O3 - REPORT

Circular economy on rural territories trends and tools

15.07.2021 – 15.11.2021

Universitatea „Vasile Alecsandri" din Bacău

INTERNATIONAL HELLENIC UNIVERSITY

Politecnico di Torino

Universitat d'Alacant
Universidad de Alicante

INTELLECTUAL OUTPUT 3

MULTITRACES

Co-funded by the Erasmus+ Programme of the European Union

TABLE OF CONTENT

Circular economy and Systemic Design (Politecnico di Torino)

To present and explain the relationship between the Circular Economy and Systemic Design, a series of slides have been produced to emphasise this connection from a theoretical point of view, but also from a practical one by showing case studies carried out by the research group in Systemic Design of the Politecnico di Torino.

The three macro sections in which we can categorise the slides presented are:

- Theoretical-methodological introduction of Systemic Design and Circular Economy (2)
- Practical case studies and project outputs (2)
- Presentation of partners that collaborate with the research group in Systemic Design (1)

The relationship between Design, in particular Systemic Design, and the Circular Economy presents a significant trend that for several years has been highlighting new approaches to design for the creation of impacts that are as positive as possible in terms of environmental, social and economic sustainability.

The first category of slides introduced, firstly, the Systemic Design approach, analysing in detail the aspects that characterise and distinguish this design methodology. It also presented the methodological steps that are addressed in the definition of a SD project. According to the same category it has been important to highlight the main concepts related to Circular Economy to define it. Additionally, the Circular Economy definition has related to the European vision of how Europe tries to move towards a new economic and productive model with a new Circular Paradigm. All these aspects have been interconnected with the rural areas, by showing the challenges and the potentialities that nowadays they must face.

To better explain the relations between these two approaches it has been defined in another section with practical case studies to show all the concepts applied to specific areas and context. The project called EnFAsi was a Regional funded project related to a local supply chain and production to reuse the output from the Cuneo local context. Instead, the Retrace project has been an Interreg Europe project to apply Systemic Vision for the defined Regional Circular Policies.

The last slides section is related to the partners and stakeholders that often collaborate with the Systemic Design Lab at Politecnico di Torino. The Polo Agrifood presentation shows the main topics on which they work on, related to Circular Economy in rural areas to develop projects with Universities and Companies placed in the Piedmont Region.

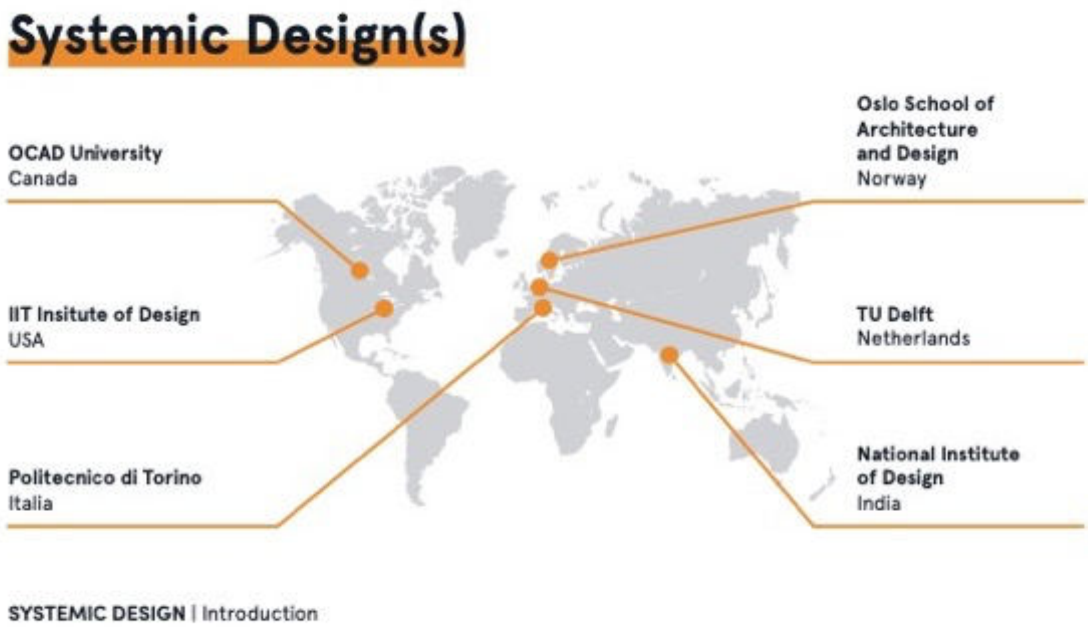
The Systemic Design Introduction

By Silvia Barbero, PhD
Associate Professor - Politecnico di Torino
Chair - Systemic Design Association


Politecnico di Torino
MULTITRACES
Introduction
September 28th, 2021
MULTITRACES joint staff training event
Circular Economy in rural territories
Trends and tools
Silvia Barbero, PhD
Associate Professor - Politecnico di Torino
Chair - Systemic Design Association
SYSTEMIC DESIGN


What do you think Systemic Design is?
SYSTEMIC DESIGN | Introduction


"Systemic Design
is a design discipline
that provides practical tools
to approach complex scenarios
with an holistic perspective,
while supporting active cooperation
among the involved stakeholders"
Giraldo Nohra, Pereno & Barbero, 2020
SYSTEMIC DESIGN | Introduction


Systemic Design(s)
OCAD University
Canada
IIT Insitute of Design
USA
Politecnico di Torino
Italia
Oslo School of
Architecture
and Design
Norway
TU Delft
Netherlands
National Institute
of Design
India
SYSTEMIC DESIGN | Introduction

Systemic Design

Approach

Systemic Design deals with **material, energy and information flows** in order to develop **open systems** in which **the output of a process becomes the input for another one**, avoiding waste and reaching zero emissions.

This methodology can be successfully applied and adapted to numerous contexts like **SMEs and industries** from different sectors (agrifood, buildings and constructions, energy etc.), **cities, regions** and **territorial/cultural heritage sites**.

SYSTEMIC DESIGN | Introduction

Systemic Design

Approach

SYSTEMIC DESIGN | Introduction

Systemic Design

Pillars

Outputs > inputs
The outputs of a system become the inputs for another productive chain.

Relationships
Relationships generate the open system itself.

Autopoiesis
Autopoietic systems support and reproduce themselves by co-evolving together.

Acting locally
The context in which we operate is fundamental and has priority over the outside world.

Human-centred design
The human being in relation to his or her environmental, social, cultural and ethical context is the focus of the project.

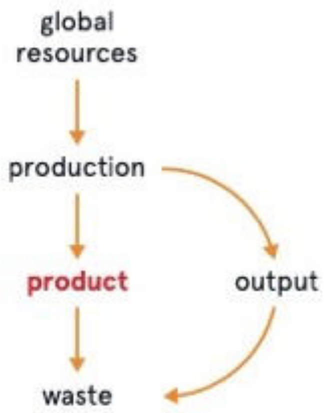
SYSTEMIC DESIGN | Introduction

Systemic Design

Paradigm Shift

Linear
production model

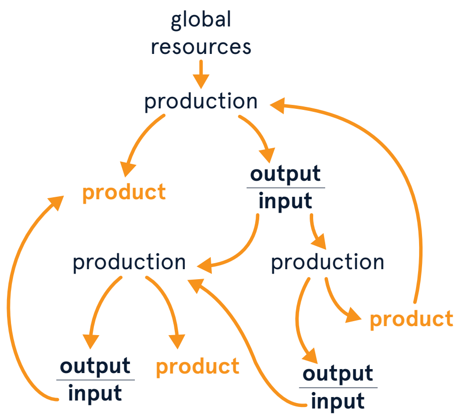
\ Product = Quantity
\ Economic value
\ Strong competition
\ Low interest in waste



SYSTEMIC DESIGN | Introduction

Systemic Design

Paradigm Shift



Systemic
production model

\ Balanced engagement of all actors

\ Networks of local relationships

\ Waste turns into a resource

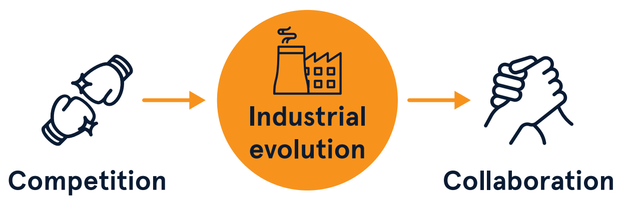
SYSTEMIC DESIGN | Introduction

Systemic Design

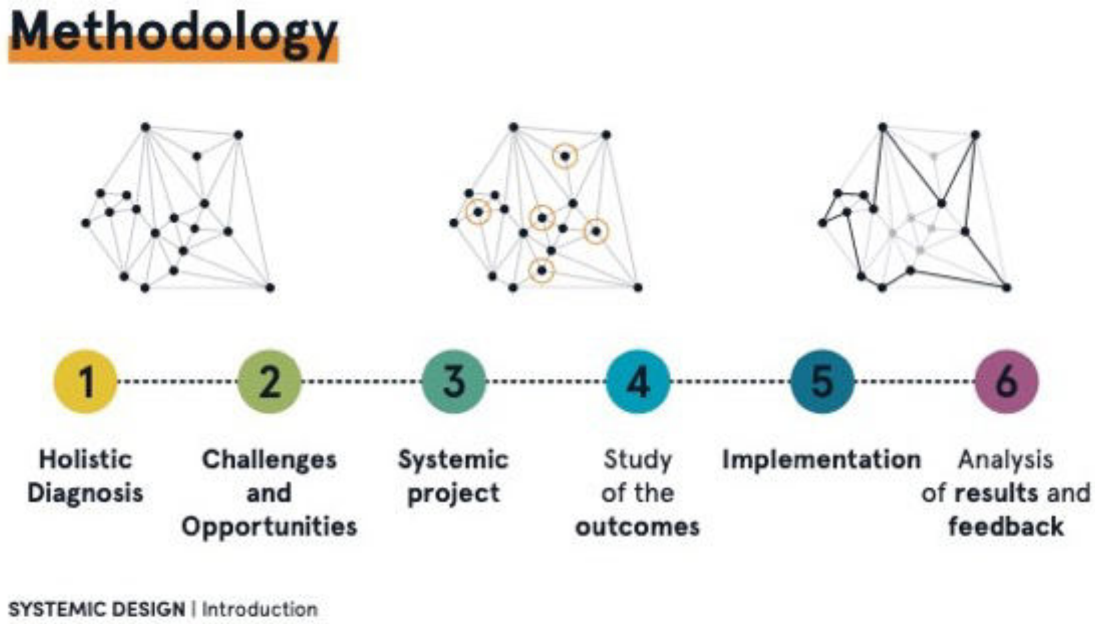
Paradigm Shift

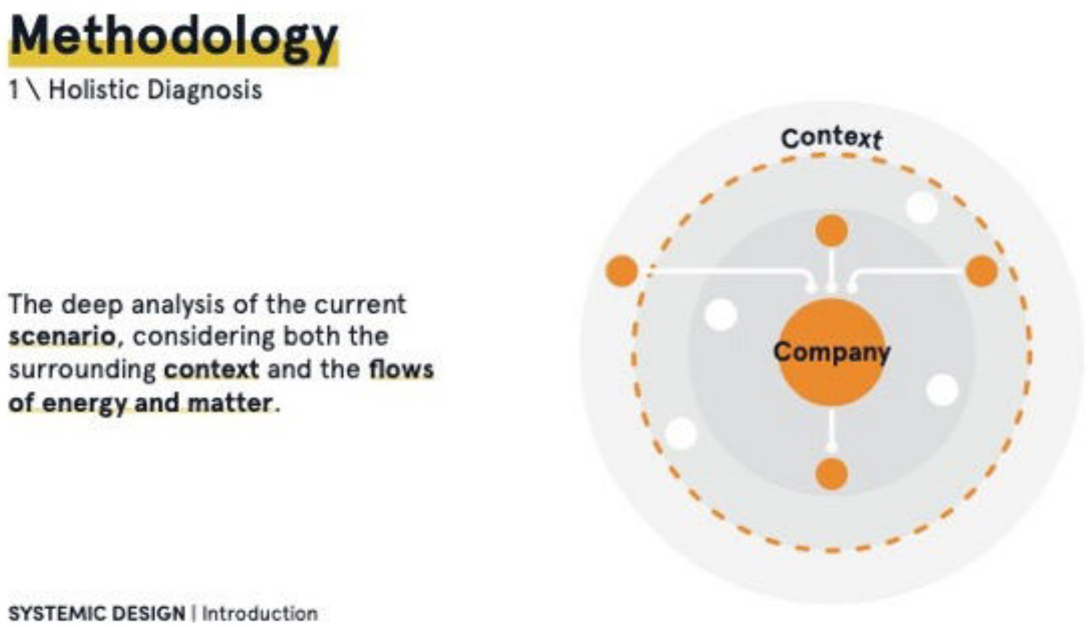
Linear production model

Systemic production model



SYSTEMIC DESIGN | Introduction

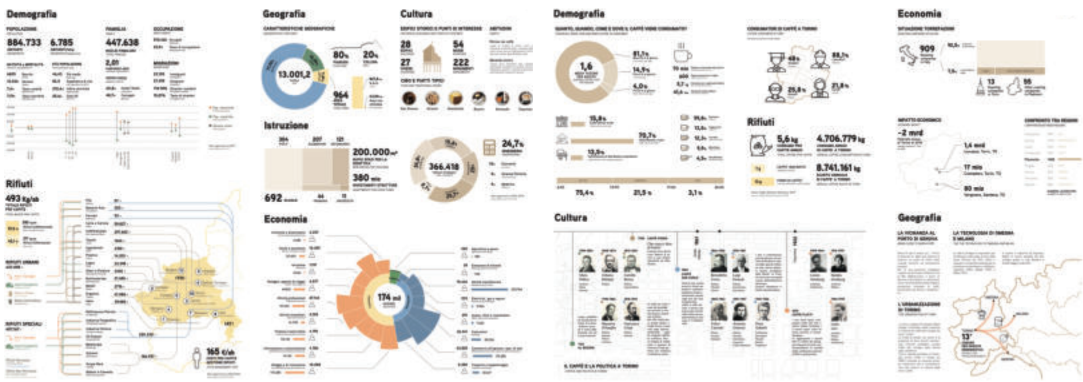

Methodology
1
2
3
4
5
6
Holistic Diagnosis
Challenges and Opportunities
Systemic project
Study of the outcomes
Implementation
Analysis of results and feedback
SYSTEMIC DESIGN | Introduction


Methodology
1 \ Holistic Diagnosis
The deep analysis of the current scenario, considering both the surrounding context and the flows of energy and matter.
Context
Company
SYSTEMIC DESIGN | Introduction

Methodology

1 \ Holistic Diagnosis example

Costadoro: Systemic coffe transformation
Academic year 2018/19
Courtesy of S. Bellisario, V. Bosso, F. Citarda, E. Giacometti, E. Molina, G. Vecelli



Methodology

1 \ Holistic Diagnosis example

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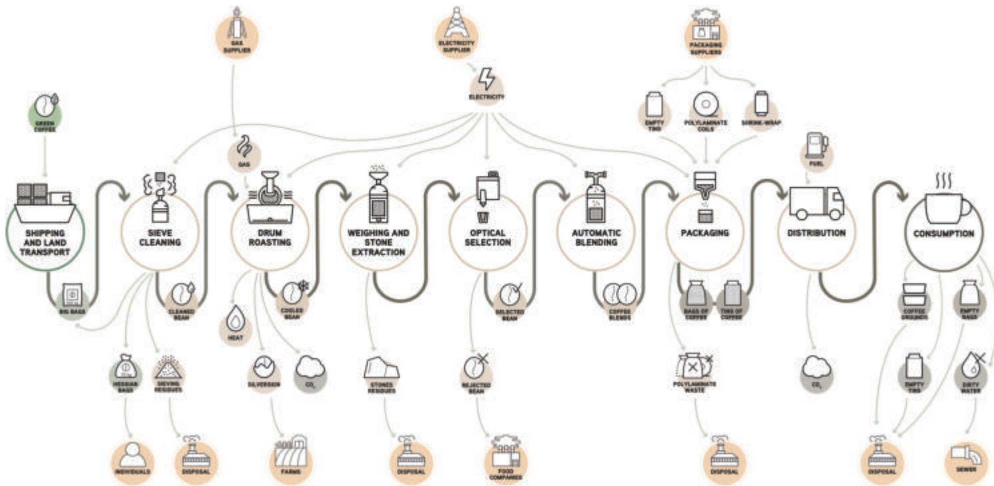
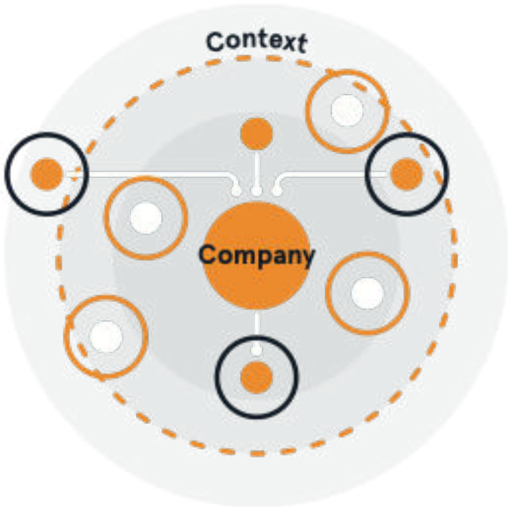


Methodology

2 \ Challenges and Opportunities

The identification of **challenges and opportunities** of the current scenario and its flows.



