preservation method that values every part of the food by enhancing its flavors and reducing waste.

Olea is an open-source distiller that reversibly adapts common household objects to facilitate the separation of essential oils, hydrolates, and water

www.polifactory.polimi.it/en/portfolio/open-food-factory-ddp/

https://distributeddesign.eu/

Distributed Design

Co-funded by the European Union

FOOD MARKET 4.0 DASHBOARD

Polifactory
Department of Design

Reflow is a Horizon 2020 innovation project (2019 – 2022) that explores urban metabolism and the circular economy within European cities.

Food Market 4.0 Dashboard is a system conceived by Polifactory as part of the pilot project developed in Reflow with the Municipality of Milan to test innovative product-service solutions for urban circularity at the business and policy-making levels.

Food Market 4.0 Dashboard is an integrated and circular system of IoT hardware and software solutions (Smart Scale, Smart Gate System, and Digital Dashboard) designed to track and monitor the flow of fruit and vegetables purchased and sold in Milan's covered municipal markets.

www.polifactory.polimi.it/en/portfolio/reflow/

https://reflowproject.eu/

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CIRCULAR AND DIGITAL FOOD PROCESSING

Funded by the Horizon 2020
Framework Programme of the
European Union

ROSE

Department of Mechanical Engineering

ROSE (Restoring Odorant Detection and Recognition in Smell Deficits) is a Horizon 2020 project (2019–2022) focused on the proof-of-concept for prosthetic devices designed to support individuals with olfactory impairments, by experimenting with miniaturized odor sensors and stimulation arrays supported by artificial intelligence.

www.mecc.polimi.it/en/about-us/news/the-rose-project-to-help-people-with-loss-of-smell

INCLUSIVE FOOD SYSTEMS

New European Bauhaus
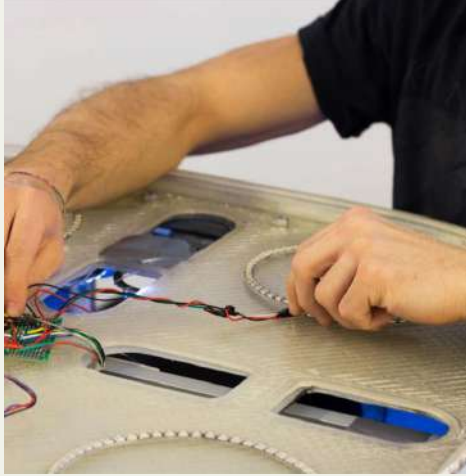beautiful | sustainable | together

LA CUCINA COLLABORATIVA

(EIT Food - New European Bauhaus, with Caritas Reggiana)

La Cucina Collaborativa is a project that promotes the circularity of the food donation system through a co-design process involving an extensive local network of key actors. These actors are called upon to envision solutions that rethink the food donation system in the Reggio Emilia area, not only to reduce waste but also to support tangible processes of social inclusion.

www.designpolicy.eu/cucina-collaborativa/

ACT5G - VODAFONE 5G SMART CITY SMART CAMPUS

(Polifactory – ANT Lab – Department of DEIB)

A pilot project coordinated by Vodafone Italy aimed at designing and prototyping a smart gate for tracking the flow of people and goods in both indoor and outdoor spaces, and a smart bin for the automated sorting of urban waste.

www.polifactory.polimi.it/en/portfolio/vodafo-ne5g–challenge/

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