SYSTEMIC DESIGN | Introduction

Methodology

2 \ Challenges and Opportunities example

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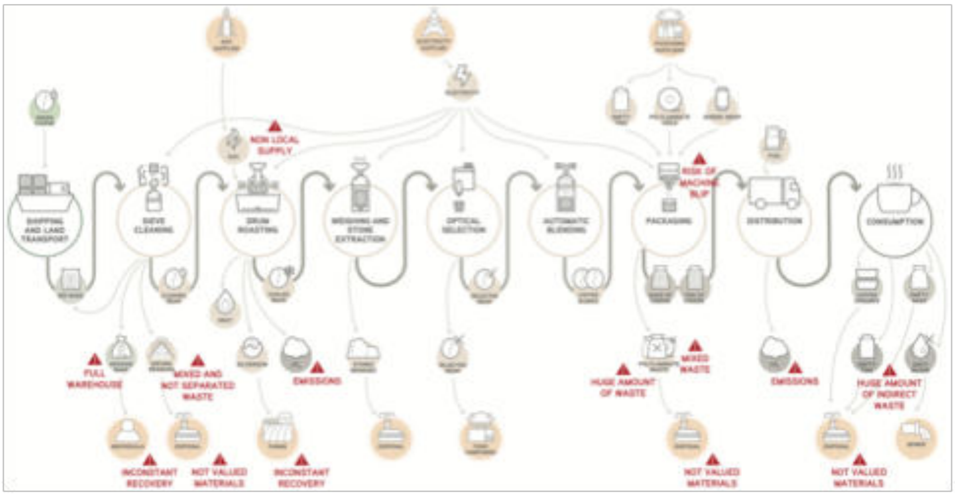

Methodology

2 \ Challenges and Opportunities example

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Methodology

2 \ Challenges and Opportunities example

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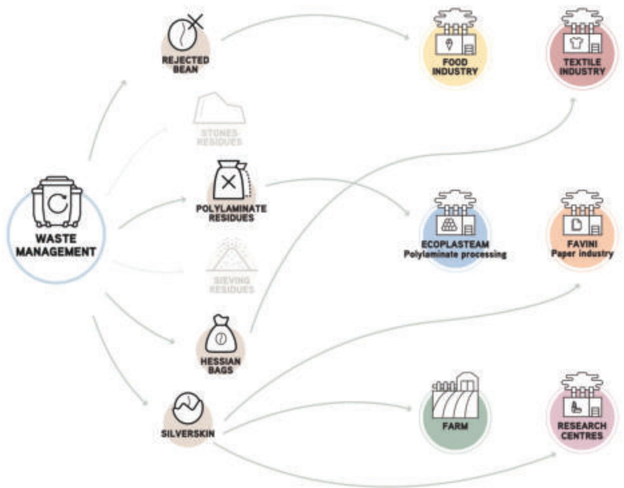
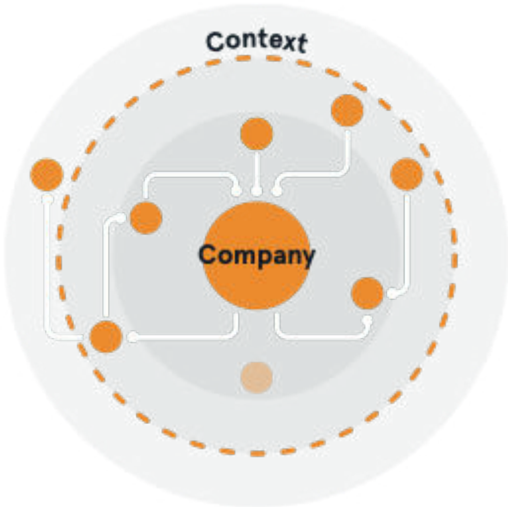


Methodology

3 \ Systemic Project

The design of a **new systemic model based on relationships** between processes and actors, which optimizes energy and material flows and gives value to waste as resources.



SYSTEMIC DESIGN | Introduction

Methodology

3 \ Systemic Project example

Costadoro: Systemic coffe transformation
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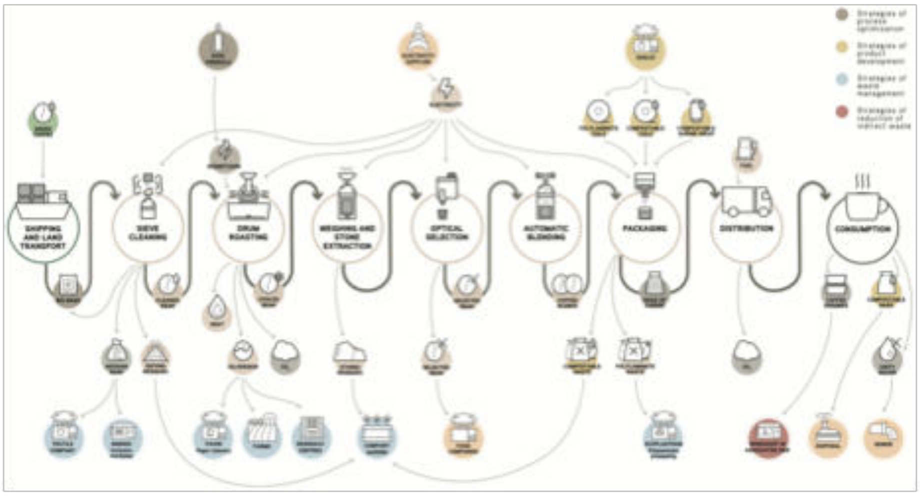
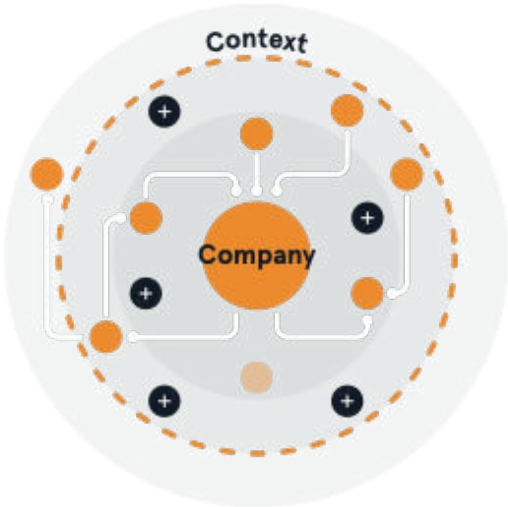


Methodology

4 \ Study of the outcomes

The identification and the study of the new **outcomes generated by the new systemic model**



SYSTEMIC DESIGN | Introduction

Methodology

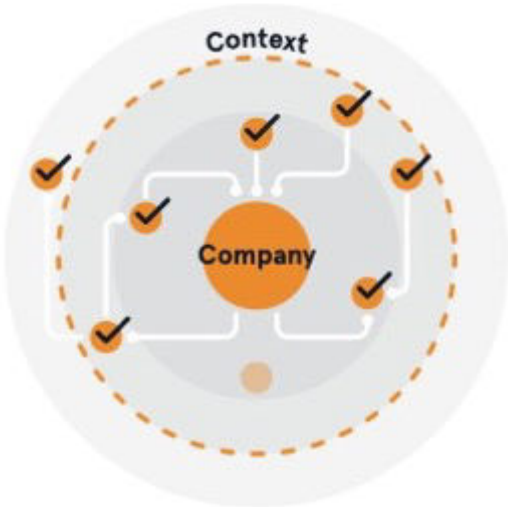
4 \ Study of the outcomes example

Costadoro: Systemic coffe transformation
Academic year 2018/19
Courtesy of S. Bellisario, V. Bosso, F. Citarda, E. Giacometti, E. Molino, G. Vecelli

Methodology

5 \ Implementation

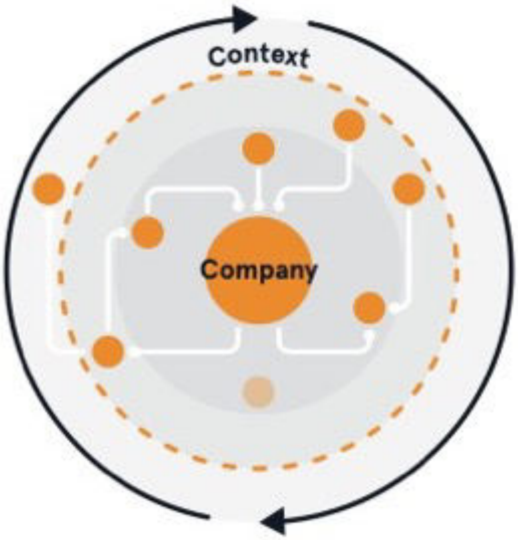
The system is **validated** from a feasability point of view with **studies and simulations**, then it is finally **put into effect** in the specific context.



Methodology

6 \ Analysis of results and feedback

Feedback following the implementation phase **continuously enable the discovery of new opportunities**, finally making the system **autopoietic**.



The Concept of Circular Economy

By Amina Pereno, PhD
Politecnico di Torino

THE CONCEPT OF CIRCULAR ECONOMY

Politecnico di Torino
Department of Architecture and Design

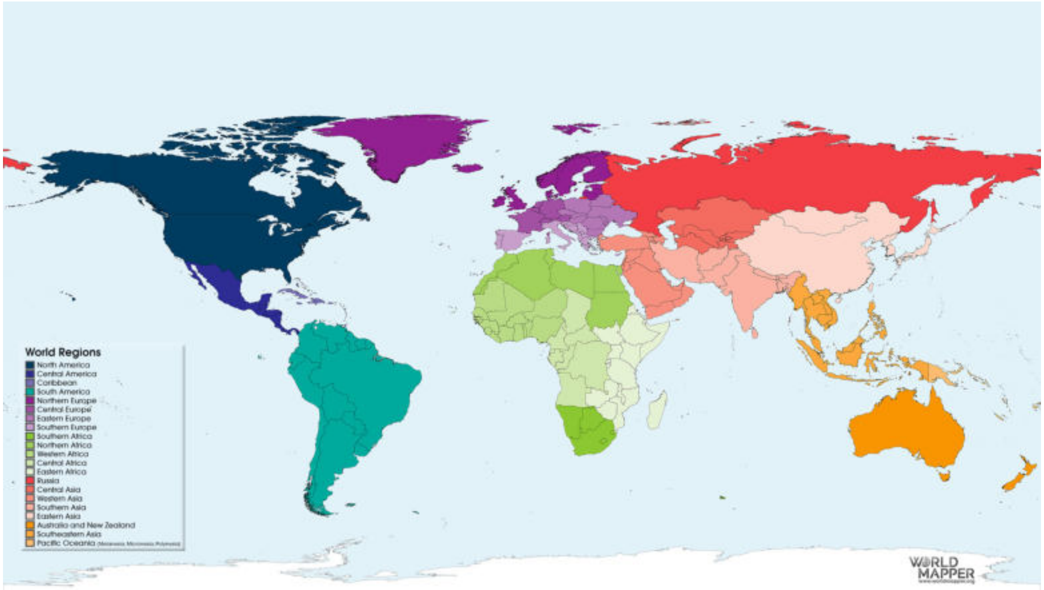
Amina Pereno, PhD

MULTITRACES joint staff training event
Circular economy in rural territories
trends and tools

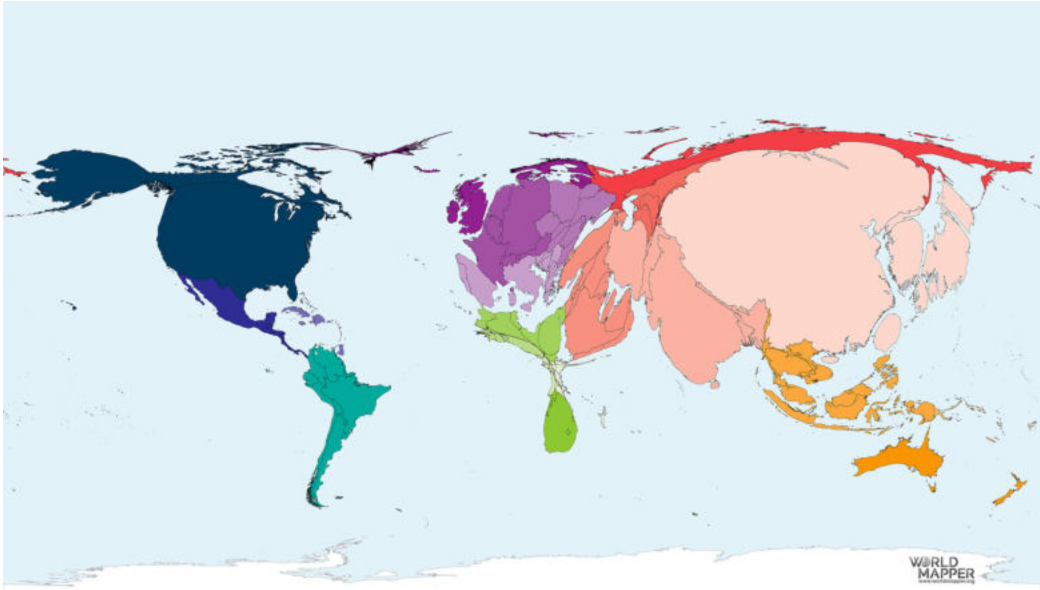
Castello del Valentino
28 September 2021

MULTITRACES

Co-funded by the Erasmus+ Programme of the European Union



World reference map
(source: World Mapper, 2021)



Carbon Dioxide Emissions 2015

(source: World Mapper, 2021)

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Towards a new Economic & Productive Model

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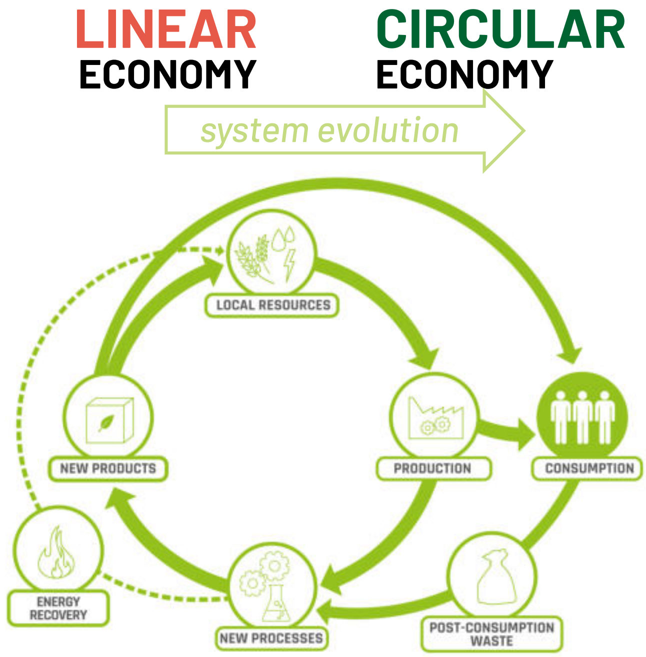

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Circular economy

Looking beyond the current "take, make and dispose" extractive industrial model, the circular economy is restorative and regenerative by design. Relying on system-wide innovation, it aims to redefine products and services to design waste out, while minimising negative impacts. Underpinned by a transition to renewable energy sources, the circular model builds economic, natural and social capital.

Ellen Macarthur Foundation

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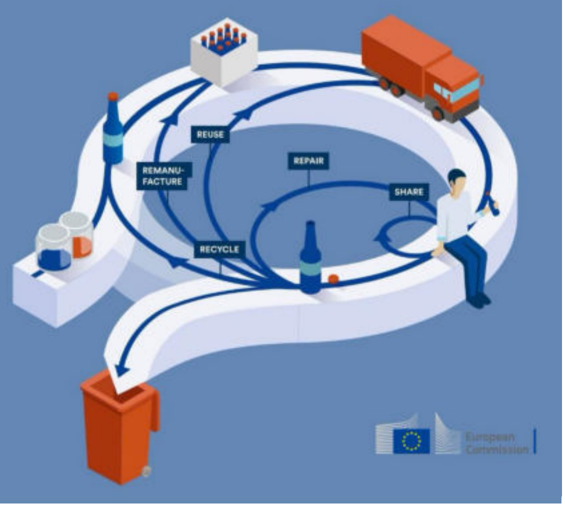
Towards a new Economic & Productive Model

The Circular Economy concept

*A circular economy aims to maintain **the value of products, materials and resources for as long as possible by returning them into the product cycle at the end of their use, while minimising the generation of waste**. The fewer products we discard, the less materials we extract, the better for our environment.*

(European Commission, 2015)



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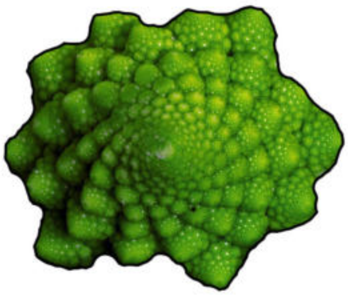
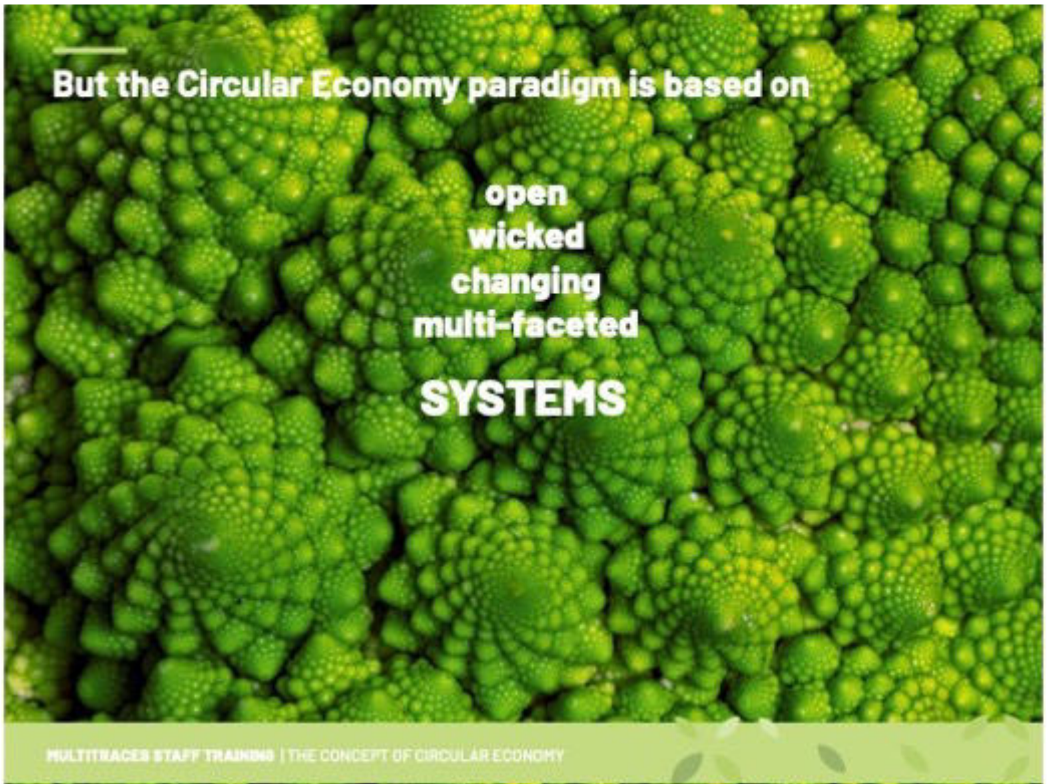
HOW TO FOSTER THE TRANSITION TO CIRCULAR ECONOMY?

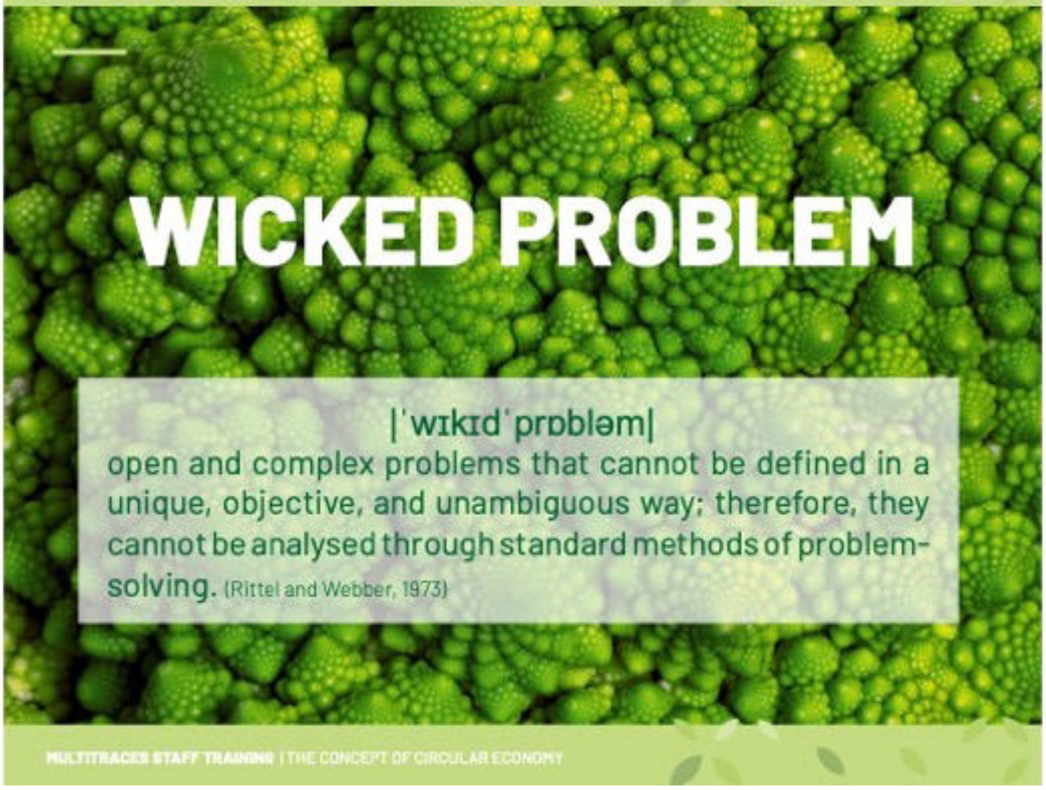
We are used to think of and design within

delimited
determined
stable
objectifiable

SYSTEMS




But the Circular Economy paradigm is based on
open
wicked
changing
multi-faceted
SYSTEMS
MULTITRACES STAFF TRAINING | THE CONCEPT OF CIRCULAR ECONOMY


WICKED PROBLEM
|ˈwɪkɪdˈprɒbləm|
open and complex problems that cannot be defined in a unique, objective, and unambiguous way; therefore, they cannot be analysed through standard methods of problem-solving. (Rittel and Webber, 1973)
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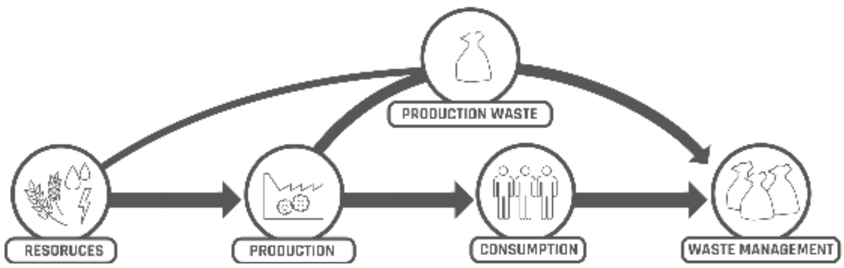
THE TRANSITION TO CIRCULAR ECONOMY IS A WICKED PROBLEM

LINEAR ECONOMY



> resource scarcity
> rising raw material prices
> weakness of the global supply chain (wars, political tensions, natural disasters)
> new protectionism of raw materials to guarantee strategic reserves
> waste management costs

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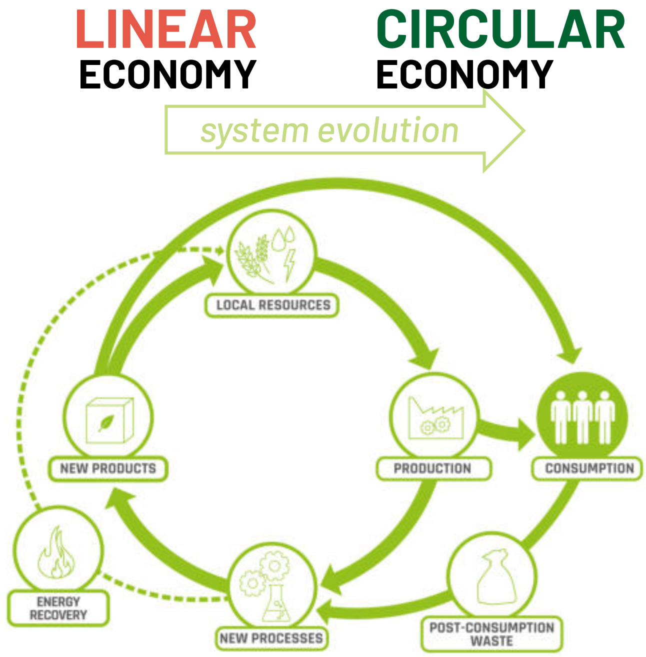

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Circular economy

Looking beyond the current "take, make and dispose" extractive industrial model, the circular economy is restorative and regenerative by design. Relying on system-wide innovation, it aims to redefine products and services to design waste out, while minimising negative impacts. Underpinned by a transition to renewable energy sources, the circular model builds economic, natural and social capital.

Ellen Macarthur Foundation

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Circular economy principles
Looking beyond the current "take, make and dispose" extractive industrial model, the circular economy is restorative and regenerative by design. Relying on system-wide innovation, it aims to redefine products and services to design waste out, while minimising negative impacts. Underpinned by a transition to renewable energy sources, the circular model builds economic, natural and social capital.
Ellen Macarthur Foundation
In a circular economy we design the whole life cycle, moving beyond the concepts of recovery and reuse, which are naturally embedded in every production process.
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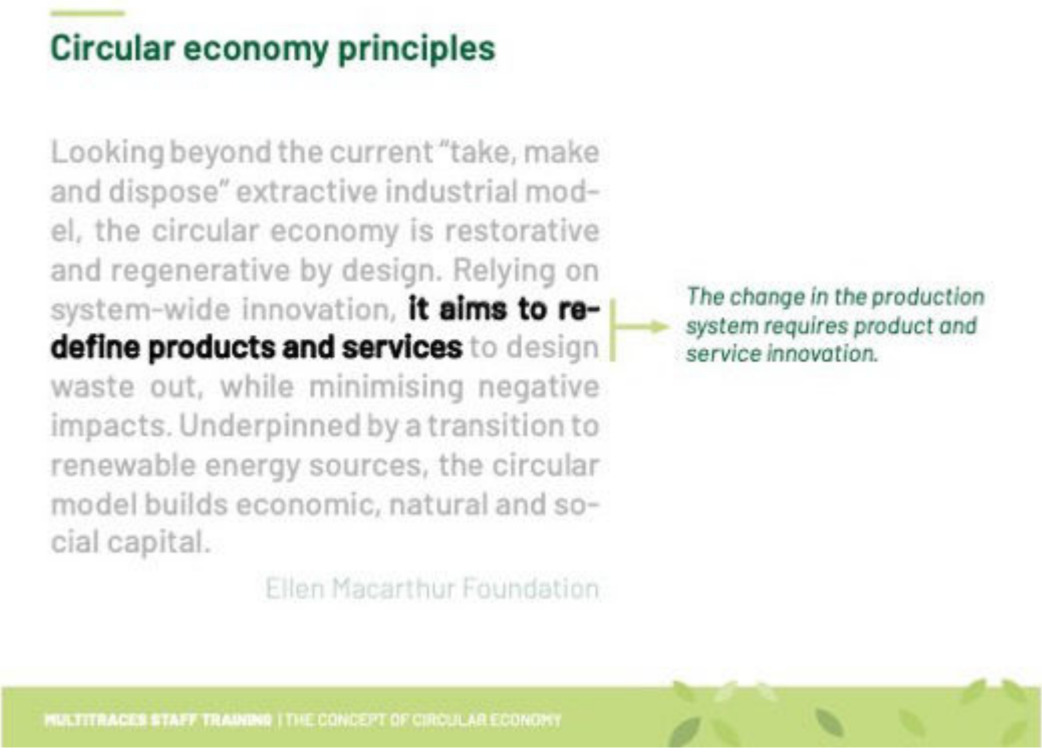
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The change in the production system requires product and service innovation.
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Circular economy principles

Looking beyond the current "take, make and dispose" extractive industrial model, the circular economy is restorative and regenerative by design. Relying on system-wide innovation, it aims to redefine products and services **to design waste out, while minimising negative impacts.** Underpinned by a transition to renewable energy sources, the circular model builds economic, natural and social capital.

Ellen Macarthur Foundation

The waste concept no longer exists: every process generates by-products that are resources for other processes.

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Circular economy principles

Looking beyond the current "take, make and dispose" extractive industrial model, the circular economy is restorative and regenerative by design. Relying on system-wide innovation, it aims to redefine products and services to design waste out, while minimising negative impacts. Underpinned by a transition to renewable energy sources, **the circular model builds economic, natural and social capital.**

Ellen Macarthur Foundation

The circular economy promotes environmentally, socially and economically sustainable local production and development.

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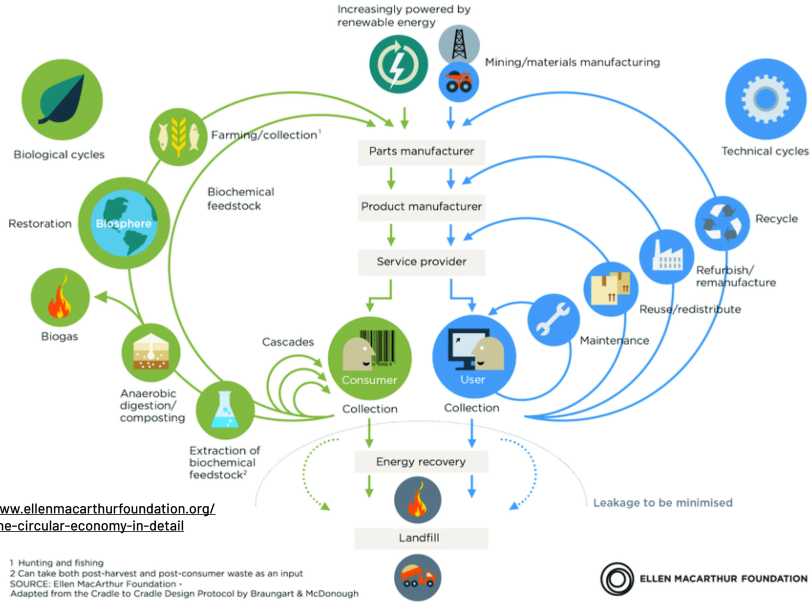
Circular economy principles



https://www.ellenmacarthurfoundation.org/explore/the-circular-economy-in-detail

Circular economy drivers

The Circular Economy paradigm is based on an economic model that meets three principles:

1. **To rediscover discarded matter as sources of material, limiting processing as much as possible**

Secondary sources of raw materials are many and not yet fully explored: waste collection, recycling systems, production waste, unsold items.

(Bompan, 2018)

Circular economy drivers

The Circular Economy paradigm is based on an economic model that meets three principles:

1. To rediscover discarded matter as sources of material, limiting processing as much as possible
2. **To end the unused value of the product, even before being discarded**

We often observe unnecessary 'depreciation' of goods with unused value:

- Warehouses full of products waiting to be disposed;

- Boxes in our storerooms that are full of clothes with no affective value;

- Objects bought and used once a year.

(Bompan, 2018)

Circular economy principles

The Circular Economy paradigm is based on an economic model that meets three principles:

1. To rediscover discarded matter as sources of material, limiting processing as much as possible
2. To end the unused value of the product, even before being discarded
3. **To stop the premature death of materials**

Although recycling and reuse are key strategies to recover material, we often throw away perfectly good materials.

It doesn't matter if the material will be recycled: often only one part of an object breaks or spoils, while the other components remain perfectly functional, yet we throw it all away.

Deep-rooted obsolescence practices need to be reviewed and changed to stop this waste of material.

(Bompan, 2018)

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EUROPE TOWARDS A CIRCULAR ECONOMY

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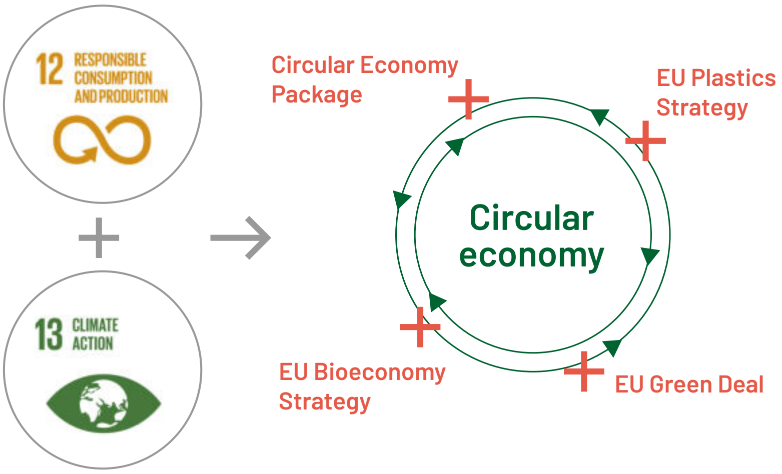
Europe Towards a new Economic & Productive Model



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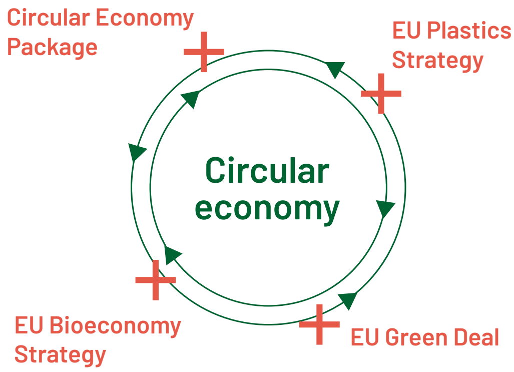
Europe Towards a new Economic & Productive Model

Promote the transition towards a Circular Economy:
- *life cycle approach*
- *waste management*
- *reuse/recycle*
- *sustainable products*



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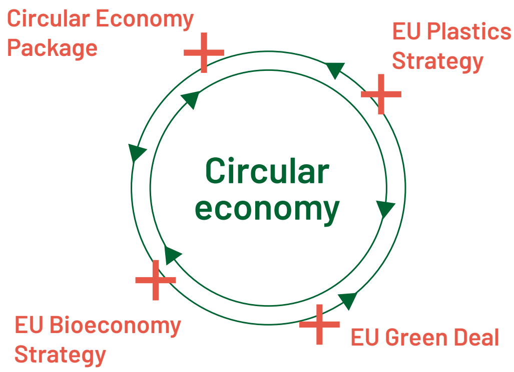
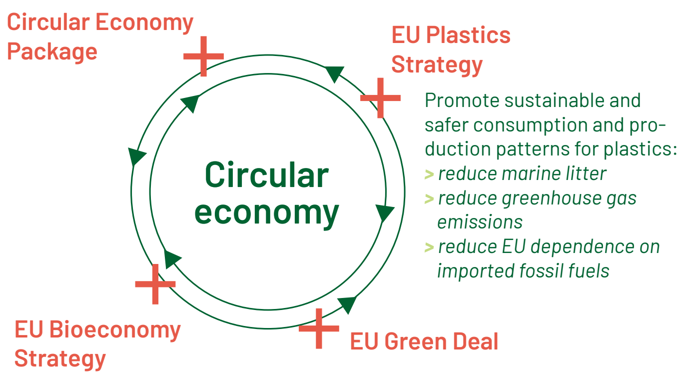
Europe Towards a new Economic & Productive Model



Accelerate the deployment of a sustainable European bioeconomy:
- *food and nutrition security*
- *sustainable management of natural resources*
- *reduce dependence on unsustainable resources*
- *limit/adapt to climate change*

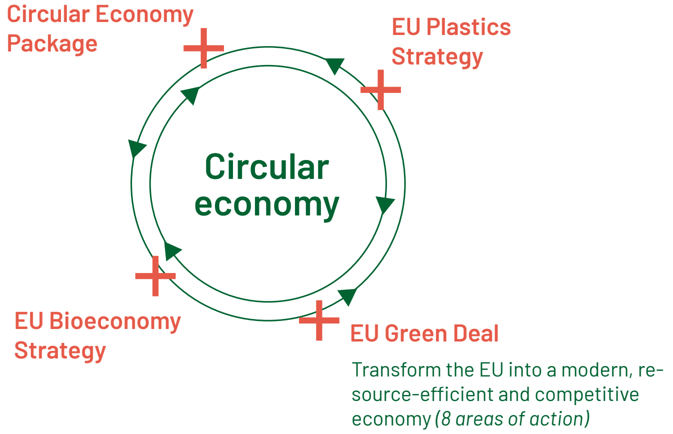
MULTITRACES STAFF TRAINING | THE CONCEPT OF CIRCULAR ECONOMY

Europe Towards a new Economic & Productive Model



MULTITRACES STAFF TRAINING | THE CONCEPT OF CIRCULAR ECONOMY

Europe Towards a new Economic & Productive Model



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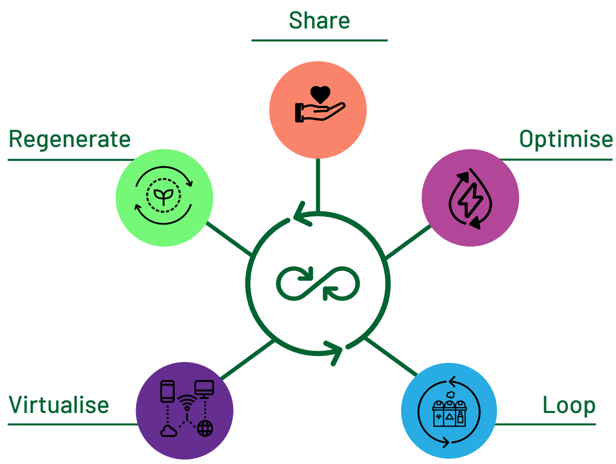
A new Circular Economy Paradigm



source: Giraldo Nohra, 2020

MULTITRACES STAFF TRAINING | THE CONCEPT OF CIRCULAR ECONOMY

CIRCULAR ECONOMY IN THE RURAL AREAS

MULTITRACES STAFF TRAINING | THE CONCEPT OF CIRCULAR ECONOMY

Deruralization


The last inhabitant of Roscigno Vecchia, Campania


Asproni, Sardinia

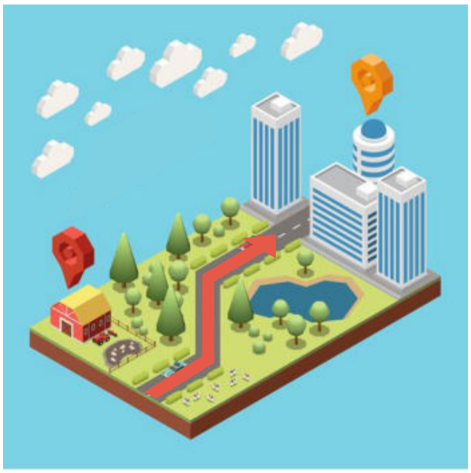

Ghost house, Piedmont

credits: Bruno Zanzottera - National Geographic, 2018

Deruralization

The share of the world's population living in urban areas is expected to increase from 55% in 2018 to 60% in 2030 (UN, 2018).

The migratory movement towards urban areas has transformed the countryside, because **traditional production faded away**, also causing the **loss of agricultural biodiversity** and local wealth.



Rural areas in Europe

Rural areas in the EU represent:

91% of the territory

56% of the population

Agri-food sector is particular relevant but also wasteful:

40% of EU soil is occupied by the food system

54% of the total EU annual waste is agricultural waste

46% of edible mass of fruit and vegetables is lost or wasted

Circular economy in rural areas

CE implies change at 3 levels:

MICRO
Rural companies improve the circularity of their production systems.

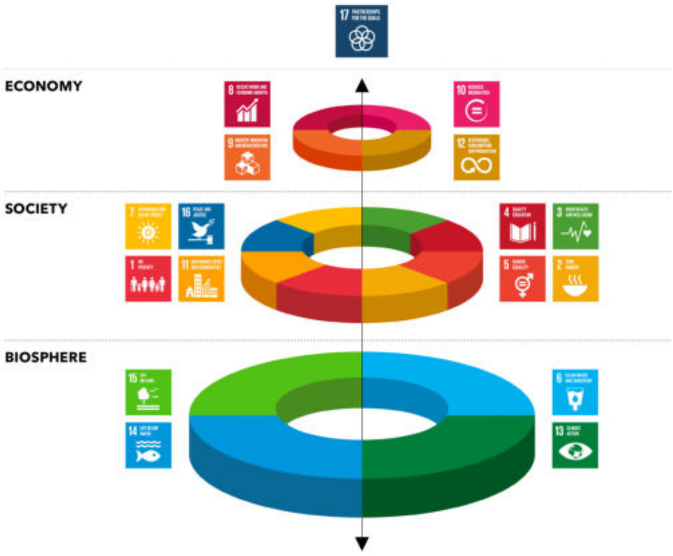
MESO
Industries traditionally working as separate entities become engaged in complex resource exchanges (industrial symbiosis).

MACRO
Integrating and re-design the production, the consumption system and its components (infrastructure and service delivering, cultural and social systems) in a sustainable way.

source: EURAC, 2018

MULTITRACES STAFF TRAINING | THE CONCEPT OF CIRCULAR ECONOMY

Circular economy in rural areas



Circular economy in rural areas

It is urgent to **educate** professionals that can provide concrete solutions to **real-world problems**, supporting the transition to Circular Economy.

Alongside disciplinary skills, a strong **ethical commitment** and solid **cultural foundations** are needed.

MULTITRACES STAFF TRAINING | THE CONCEPT OF CIRCULAR ECONOMY

The EN.FA.SI Project

By Amina Pereno, PhD
Politecnico di Torino

Politecnico di Torino
Department of Architecture and Design

Systemic Design
the EN.FA.SI. project

Amina Pereno
Politecnico di Torino,
Department of Architecture and Design (DAD)

MULTITRACES
joint staff training event
Circular economy in rural territories trends and tools

Castello del Valentino
29 September 2021

EN.FA.SI. PROJECT

Systemic Design case study applied to Cuneo Bean from field to distribution

Department of Architecture and Design
Politecnico di Torino

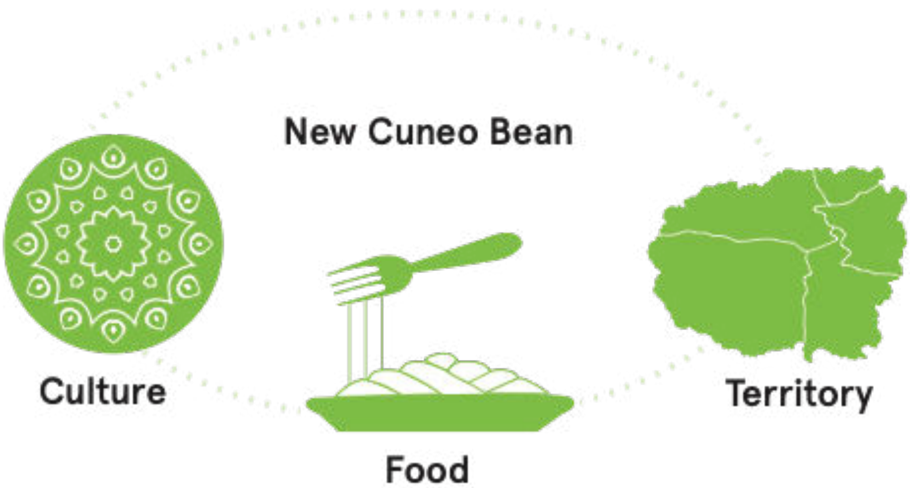
With the support of the Piemonte Region
POR FESR 07/13 - I.1.3. Innovazione e PMI - Poli di Innovazione

Scenario

https://vimeo.com/112259507

Systemic approach

Local development



PGI Cuneo Bean

Billò variety

dehydrated product

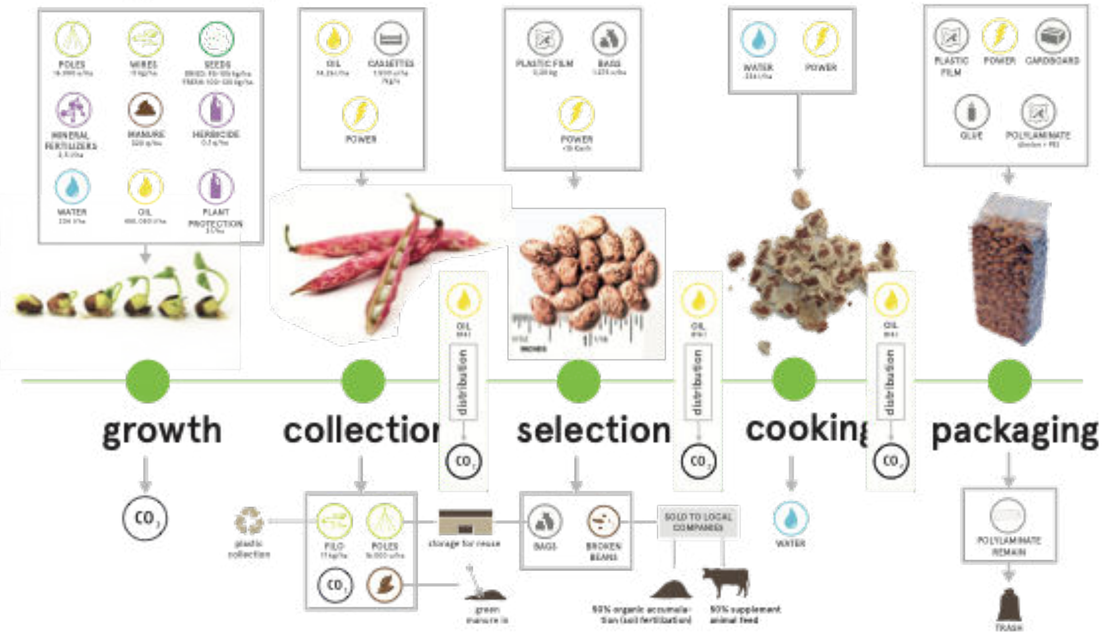
6.200 tons/year
3.000 ha
for transformation

fresh product

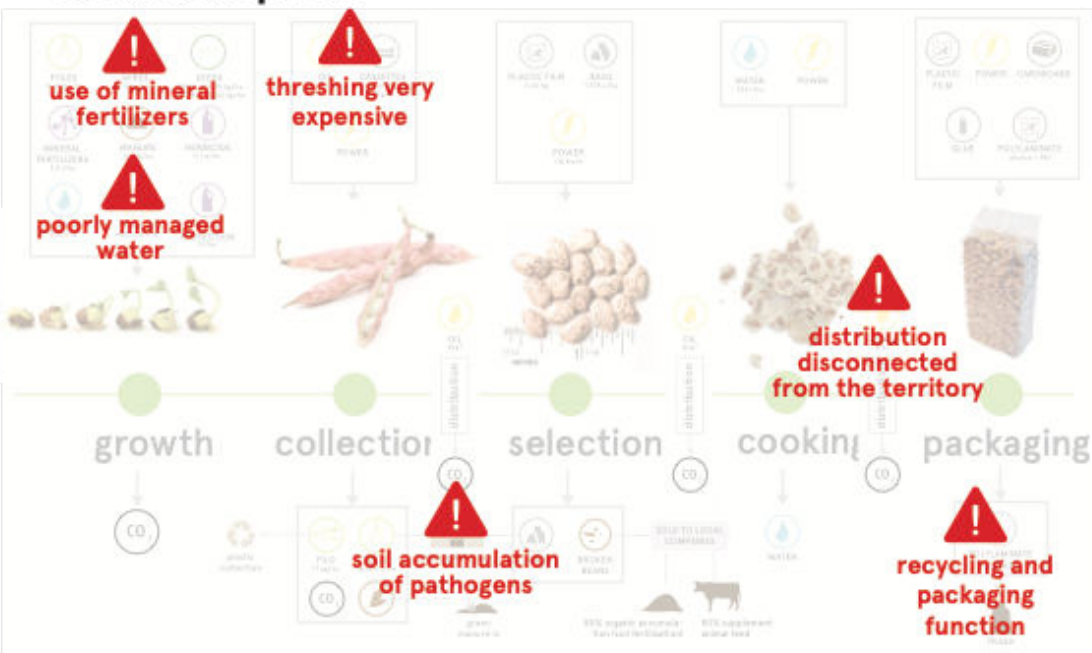
15.500 tons/year
1.900 ha
for direct consumption

Stages of production

Stages of production

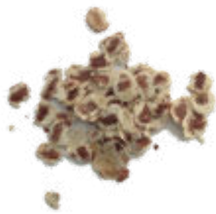


Critical aspects



New products

1 fresh beans **2 bean flakes** **3 precooked whole bean**


products derived from systemic approach

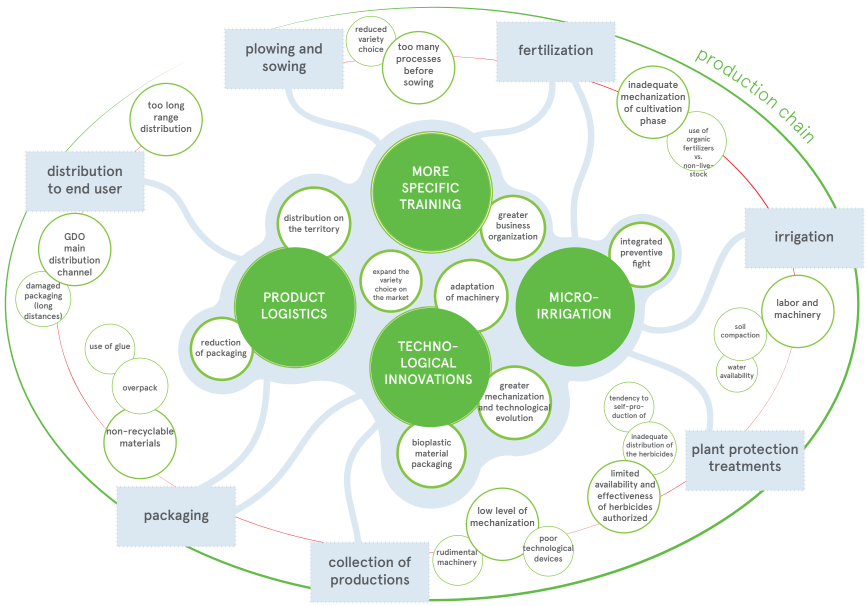
purified water | feedings | paper | extraction liquid | organic fertilizer | biopolymers e biofilm

Results

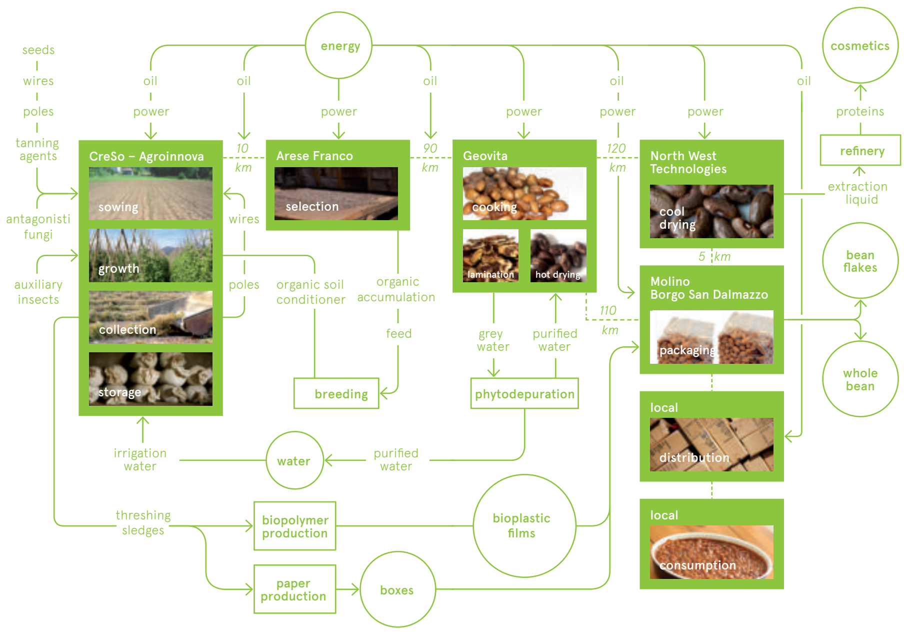
Production processes




Critical aspects/solutions



Enfasi - new system



Results

Distribution and consumption

Dissemination

Polito Design Stories

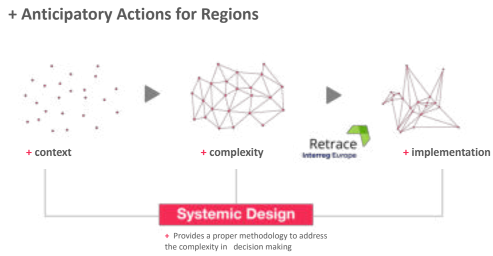
Editorial project for the dissemination of research projects

Polito Design Stories is a collection of booklets that was made to promote the project to non-experts.

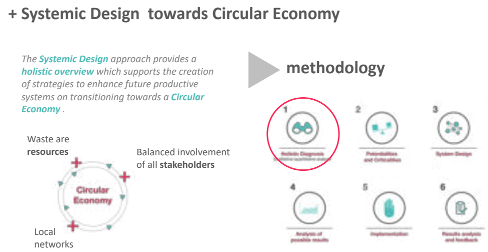
The Systemic Design Method
delivering Circular Economy business Model for regions
Retrace Interreg Europe Project

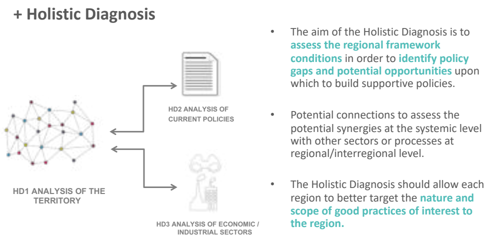
By Carolina Giraldo Nohra, PhD
Politecnico di Torino

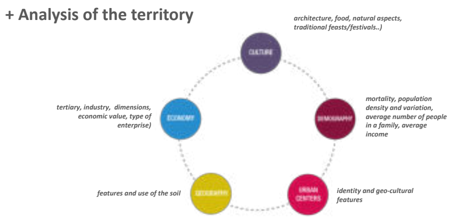

Systemic Design Method :
delivering Circular Business Models for regions
RETRACE Interreg Europe Project
Carolina Giraldo Nohra PhD
Research Fellow
Department of Architecture and Design
Politecnico di Torino
Multitraces Eramus plus
Training session
28th September 2021

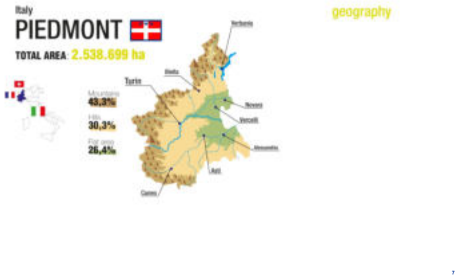

+ Anticipatory Actions for Regions
+ context
+ complexity
Retrace
Interreg Europe
+ implementation
Systemic Design
+ Provides a proper methodology to address the complexity in decision making

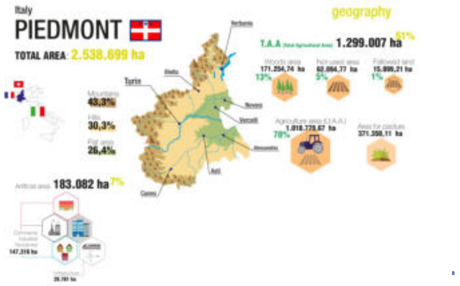

+ RETRACE project 2016-2020
European Union
European Regional Development Fund
Retrace
Interreg Europe
A Systemic Approach for REgions TRAnsitioning towards a Circular Economy
+ Goal
Aims at promoting systemic design as a method allowing local and regional policies move towards a circular economy when waste from one productive process becomes input in another, preventing waste being released into the environment.

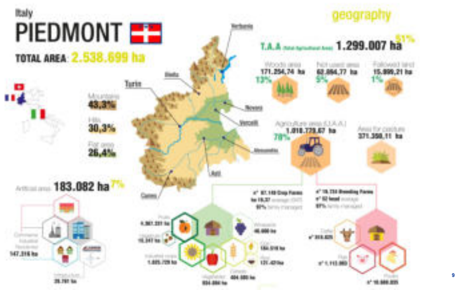

+ Systemic Design towards Circular Economy
The Systemic Design approach provides a holistic overview which supports the creation of strategies to enhance future productive systems on transitioning towards a Circular Economy .
methodology
Waste are resources
Balanced involvement of all stakeholders
Circular Economy
Local networks

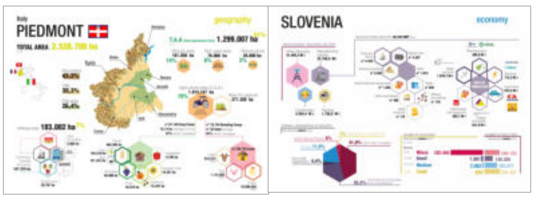

+ Holistic Diagnosis
HD2 ANALYSIS OF CURRENT POLICIES
HD1 ANALYSIS OF THE TERRITORY
HD3 ANALYSIS OF ECONOMIC / INDUSTRIAL SECTORS
The aim of the Holistic Diagnosis is to assess the regional framework conditions in order to identify policy gaps and potential opportunities upon which to build supportive policies.
Potential connections to assess the potential synergies at the systemic level with other sectors or processes at regional/interregional level.
The Holistic Diagnosis should allow each region to better target the nature and scope of good practices of interest to the region.

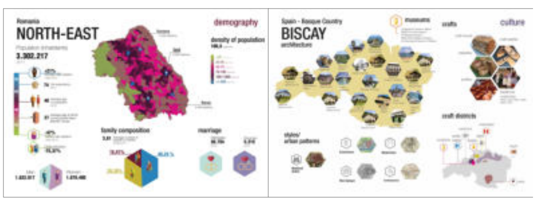

+ Analysis of the territory
architecture, food, natural aspects, traditional feasts/festivals..)
tertiary, industry, dimensions, economic value, type of enterprise)
mortality, population density and variation, average number of people in a family, average income
features and use of the soil
identity and geo-cultural features









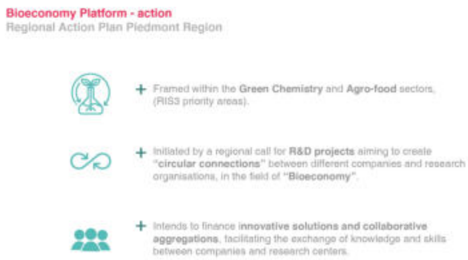


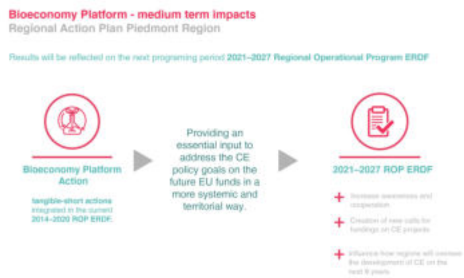
+ Success factors

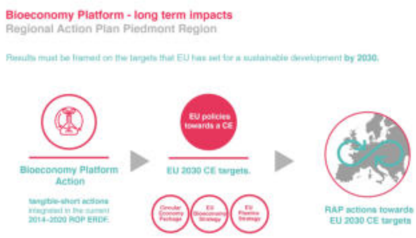
- Accelerates the realization of Systemic Design projects towards an Circular Economy in Europe
- Increases the exchange of Good Practices
- Encourages theoretical and practical debate on Systemic Design and Circular Economy between universities, businesses and public bodies

+ Success factors

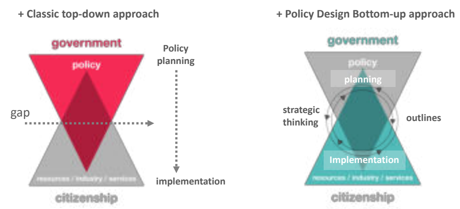
Piedmont Regional Action Plans







+ Success Factors

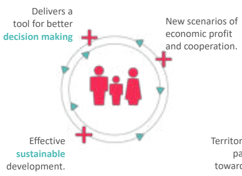


+ Limitations of the Approach

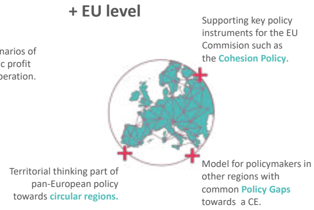
1. ***Cultural / Lenguage barriers (english vs native lenguage)***
2. ***Data accesability***
3. ***Policy Barriers***
4. ***Vertical Governance approach***
5. ***Traditional business structure***
6. ***Lack Knowledge concerning Circular Economy***

+ Advantages for main actors

+ For Policymakers



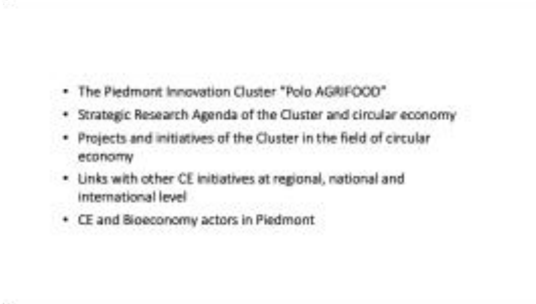
+ EU level



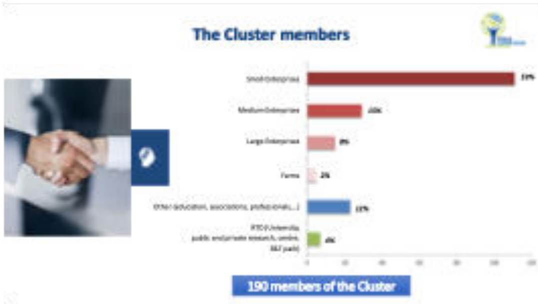
Agrifood in Piedmont and Circular Economy

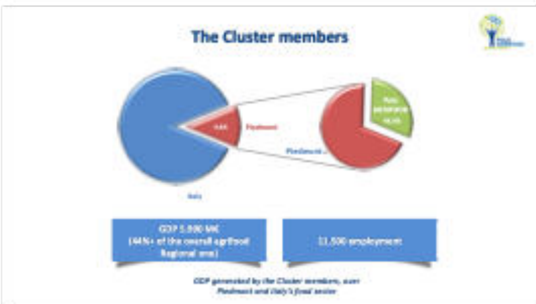
By Dario Vallauri
Cluster Manager
Polo Agrifood


Agrifood in Piedmont and Circular Economy
POLO AGRIFOOD
Dario Vallauri (M.I.A.C. Scpa) – Cluster Manager Polo AGRIFOOD

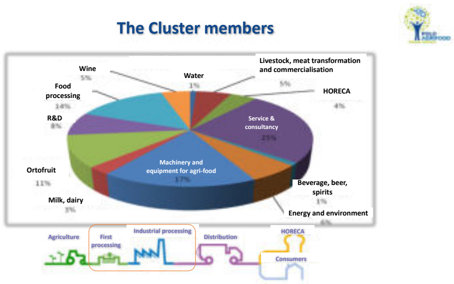

• The Piedmont Innovation Cluster "Polo AGRIFOOD"
• Strategic Research Agenda of the Cluster and circular economy
• Projects and initiatives of the Cluster in the field of circular economy
• Links with other CE initiatives at regional, national and international level
• CE and Bioeconomy actors in Piedmont

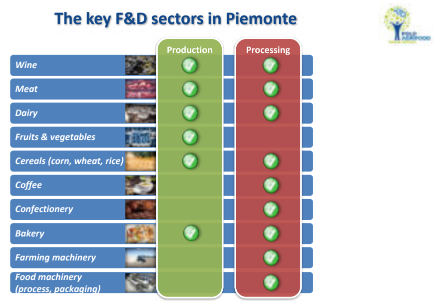

AGRIFOOD Innovation Cluster of Piemonte Region
• Network of F&D industry, research and institutions at regional level
• Funded in 2009, renewed in 2016
• Mission: to identify the innovation needs of the regional agrifood industry, mainly SMEs, and to support them to innovate their processes and to foster their competitiveness
• Actions for members:
• R+D+I: project building at regional, national and EU level
• Fund raising for research and development and technology transfer
• Services, skills and laboratories focused on innovation and technology transfer in specific areas (e.g. packaging, sanitization, product/process innovation)
• Organization of/participation to: workshops, seminars, B2B, conferences


The Cluster members
190 members of the Cluster


The Cluster members
Italy
Piedmont
GDP 5.800 M€ (44%+ of the overall agrifood Regional one)
11.500 employment
GDP generated by the Cluster members, over Piedmont and Italy's food sector


The Cluster members


The Cluster members
Wine
Water
Livestock, meat transformation and commercialisation
HORECA
Food processing
R&D
Service & consultancy
Machinery and equipment for agri-food
Ortofruit
Milk, dairy
Beverage, beer, spirits
Energy and environment
Agriculture
First processing
Industrial processing
Distribution
HORECA
Consumers


The key F&D sectors in Piemonte
Production
Processing
Wine
Meat
Dairy
Fruits & vegetables
Cereals (corn, wheat, rice)
Coffee
Confectionery
Bakery
Farming machinery
Food machinery (process, packaging)


AGRIFOOD Innovation Cluster – the Boards
STEERING COMMITTEE
TRADE ASSOCIATIONS
(agriculture and F&D industry)
RTD
(Academia, Research centers)
INDUSTRY
(LEs and SMEs; ETP Food for Life)
SCIENTIFIC BOARD


AGRIFOOD Innovation Cluster – the Boards
STEERING COMMITTEE
CONFCOOPERATIVE
unito.it
UPO
LAVAZZA
FERRERO
BALOCCO
inalpi
Confagricoltura
CNA
PONTI
CONFAPI
PSP
Plastipak
mec
Agrion
SCIENTIFIC BOARD

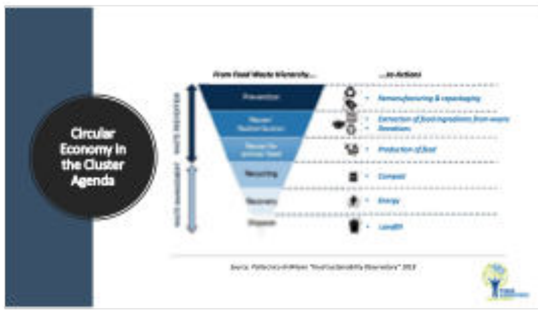

Research Agenda
TRACK-TO-MARKET
FOOD-CORE
FOOD-SUSTAINABILITY
FARM-OF-THE-FUTURE
• Traceability, track-chain, logistics;
• Distribution and commercialization, marketing, communication, internazionalition


Research Agenda
TRACK-TO-MARKET
FOOD-CORE
FOOD-SUSTAINABILITY
FARM-OF-THE-FUTURE
• Product innovation
• Process innovation
• Food safety and quality
• Packaging innovation and shelf life improvement


Research Agenda
TRACK TO MARKET
FOOD CORE
FOOD SUSTAINABILITY
FARM OF THE FUTURE
New models for efficient and sustainable food manufacturing
Reduction of food waste and recovery of surplus production
Recovery and valorization of by-products of the food industry and re-use as high added value components in the food supply chain

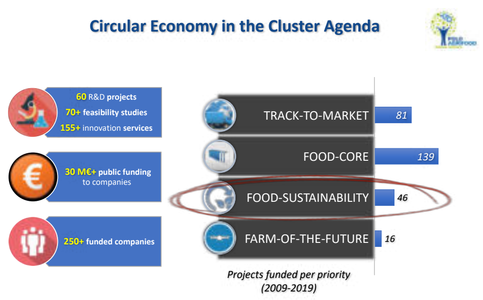

Research Agenda
TRACK TO MARKET
FOOD CORE
FOOD SUSTAINABILITY
FARM OF THE FUTURE
Precision farming and livestock
Innovation in agricultural machinery


Polo AGRIFOOD – the services
Technology audit and innovation check-up
Support to fund raising and project building
Technology scouting
Technology matching
Education and training on TT, novel technologies and innovation management
Support to licensing and IPR
Labs for demonstration/TT of novel technologies
(food safety, packaging & shelf life, product innovation + food reformulation, traceability, precision farming)

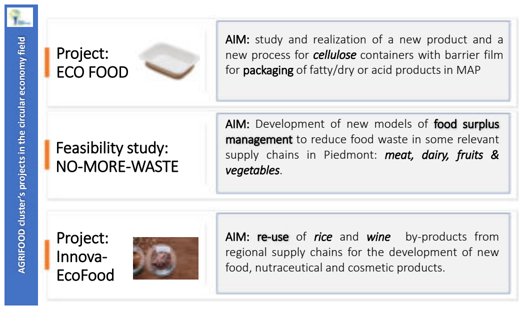

Circular Economy in the Cluster Agenda


Circular Economy in the Cluster Agenda
Recovery and re-use of waste and by-products from agricultural and agro-industrial supply chains aimed at the production of value-added products (ingredients for food & feed, cosmetics, energy, etc.)
Sustainable packaging for food (biodegradable / compostable, recyclable packaging)
Implementation of traceability initiatives
Improvement of the sustainability of agri-food chains, also through regional, national and European research and innovation projects
Organization of dissemination events / workshops / infodays / training courses (ex. Bioeconomy Day, Salone del Gusto, Ecomondo, etc.)

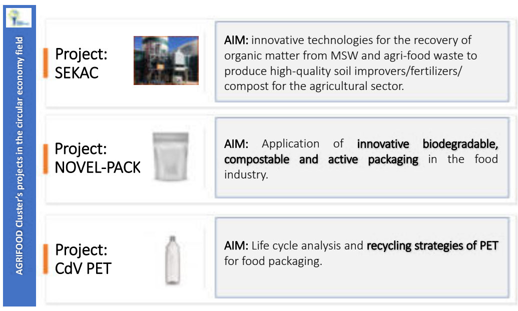

Circular Economy in the Cluster Agenda
Reduction of waste and energy consumption;
Recovery of by-products
Types of waste:
Wine Industry → Pomace
Fruit Processing → Peels, seeds and pulp residues
Vegetable Processing → Peels, seeds and pulp residues
Oil Industry → Solid residues, vegetation water
Milling Industry → Bran, germ
Dairy Industry → Whey
Fish Industry → Head, skin, fishbones



Circular Economy in the Cluster Agenda
60 R&D projects
70+ feasibility studies
155+ innovation services
30 M€+ public funding to companies
250+ funded companies
TRACK-TO-MARKET 81
FOOD-CORE 139
FOOD-SUSTAINABILITY 46
FARM-OF-THE-FUTURE 16
Projects funded per priority (2009-2019)



AGRIFOOD cluster's projects in the circular economy field
Project: ECO FOOD
AIM: study and realization of a new product and a new process for cellulose containers with barrier film for packaging of fatty/dry or acid products in MAP
Feasibility study: NO-MORE-WASTE
AIM: Development of new models of food surplus management to reduce food waste in some relevant supply chains in Piedmont: meat, dairy, fruits & vegetables.
Project: Innova-EcoFood
AIM: re-use of rice and wine by-products from regional supply chains for the development of new food, nutraceutical and cosmetic products.

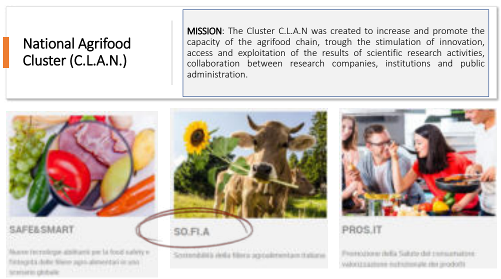


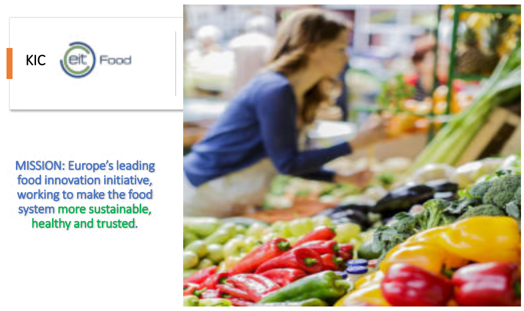
AGRIFOOD Cluster's projects in the circular economy field
Project: SEKAC
AIM: innovative technologies for the recovery of organic matter from MSW and agri-food waste to produce high-quality soil improvers/fertilizers/ compost for the agricultural sector.
Project: NOVEL-PACK
AIM: Application of innovative biodegradable, compostable and active packaging in the food industry.
Project: CdV PET
AIM: Life cycle analysis and recycling strategies of PET for food packaging.

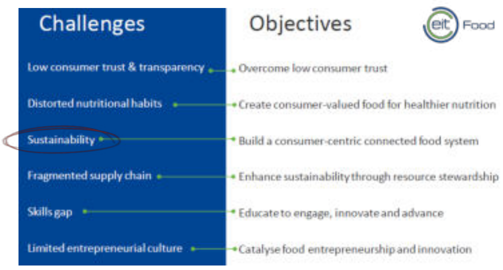
Links with other CE initiatives
"Bioeconomy Technology Platform" - Competitive call funded by Piedmont Region
Projects funded 2019-2022
Overall funding: 40 M€
Industrial research and technology innovation
Collaborative research among academia, large enterprises and SMEs on bio- and circular economy
Knowledge and competence transfer among research actors and industries, along the whole supply chain (farm-to-fork)
To foster competitiveness and job creation along the whole agrifood supply chain

Project NUTRAcore
5 M€ public funding
AIM:
Design, technological development and evaluation of innovative "functional" and "healthy" ingredients and food produced and/or enhanced through sustainable solutions based on bioeconomy, biotechnology and green chemistry.
Activity of Polo AGRIFOOD:
The AGRIFOOD Cluster collaborates with activities related to innovative techniques for products packaging developed within the project and the related evaluation of shelf life. In particular, on the definition of innovative materials suitable for packaging, the assessment of compliance with food contact and testing of packaging with innovative sustainable materials:
Monomaterials
Recyclable materials
Compostable/biodegradable materials
PACKLAB

National Agrifood Cluster (C.L.A.N.)
MISSION: The Cluster C.L.A.N was created to enhance the competitiveness of the Italian agrifood supply chain, by stimulating innovation, access and exploitation of the results of scientific research activities, collaboration between research companies, institutions and public administration.
Strategic Research Agenda 2018-2021
PRIORITIES
1
2
3
AGRIFOOD «SUSTAINABLE»
AGRIFOOD «MADE IN»
AGRIFOOD «HEALTHY»

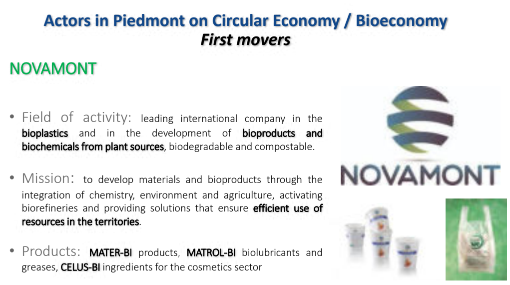

National Agrifood Cluster (C.L.A.N.)
MISSION: The Cluster C.L.A.N was created to increase and promote the capacity of the agrifood chain, trough the stimulation of innovation, access and exploitation of the results of scientific research activities, collaboration between research companies, institutions and public administration.
SAFE&SMART
SO.FI.A
PROS.IT


KIC
eit Food
MISSION: Europe's leading food innovation initiative, working to make the food system more sustainable, healthy and trusted.


Challenges
Objectives
eit Food
Low consumer trust & transparency
Overcome low consumer trust
Distorted nutritional habits
Create consumer-valued food for healthier nutrition
Sustainability
Build a consumer-centric connected food system
Fragmented supply chain
Enhance sustainability through resource stewardship
Skills gap
Educate to engage, innovate and advance
Limited entrepreneurial culture
Catalyse food entrepreneurship and innovation


The EIT Food community
eit Food
5 Co-location Centers (CLCs)
Leuven/Brussels
Reading
Madrid/Bilbao
Munich
Warsaw
Core partners
Industry
Higher education
Research
RisingFoodStars
Start-ups
Network partners
Civil society • Regional and public authorities
Cooperation with partner Università di Torino
(CLC South)


European Green Deal Call – Horizon 2020
The European Green Deal
Call H2020-LC-GD-2020
Subtopic C. (2021): Reducing the dependence on hazardous pesticides
PROPOSAL: European IncluSive ParticipatoRy Agro-EcoLogy (E-SPIRAL)
Keywords: Fertilisation; Agroecology; Environment, resources and sustainability; Circular economy
Coordinator from Israel + 11 EU partners
Role of Polo AGRIFOOD:
Implementation of a dynamic protocol for fruit crops (vine grapes and berries) in Italy on the farm side and on the fork side (processed foods, logistics, packaging, traceability)


Actors in Piedmont on Circular Economy / Bioeconomy
First movers
NOVAMONT
Field of activity: leading international company in the bioplastics and in the development of bioproducts and biochemicals from plant sources, biodegradable and compostable.
Mission: to develop materials and bioproducts through the integration of chemistry, environment and agriculture, activating biorefineries and providing solutions that ensure efficient use of resources in the territories.
Products: MATER-BI products, MATROL-BI biolubricants and greases, CELUS-BI ingredients for the cosmetics sector
NOVAMONT


Actors in Piedmont on Circular Economy / Bioeconomy
Innovative SMEs
AGRINDUSTRIA TECCO
AGRINDUSTRIA
• Field of activity: the company deals with re-processing by-products and waste from the agrifood industries (ex. almond shells, corn cobs, wood sawdust) to produce new value-added products (fibers, flours, granules, biomass fuel)
• Mission: Agrindustria looks at nature and learns from it, to create products as simple as they are practical, useful in food, industrial, craft and domestic applications
• Products: precooked food flours, soft vegetable abrasives, cosmetics, raw materials for pharmaceutical and animal feed industry, vegetable materials and fillers for multiple uses


Actors in Piedmont on Circular Economy / Bioeconomy
Start-ups
VORTEX
• Start-up active from 2020
VORTEX
• Field of activity: food waste/cosmetics
• Mission: fighting food waste by creating and commercializing sustainable products and educating consumers.
• Products: natural, eco-friendly, organic, functional cosmetics and food ingredients, starting from wastes of organic juices produced from ancient cultivars of apples (Slow Food Presidium).


Actors in Piedmont on Circular Economy / Bioeconomy
Start-ups
Last Minute Sotto Casa
LMSC
LAST MINUTE SOTTO CASA
• Field of activity: food waste
• Mission: recovering food waste and helping local trade
• Products: "LastMinuteSottoCasa", an app that connects businesses with unsold and close-to-expiry fresh products with consumers interested in buying them discounted.


Actors in Piedmont on Circular Economy / Bioeconomy
Start-ups
Mercato Circolare
mercato circolare
• Field of activity: innovative start-up with a social vocation and benefit company, founded in Turin in 2018 to bring out, and grow, the attention of the public for the circular economy and its businesses, starting with the intelligent use of digital technologies.
• Mission: make the concept of circular economy APPlicable, creating digital and cultural connections between businesses, citizens and institutions.
• Products: APP «Mercato Circolare», first app in Italy to connect users and actors of the circular economy; educational and cultural events; consultancy about circular economy.


"SpesaSospesa" project
• Food baskets financed through fundraising activities, and distribution managed by NGOs;
SPESA
SOSPESA


Cuneo, Italy

Circular economy and Sustainable Business Model (Universidad de Alicante)

Under the context of an increased competition with direction towards each time more environmental-friendly development, companies (small, medium, and big) are expected to follow the national and supranational strategies of sustainable development. The European Green Deal, together with the Circular Economy Action Plan and the Sustainable Development Goals, underlines the need for growth based on innovation through recycling and reuse philosophy. It is expected to have a global economic model based on minimizing the negative effects of finite resources consumption, by focusing on intelligent design of materials, products and systems. Circular business models could minimise material input into and leakage out of the economic system and play an essential role in utilising the resources and capabilities of the private sector for the transition to more sustainable economic development. Even though there is still considerable uncertainty on how to implement new circular business models in existing global supply chains, circularity brings more than inspiration, but also new challenges for facing this paradigm shift, with a room for multidisciplinary research in the coming decades to overcome the current understanding. In fact, the leverage circular economy approaches for sustainable development on an organisational level demands a new understanding of value. Thus, academia should keep "a watchful eye on the 'bigger picture' whole-systems research", reinforcing the dependency between a single organisation, a specific CBM, and its value network in a circular supply chain.

Many circular business models arise having at their heart the concept of helping in the process of prolonging the lifetimes of products and parts through successive cycles of reuse, repair, remanufacturing and closing material loops. There are at least six different types of circular business models, i.e., sharing platforms, product as a service, loops, circular supply chains, resource recovery, product life extension.

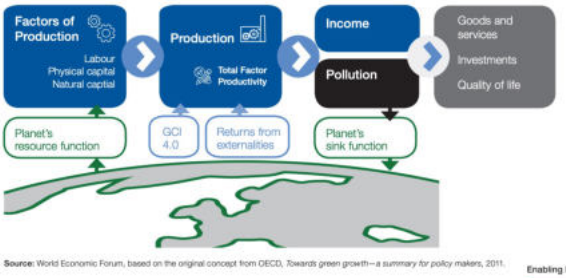
Some examples of the types of circular business models are considered from both theoretical and more practical perspectives. A short description of the types of circular business models is followed by an imaginary company exploiting olive stones (O-live). A business plan is developed as an example students should be able to conduct without forgetting the relevance of case studies.

A real case such as the one of the Comunidad de Regantes de Pliego is presented aiming at understanding the need of a combination of factors that could transform a weakness into a strength through innovation and a more efficient use of resources. The region of Pliego is facing a huge problem of water availability due to its location and the low presence of sufficient water for irrigation in a predominantly agricultural region. The use of renewable energy sources could be just an example of an innovative business model used for coping with their main weakness.

Circular Business Models

By Oana M. Driha, PhD
Universidad de Alicante

Background



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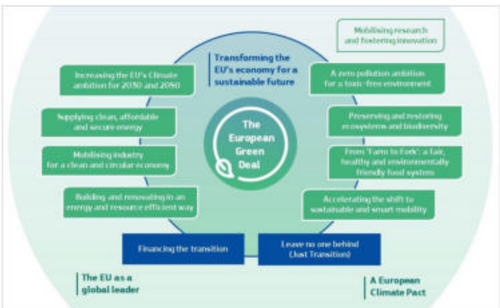
Background



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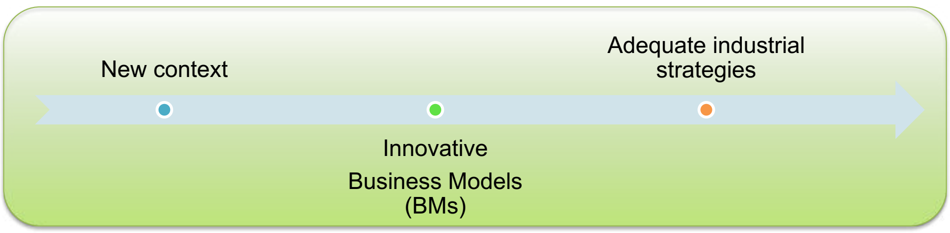
Background

Background

Among the main challenges to be faced by the industry, these 3 are the most important for our topic



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Background

Circular economy, inspired by the concept of **closed-loop economy**, - is defined as a global **economic model** minimizing the negative effects of finite resources consumption, by focusing on intelligent design of materials, products and systems.

⇒ to **minimise** emissions, resource use, pollution and waste
⇒ To **maximise** the resource efficiency of material assets

Interest in **environmental impacts of products and processes and the sustainable use of natural resource**s → CE´s relevance was amplified worldwide

⇒ traditional linear (open-ended) economy, treating the environment as a waste reservoir, → a linear lifecycle
⇒ starting from conceptualization and design, went through development, inservice and finished with disposal.

⇒ closed-loop production and consumption patterns & completely focused on resource efficiency and waste reduction & able to better balance and harmonize economy, environment and societal needs.

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Circular business models

Business model (BM)

- It describe the rationale of how an organization ***creates, delivers, and captures value***
- **BMs** a **mean for driving competitiveness** and **set up a company's market strategy**

BM → a framework to formulate a **business strategy**

A **strategy** is an approach to ***outperform competitors and gain competitive advantage***

A strategy defines:
❑ ***the value proposition*** (which needs of which customer segments to satisfy)
❑ ***value creation*** (resources and processes required to create value including the relationships with suppliers and customers)
❑ ***value delivery*** (resources and processes required to deliver value to customers)
❑ ***value capture*** (cost structure and revenue streams)

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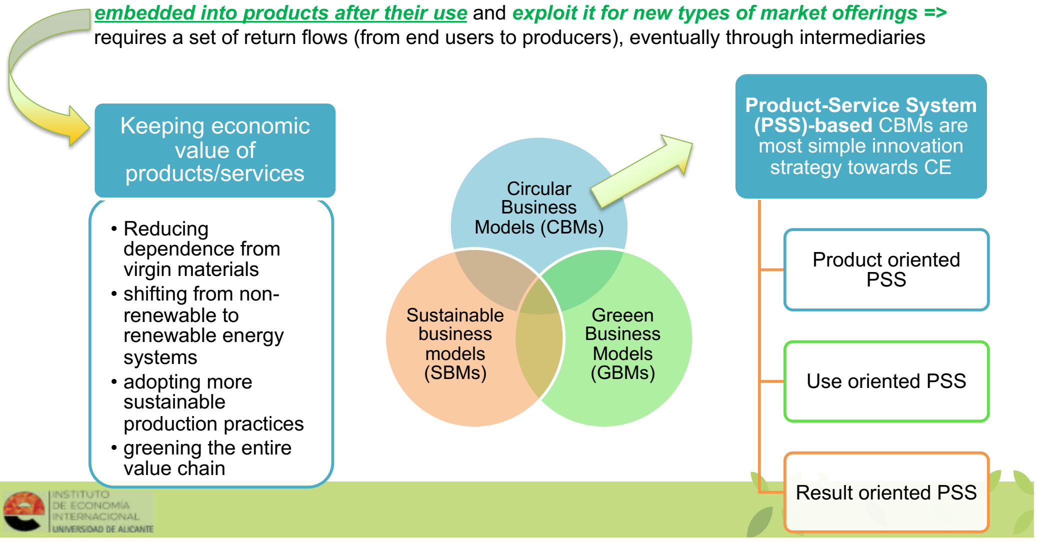
Circular business models

Circular business models (CBMs)

- A new kind of BMs, where **the value creation** is grounded on ***keeping the economic value embedded into products after their use*** and ***exploit it for new types of market offerings =>*** requires a set of return flows (from end users to producers), eventually through intermediaries



Circular business models

Circular business models (CBMs)

- CBMs could minimise material input into and leakage out of the economic system and play an essential role in utilising the resources and capabilities of the private sector for the transition to more sustainable economic development.

- there is still considerable uncertainty on how to implement new circular business models in existing global supply chains.

- The European Commission's **Horizons2020** Project suggests promising figures for the **implementation of the Circular Economy (CE)**, leveraging the region's **GDP** by **up to 0.5% by 2030**, in addition to the creation of **700 thousand new jobs**

⇒ new sustainable business models (SBM) are required

⇒ CBMs stand out as **a better adjusted SBM strategy**, with a **significant increase in efficiency** for organizations in the **consumption of resources, primarily based on appropriate regulation, investment in innovation and the development of appropriate business models**, capable of generating and flowing value in the supply chain

Circular business models

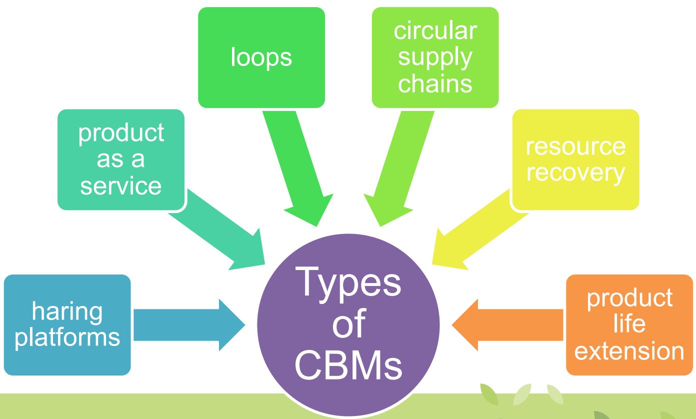
Circular business models (CBMs)

- circularity brings more than inspiration, but also new challenges for facing this paradigm shift, with a room for multidisciplinary research in the coming decades to overcome the current understanding
- The leverage CE approaches for sustainable development on an organisational level demands a new understanding of value => academia should keep "a watchful eye on the 'bigger picture' whole-systems research", reinforcing the **dependency between a single organisation, a specific CBM, and its value network in a circular supply chain**
- The complex value interaction in CBM implies trade-offs that ascend as obstacles to CE's promotion, whose understanding of structural dynamics of the business ecosystem is prerogative to leverage the skills and resources of members of the value chain → a sharing of language and understanding between the different perspectives of goals and interests is required
- There is a broadly agreeing by experts about the need for expanding the types of values to include more diverse values and metrics besides economic
- Besides, the current CE phase stagnates on low-value resource retention options

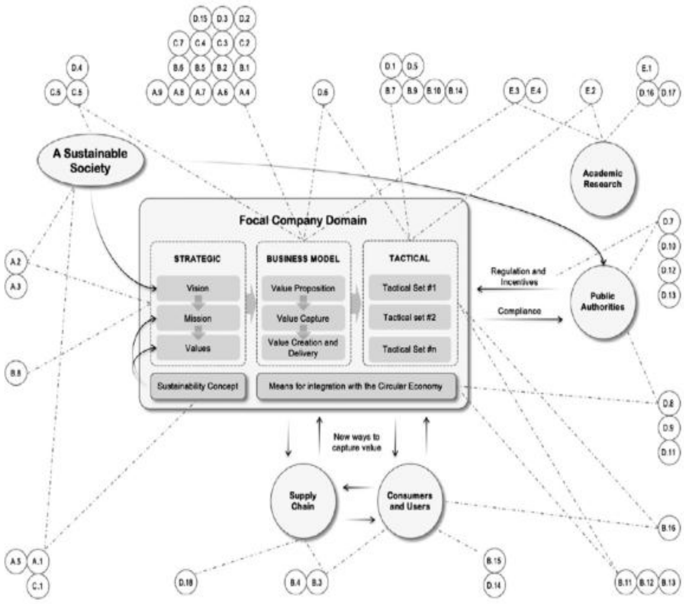
Circular business models

Circular business models (CBMs)

- the main aspect of CBM concept is to **"help to prolong lifetimes of products and parts through successive cycles of reuse, repair, remanufacturing and closing material loops"** Extending product lifetimes by reversing product obsolescences is known as the Product Value model

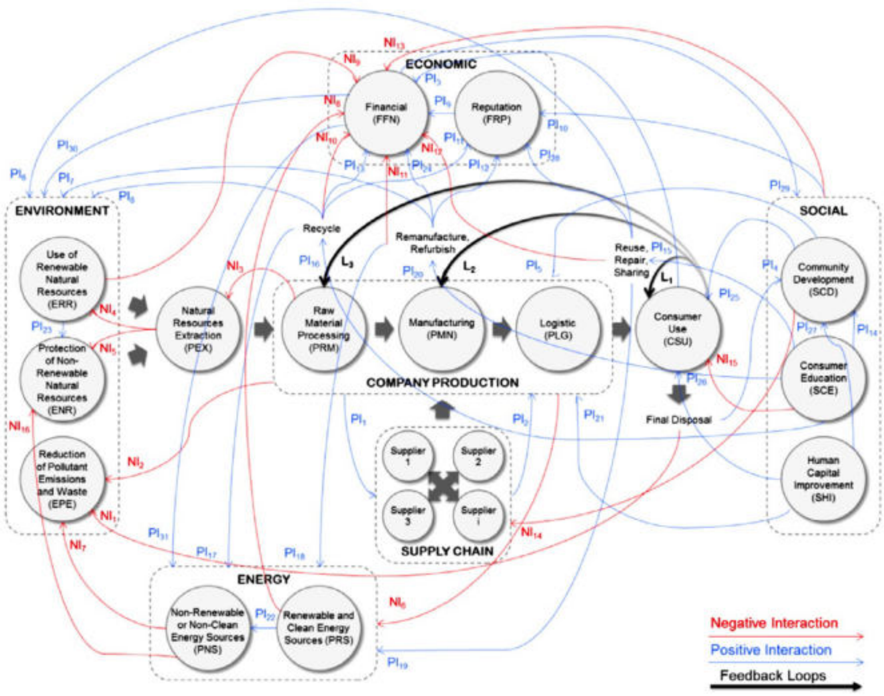


CBM in a Business Ecosystem

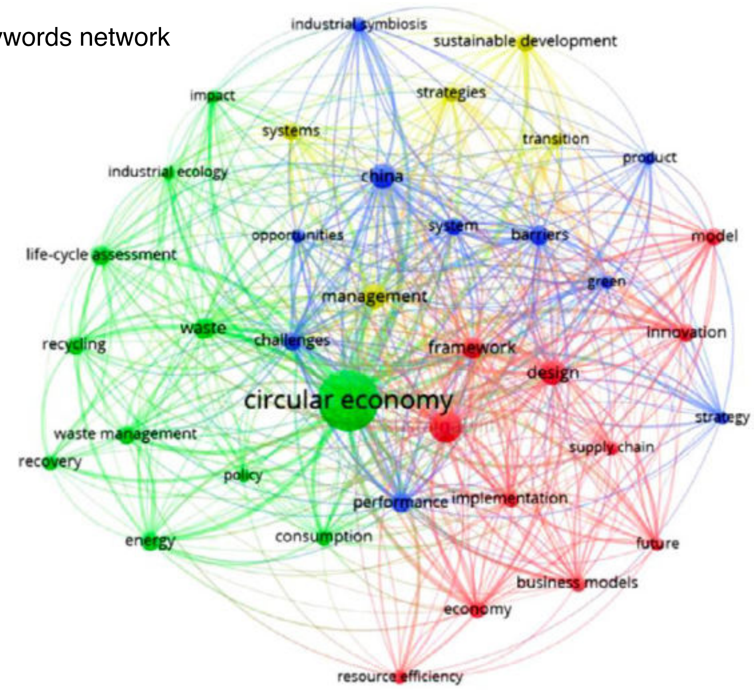


- **Tactics →** the competitive choices within the business model.
- In CBM they should **allow profit to be realised within the cyclical activities**, considering that **value is generated based on the efficiency of the material Loops**.
- Tactics would be the **strategic expressions for value capture in interaction with other players in the ecosystem**. => tactics must **allow new forms of value capture, still unexplored**.
- Still, in this context, the whole product and its service lifecycle and the material/energy loops must be analysed and properly orientated, by means of broadening the organisation's perception of its own field of activity.

Company Production in the context of the CBM



Keywords network



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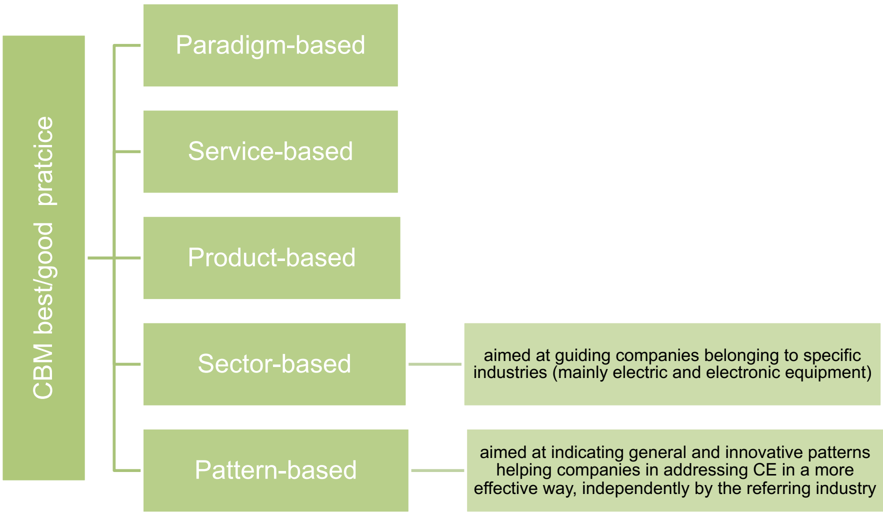
Circular business models



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research gap in terms of consolidated circular practices guiding companies in improving the circularity of either product or services.

Circular business models

CBM best practice classification.

Author	CBM best practice classification				
	Paradigm-based	Service-based	Product-based	Sector-based	Pattern-based
Adam et al. (2017)	x				
Beulque and Aggeri (2016)					x
(Bocken et al. (2017)			x		
(Bressanelli et al. (2017)			x		
Dewberry et al. (2016)					x
Gnoni et al. (2017)			x		
Goyal et al. (2016)					x
Guldmann (2016)					x
Hindley (2016)				x	
Jagger (2016)				x	
Kim et al. (2016)				x	
(Laubscher and Marinelli, 2014)				x	
Ma et al. (2014)				x	
McIntyre and Ortiz (2015)				x	
Morioka et al. (2017)					x
Piciu (2016)		x			
(Prendeville et al., 2017b)	x				
Rattalino (2017)				x	
Regenfelder et al. (2016)					x
Sarasini et al. (2016)				x	
Scheel (2016)					x
(Sousa-Zomer et al., 2017)				x	
(Sousa-Zomer et al., 2017)				x	
Stål and Corvellec (2018)				x	
Svatikova et al. (2015)				x	
(Venselaar and van de Kelft, 2014)					x
Whalen et al. (2017)	x				
Yazan et al. (2015)				x	

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Circular business models

Challenges related with the adoption of the CE paradigm

CBM challenges classification.

Author	CBM challenges classification				
	Sustainability-based	Supply chain-based	Company-based	ICT-based	Lean-based
Chertow and Ehrenfeld (2012)		x			
(de Lange and Rodic, 2013)			x		
Franco (2017)			x		
Guldmann and Jensen (2015)			x		
(Howell et al., 2018)				x	
Kurilova-Palisaitiene et al. (2018)				x	
Lüdeke-Freund and Dembek (2017)	x				
Morlat and Pinto-Silva (2014)	x				
Pagoropoulos et al. (2017)				x	
Planing (2017)				x	
Rizos et al. (2015)			x		
Rizos et al. (2016)			x		
Romero and Rossi (2017)					x
Roos (2014)	x				
Sannö et al. (2014)	x				
Smith-Gillespie (2017)	x				

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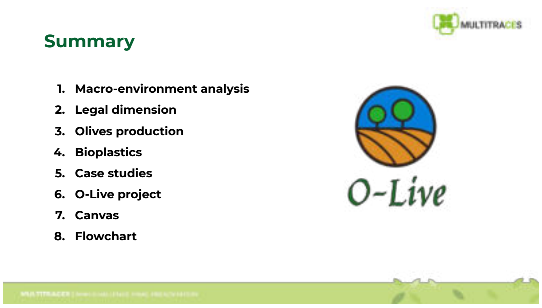
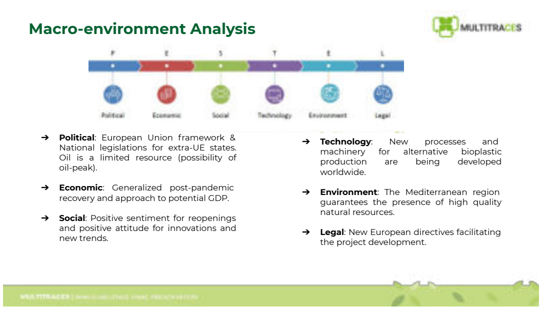
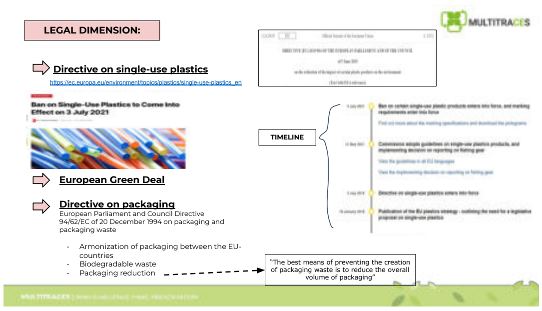
O-live Case study

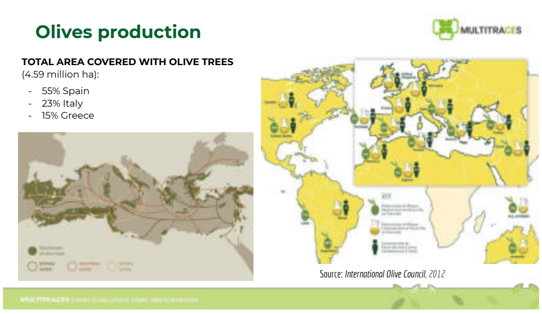
By Elena Olmos
University of Alicante

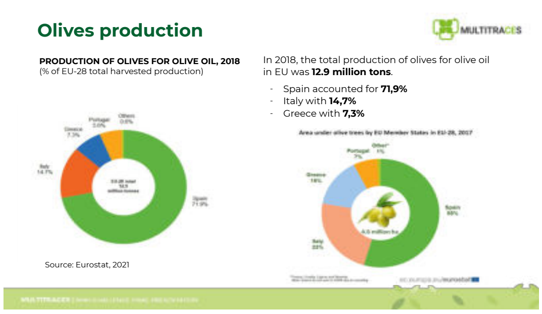

MODULE 4
GROUP N°6
O-Live
Bio-plastic made from Olive stone
MULTITRACES

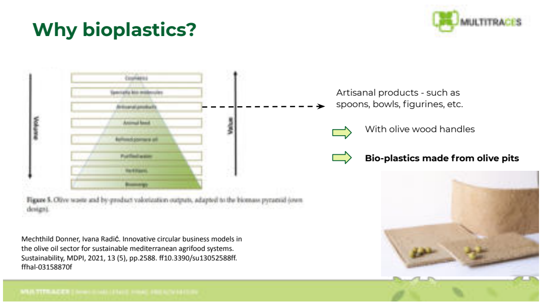

Summary
MULTITRACES
1. Macro-environment analysis
2. Legal dimension
3. Olives production
4. Bioplastics
5. Case studies
6. O-Live project
7. Canvas
8. Flowchart
O-Live

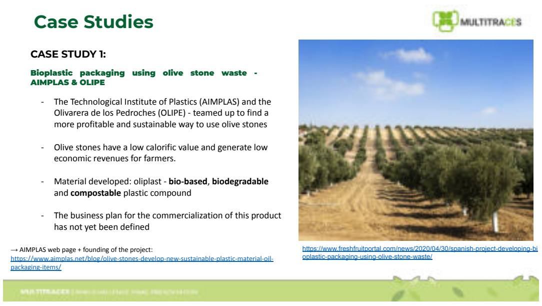

Macro-environment Analysis
MULTITRACES
Political
Economic
Social
Technology
Environment
Legal
Political: European Union framework & National legislations for extra-UE states. Oil is a limited resource (possibility of oil-peak).
Economic: Generalized post-pandemic recovery and approach to potential GDP.
Social: Positive sentiment for reopenings and positive attitude for innovations and new trends.
Technology: New processes and machinery for alternative bioplastic production are being developed worldwide.
Environment: The Mediterranean region guarantees the presence of high quality natural resources.
Legal: New European directives facilitating the project development.

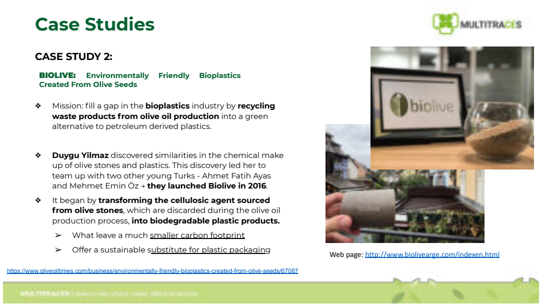

LEGAL DIMENSION:
MULTITRACES
Directive on single-use plastics
https://ec.europa.eu/environment/topics/plastics/single-use-plastics_en
Ban on Single-Use Plastics to Come into Effect on 3 July 2021
TIMELINE
European Green Deal
Directive on packaging
European Parliament and Council Directive 94/62/EC of 20 December 1994 on packaging and packaging waste
- Armonization of packaging between the EU-countries
- Biodegradable waste
- Packaging reduction
"The best means of preventing the creation of packaging waste is to reduce the overall volume of packaging"

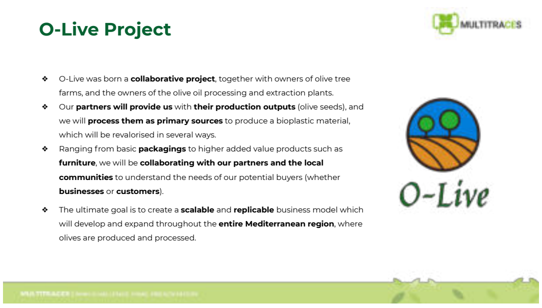

Olives production
MULTITRACES
TOTAL AREA COVERED WITH OLIVE TREES
(4.59 million ha):
- 55% Spain
- 23% Italy
- 15% Greece
Source: International Olive Council, 2012

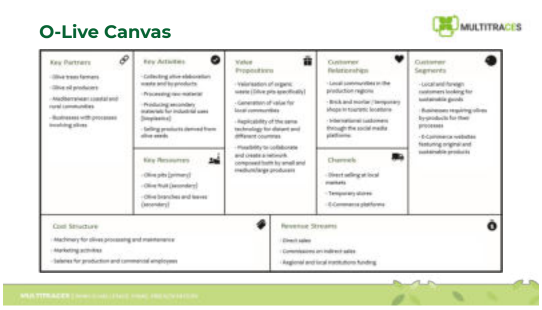

Olives production
MULTITRACES
PRODUCTION OF OLIVES FOR OLIVE OIL, 2018
(% of EU-28 total harvested production)
In 2018, the total production of olives for olive oil in EU was 12.9 million tons.
- Spain accounted for 71,9%
- Italy with 14,7%
- Greece with 7,3%
Source: Eurostat, 2021

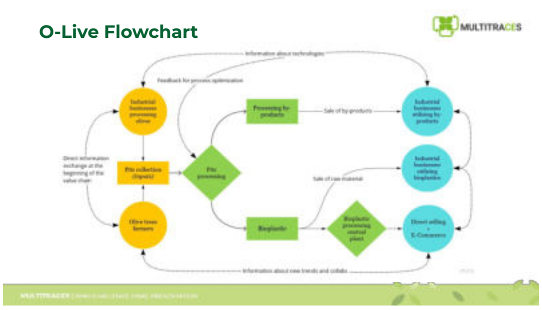

Why bioplastics?
MULTITRACES
Volume
Value
Figure 5. Olive waste and by-product valorization outputs, adapted to the biomass pyramid (own design).
Artisanal products - such as spoons, bowls, figurines, etc.
With olive wood handles
Bio-plastics made from olive pits
Mechthild Donner, Ivana Radić. Innovative circular business models in the olive oil sector for sustainable mediterranean agrifood systems. Sustainability, MDPI, 2021, 13 (5), pp.2588. ff10.3390/su13052588ff. ffhal-03158870f


Case Studies
MULTITRACES
CASE STUDY 1:
Bioplastic packaging using olive stone waste - AIMPLAS & OLIPE
- The Technological Institute of Plastics (AIMPLAS) and the Olivarera de los Pedroches (OLIPE) - teamed up to find a more profitable and sustainable way to use olive stones
- Olive stones have a low calorific value and generate low economic revenues for farmers.
- Material developed: oliplast - bio-based, biodegradable and compostable plastic compound
- The business plan for the commercialization of this product has not yet been defined
→ AIMPLAS web page + founding of the project:
https://www.aimplas.net/blog/olive-stones-develop-new-sustainable-plastic-material-oil-packaging-items/
https://www.freshfruitportal.com/news/2020/04/30/spanish-project-developing-bioplastic-packaging-using-olive-stone-waste/


Case Studies
MULTITRACES
CASE STUDY 2:
BIOLIVE: Environmentally Friendly Bioplastics Created From Olive Seeds
❖ Mission: fill a gap in the bioplastics industry by recycling waste products from olive oil production into a green alternative to petroleum derived plastics.
❖ Duygu Yilmaz discovered similarities in the chemical make up of olive stones and plastics. This discovery led her to team up with two other young Turks - Ahmet Fatih Ayas and Mehmet Emin Öz → they launched Biolive in 2016.
❖ It began by transforming the cellulosic agent sourced from olive stones, which are discarded during the olive oil production process, into biodegradable plastic products.
➢ What leave a much smaller carbon footprint
➢ Offer a sustainable substitute for plastic packaging
biolive
Web page: http://www.biolivearge.com/indexen.html
https://www.oliveoiltimes.com/business/environmentally-friendly-bioplastics-created-from-olive-seeds/67087


O-Live Project
MULTITRACES
❖ O-Live was born a collaborative project, together with owners of olive tree farms, and the owners of the olive oil processing and extraction plants.
❖ Our partners will provide us with their production outputs (olive seeds), and we will process them as primary sources to produce a bioplastic material, which will be revalorised in several ways.
❖ Ranging from basic packagings to higher added value products such as furniture, we will be collaborating with our partners and the local communities to understand the needs of our potential buyers (whether businesses or customers).
❖ The ultimate goal is to create a scalable and replicable business model which will develop and expand throughout the entire Mediterranean region, where olives are produced and processed.
O-Live

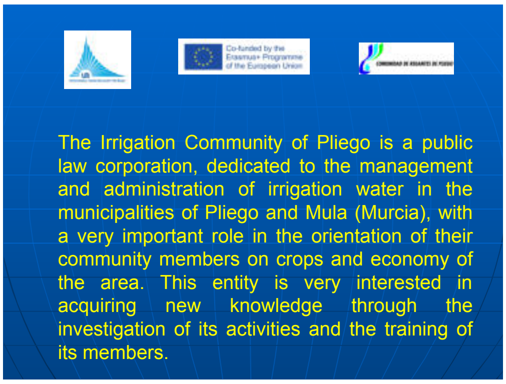

O-Live Canvas
MULTITRACES
Key Partners
Key Activities
Value Propositions
Customer Relationships
Customer Segments
Key Resources
Channels
Cost Structure
Revenue Streams


O-Live Flowchart
Information about technologies
Feedback for process optimization
Processing by-products
Sale of by-products
Pits processing
Sale of raw material
Bioplastic
Information about new trends and collabs

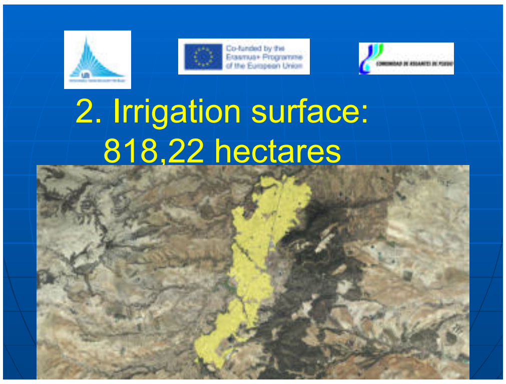
Comunidad de Regates de Pliego

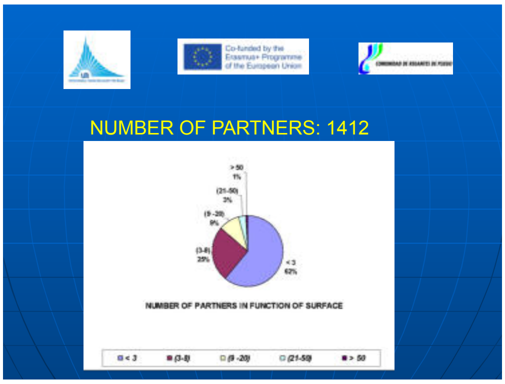
By Martin Jiménez
CEO Comunidad de Regantes de Pliego


IRRIGATION COMMUNITY OF PLIEGO

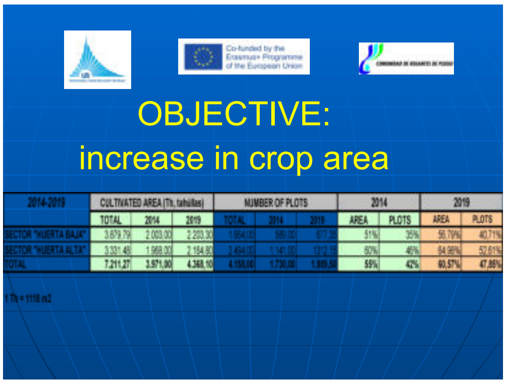

The Irrigation Community of Pliego is a public law corporation, dedicated to the management and administration of irrigation water in the municipalities of Pliego and Mula (Murcia), with a very important role in the orientation of their community members on crops and economy of the area. This entity is very interested in acquiring new knowledge through the investigation of its activities and the training of its members.


1. Location:
SPAIN
REGION OF MURCIA
PLIEGO


2. Irrigation surface:
818,22 hectares

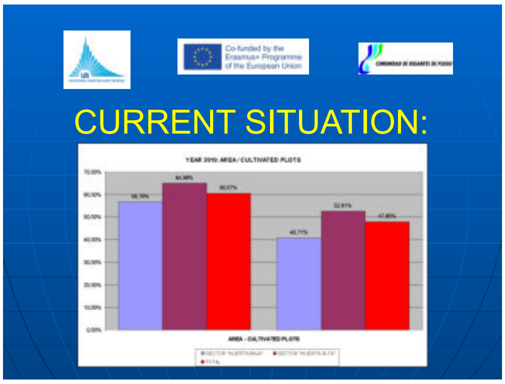

NUMBER OF PARTNERS: 1412
NUMBER OF PARTNERS IN FUNCTION OF SURFACE

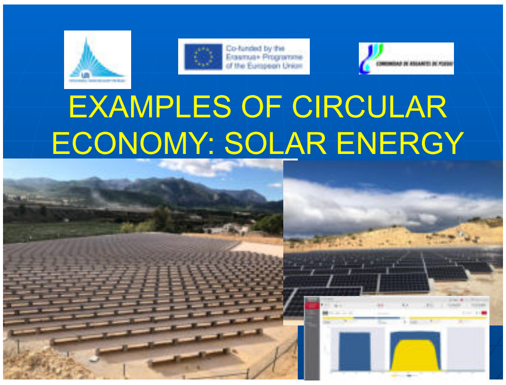

3. Water volumes available:
-Groundwater (2.326.156 m3/year).
-Surface water transfer (1.140.000 m3/year).
- Reclaimed waters (163.203 m3/year).

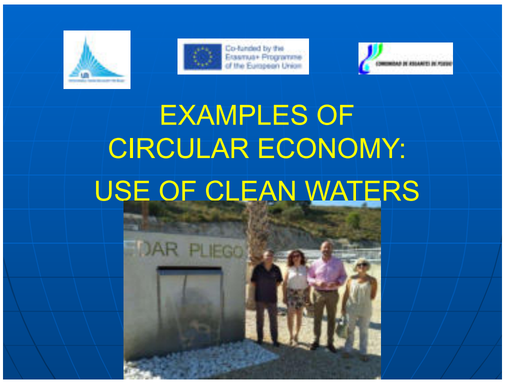


2014-2019	CULTIVATED AREA (Th. tahúllas)			NUMBER OF PLOTS			2014		2019	
	TOTAL	2014	2019	TOTAL	2014	2019	AREA	PLOTS	AREA	PLOTS
SECTOR "HUERTA BAJA"	3.879,79	2.003,00	2.203,30	1.664,00	589,00	677,35	51%	35%	56,79%	40,71%
SECTOR "HUERTA ALTA"	3.331,48	1.968,00	2.164,80	2.494,00	1.141,00	1312,15	60%	46%	64,98%	52,61%
TOTAL	7.211,27	3.971,00	4.368,10	4.158,00	1.730,00	1.989,50	55%	42%	60,57%	47,86%

1 Th = 1118 m2






EXAMPLES OF
CIRCULAR ECONOMY:
USE OF CLEAN WATERS


EXAMPLES OF CIRCULAR
ECONOMY: SHREDDING OF
PLANT DEBRIS

By-product's valorisation and waste reduction (Bacau University)

The Module led by University of Bacau "***New vision with regard to the specific economic activities of the rural environment: by-products valorisation and waste reduction***" within the MULTITRACES international project, aims for students, based on the knowledge and skills, entrepreneurial accumulated, to understand how to think from the project phase an agri-food business, based on the intelligent use of by-products / waste from rural activities. Thus, by opening a business, the degree of employment and career development opportunities increase.

Mankind is facing a major crisis of material and energy resources, a context in which the food crisis is at the forefront. Under these circumstances, it is necessary as a measure of maximum necessity to valorise the useful substances from by-products from the food industry.

By-product and waste valorisation with their reintroduction into the economic circuit is the basic principle of a circular economy.

From the processing of raw materials of the different branches of food industry, beside the main products, several by-products and wastes are obtained whose share varies according to the nature of the raw materials, the finished products, the technology, and the equipment used.

Agriculture plays a key role in the valorisation of the biological resources at its disposal. To produce food, agricultural activities create both planned products (e.g., fruit and vegetables) and waste (e.g., orange peel and wheat straw). Given that agriculture aims to create food for human consumption and has a considerable impact on the environment, creating more sustainable agricultural practices is essential if we are to shape a more sustainable future.

Agri-food by-products / wastes (organic residues) comprise important sources of sugars, lipids, carbohydrates, minerals, inorganic compounds (e.g., silica), dietary fibre or phenols, carotenoids, and tocopherols. Phytochemicals are a valuable source for the food, pharmaceutical and cosmetics sectors.

The current methods of valorisation of by-products have been developed along with the traditional production lines, being closely connected to the agricultural origin of raw materials.

There are two traditional methods of by-product valorisation in the food industry: as animal feed or as fertilizer.

The technological processes in the food industry must be oriented towards a maximum valorisation of the raw materials so that the quantities of waste are reduced to the maximum, because they raise numerous economic, hygienic-sanitary, and other issues.

Currently, research in the field is focused on finding new methods to capitalize on by-products / waste from the agri-food industry, to increase and expand innovation opportunities by achieving a zero-waste economy. This being the main objective of the circular economy.

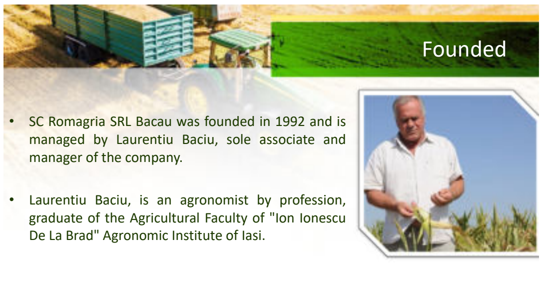
In this context, the present material briefly presents the main by-products e.g., resulting from dairy industry, beekeeping, processing of cereals, fish industry, slaughterhouse, sugar industry, oil industry, vegetable canning industry, beer industry, wine industry, wood processing, processing of eggs and also the main methods of their valorisation.

This material presents some suggestive examples which can inspire future research on the valorisation of agri-food by-products and waste.

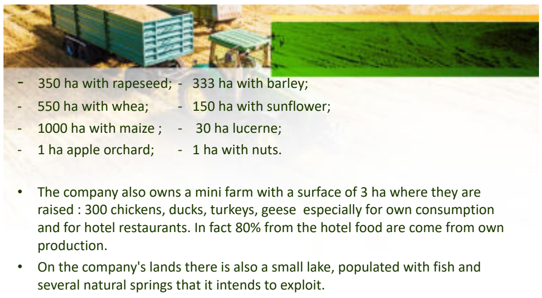
Romagria SRL

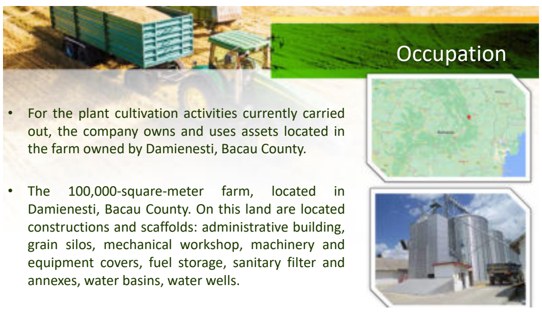
By Liliana Topliceanu, PhD
Full Professor
University of Bacau


SC Romagria SRL Bacau


Founded
• SC Romagria SRL Bacau was founded in 1992 and is managed by Laurentiu Baciu, sole associate and manager of the company.
• Laurentiu Baciu, is an agronomist by profession, graduate of the Agricultural Faculty of "Ion Ionescu De La Brad" Agronomic Institute of Iasi.


Occupation
• SC Romagria SRL Bacau has businesses in the field of agriculture, but also in the hotel field.
RECEPTION
The agricultural sector
• SC Romagria SRL is one of the largest agricultural holdings from Bacau County operateing a considerable area of land - over 2,400 ha .
• This area this area is cultivated with:


- 350 ha with rapeseed; - 333 ha with barley;
- 550 ha with whea; - 150 ha with sunflower;
- 1000 ha with maize ; - 30 ha lucerne;
- 1 ha apple orchard; - 1 ha with nuts.
• The company also owns a mini farm with a surface of 3 ha where they are raised : 300 chickens, ducks, turkeys, geese especially for own consumption and for hotel restaurants. In fact 80% from the hotel food are come from own production.
• On the company's lands there is also a small lake, populated with fish and several natural springs that it intends to exploit.


Occupation
• For the plant cultivation activities currently carried out, the company owns and uses assets located in the farm owned by Damienesti, Bacau County.
• The 100,000-square-meter farm, located in Damienesti, Bacau County. On this land are located constructions and scaffolds: administrative building, grain silos, mechanical workshop, machinery and equipment covers, fuel storage, sanitary filter and annexes, water basins, water wells.


Occupation
Other agricultural equipment:
• Fend tractors with 5 reversible plows;
• John Deere tractors;
• Trailers;
• Rotary harrows;
• Complex combiner;
• Cultivators;
• Agricultural seed drills;
• Harvesters;
• Spraying machines;
• Baler;
• Plow;
• mowers;
• Submersible aerators;
• Fertilizer spreaders;
• Herbicide plants.


Occupation
The hotel sector
• In 2007 SC Romagria SRL started the works for the first 4 star hotel in Bacau and in May 2009 it was put into operation.
• The hotel is located in Bacau town, I.S.Sururza, nr.11, about 300-400 m from the city center.
• The hotel has 32 accommodation spaces - 4 single rooms, 24 double rooms, 4 apartments - 3 restaurants with a capacity of 150, 50 and 20 seats and a terrace on the 5th floor of the hotel.


• The company has some development plans and a part of them could be a source of inspiration for the student projects.
The subject proposed are :
1. Photovoltaic panels on the roofs of farm buildings;
2. RES system for supplying the irrigation network;
3. Recovery of vegetable waste for the production of pellets;
4. The company intends to develop the part of the tourism activity going towards agrotourism. In this idea they want to create an Angus cow farm, to create a lake and build some guest houses. The students can inspire from this for projects.

By-products valorisation and waste reduction

By Vasilica Alisa ARUȘ, PhD
Associate Professor
University of Bacau

"VASILE ALECSANDRI" UNIVERSITY OF BACĂU
FACULTY OF ENGINEERING

MODULE 2

NEW VISION WITH REGARD TO THE SPECIFIC ECONOMIC ACTIVITIES OF THE RURAL ENVIRONMENT: BY-PRODUCTS VALORISATION AND WASTE REDUCTION

MULTITRACES

Co-funded by the Erasmus+ Programme of the European Union

MULTITRACES - Module 2

SKILLS
Knowledge: • Description and use of basic theories, concepts and methods on agri-food technologies. • Explaining and interpreting the principles and methods used in the technological processes in the food chain, identifying the by-products and wastes resulting from the different chain of raw materials valorisation • Management of technologies for valorisation of by-products and waste in the food industry and ensuring environmental protection.
Abilities: • Monitoring and control of the technological processes in the food industry, application of basic principles and methods in the field for identifying risk situations and proposing solutions. • Knowledge of the problems regarding the valorisation of the by-products that result in the technological processes of obtaining food products and the proposal of measures for the most efficient use of the handy substances from the by-products and waste resulted in the food industry
GENERAL OBJECTIVE OF THE COURSE
Knowledge of the principles and methods for the most efficient valorisation of by-products and waste from the agri-food sector. Their reintroduction into the economic circuit is the basic principle of the circular economy.

CONTENT OF MODULE 2

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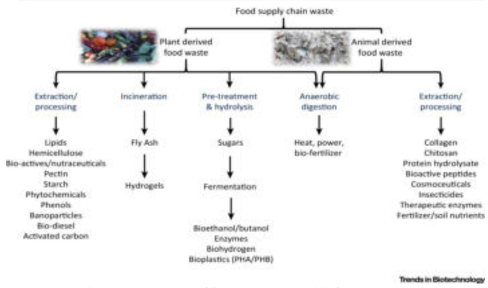
1. Valorisation of by-products and waste in the agri-food sector by implementing the circular economy



Food wastes valorisation (*Ravindran and Jaiswal, 2016*)

Waste *means any substance, preparation or any object from the categories established by the specific legislation on the waste regime, which the holder discards, intends or has the obligation to dispose of.*

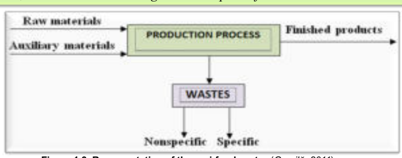


Figure 1.3. Representation of the agri-food sector (*Gavrilă, 2011*).

Non-specific waste

The quantity and quality of non-specific waste is practically independent of the type and quality of the finished product (*Botiş Nistoran, 2014*).

E.g.: containers for chemicals used in the cleaning and disinfection of installations.

Specific waste

The quantity generated by the specific waste reported at the production level can only be modified by technical means (*Botiş Nistoran, 2014*).

E.g.: barley grains depleted from brewing, slaughter by-products from meat production, potato or citrus peels, stale bread, etc.

By-product means a substance or object which results from a production process the main objective of which is not to produce it and which satisfies, cumulatively, the following conditions:

a) *the subsequent use of the substance or object is certain;*
b) *the substance or object may be used directly, without being subjected to any other processing in addition to that provided by ordinary industrial practice;*
c) *the substance or object is produced as an integral part of a production process;*
d) *the subsequent use is legal, in the sense that the substance or object meets all relevant requirements related to the product, environmental protection and health protection for the specific use and will not produce overall harmful effects on the environment or public health.*

Valorisation *is any operation whose main result is that the waste serves a useful purpose by replacing other materials that have been used for a particular purpose or that the waste is prepared to serve that purpose in businesses or in the economy in general.*

Circular economy - as a model of production and consumption that involves the sharing, reuse, repair, renovation and recycling of existing materials and products as much as possible. In this way, the product life cycle is extended.

The **circular economy** (*Figure 1.2b*) is different from the traditional economic model, the **linear economy**, which consists of "buy-consume-throw" (*Figure 1.2a.*)

Figure 1.2 a) **Linear economy** (*Rajković et al., 2020*); b) **Circular economy**.

CIRCULAR ECONOMY
IS AN ECONOMY THAT PRODUCES ZERO WASTE

REDUCING FOOD LOSS AND WASTE PRESENTS UNIQUE OPPORTUNITIES TO CREATE VALUE, LOCAL BUSINESSES AND JOBS.

CIRCULAR ECONOMY knows several definitions and interpretations. In its most generous terms it means:

- superior valorisation of raw materials,
- sustainable use of nature offers us, including renewable energy sources,
- reintroduction in new economic cycles of by-products and waste
- reintroduction in new technological processes of the different components of the final product when it reaches the end of its lifecycle;
- high energy efficiency, automation and computerisation of production activities.

The result will be the innovation of new products and technologies, a decrease in the amount of disposable waste as close to zero as possible, a cleaner and healthier environment for all of us.

The most correct way to achieve these objectives is for the design of new production capacities, the opening of a new business to be done by considering the circular economy at each stage of the raw material transformation chain.

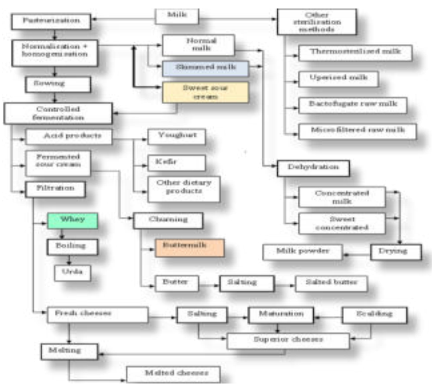
The purpose of this Module 2 is for you to understand how it should be thought, since the project phase, an agri-food business, the way in which by-products and waste can be valorised.

2. Valorisation of dairy industry by-products

Milk is a white-yellow, sweet-tasting liquid which is obtained by the complete and uninterrupted milking of healthy, properly fed and cared for animals

From the main technological processes which take place in the dairy industry result three **by-products**:
• **skimmed milk** resulting from the separation of cream from milk;
• **buttermilk** resulting from the butter manufacture;
• **whey** resulting from the manufacture of cheeses, casein and protein coprecipitates.

These by-products as well as the products resulting from their industrial processing can be used in human food, for animal feed, as well as for various technical purposes (chemical industry, pharmaceutical industry, paper industry, textile industry, etc.).



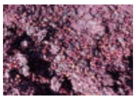
3. VALORISATION OF THE WINE INDUSTRY BY-PRODUCTS AND WASTES

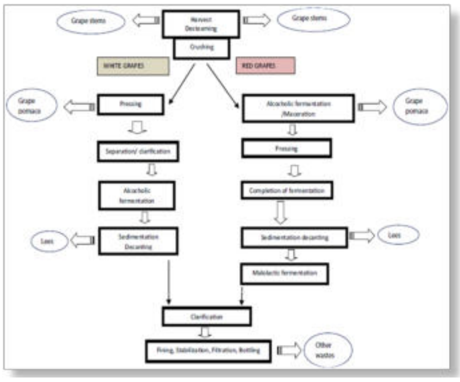
Grapes, as a raw material for industrialisation, are used to obtain food products such as fresh grape wine pressing, juice, wines, distillates, etc.

Wine is a drink obtained by partial or total alcoholic fermentation of sugars from crushed grapes or wine pressing (Figure 3.2.).

Wine pressing is the liquid resulting from fresh grapes, by free draining or by authorised physical processes.

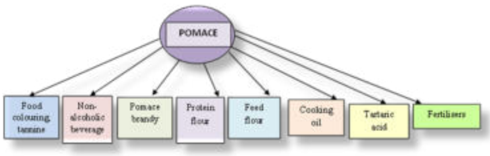
In the wine industry in the technological stages for obtaining wine as a finished product, a series of **by-products and wastes** results for which the mass weight, the chemical composition and the vegetal structure vary in wide limits





The wine industry results in a series of by-products and wine waste, such as:

- bunches:
- pomace:
- wine yeasts
- deposits or sediments
- deposits from the wine clarifying
- tartar (lime stone)
- draff
- ethyl alcohol
- tartaric acid and tartrates
- seed oil
- tannin:
- food colouring
- grits



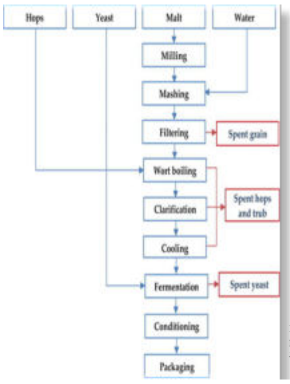
4. Valorisation of the beer industry by-products and wastes

Beer is a low-alcohol, non-distilled beverage, obtained by alcoholic fermentation, with the help of yeast, a wort made from malt, water and hops, the malt being able to be partially replaced with unmalted cereals (corn, broken rice, barley) and possibly enzymes

The main raw materials used in the beer industry are barley, water and hops, also adding unmalted cereals and selected yeast crops.

Malt is a product obtained by germinating barley seeds under special conditions, in order to accumulate enzymes and disintegrate macromolecular substances in the grain.

Hops is a plant with yellow-green flowers, whose aromatic and bitter female inflorescences are used in brewing. Due to the compounds it contains in the cones, hops largely influences the taste, aroma, colour, clarity and preservation power of beer.



The by-products obtained in the beer industry are the following:

- cereal waste;
- malt germs (rootlets) ;
- malt draff;
- protein sediment (trub);
- primary fermentation foam;
- yeast;
- carbon dioxide.

Figure 4.2 Schematic representation of the brewing process and points where the main by-products are generated (Karlović et al., 2020)

5. Valorisation of the vegetable canning industry by-products and waste

By-products from fruit and vegetables are leftover like seed, pulp, skin or pomace, accounting to 10–35% of raw mass.

Generally, they are used as animal feed or for production of biomaterials, biofuels, biogas, platform chemicals and bio-fertilisers through biological processes (Dilucia et al., 2020).

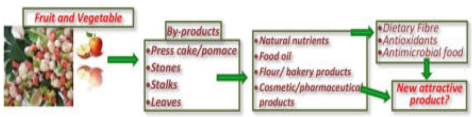


Figure 5.1. Valorisation of fruit and vegetable by-products (Kowalska et al., 2017)

9. Valorisation of slaughterhouse By-products and waste

Meat and meat products form an important segment of the human diet because they provide essential nutrients which cannot be easily obtained through vegetables and their derived products.

Animal by-products include all parts of a live animal that are not part of the dressed carcass such as liver, heart, rumen contents, kidney, blood, fats, spleen and meat trimmings.

Animal by-products can be grouped into:

- **non-carcass meat (EBPs)**
- **non-meat products (IEBPs)**

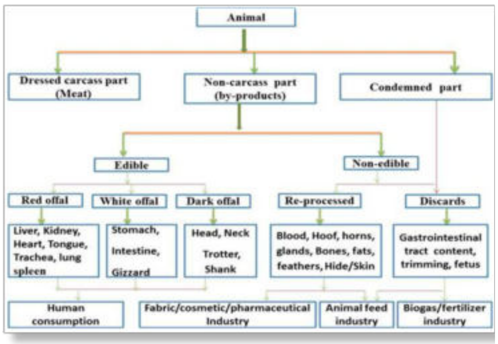


Figure 9.1. Classification of animal by-products (Alao et al. 2017)

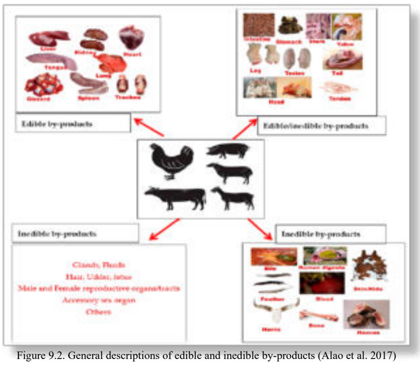


Figure 9.2. General descriptions of edible and inedible by-products (Alao et al. 2017)

10 . Valorisation of the fish industry by-products

In the fish industry, as in the meat industry, the processing of the raw material results in a series of by-products and waste (Figure 10.1.) consisting of parts which separate in the processing of the main product, consisting of easily alterable substances, which if not immediately recovered, can form outbreaks of infection within the enterprise.

Fish industry by-products

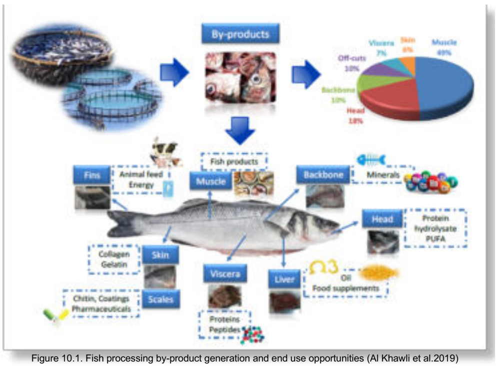


Figure 10.1. Fish processing by-product generation and end use opportunities (Al Khawli et al.2019)

11. Recovery of by-products and cereal waste

The most well-known and frequently used cereals (Figure 11.1.) for human food are the following: wheat, rye, triticale, corn, barley, rice, oats, millet, sorghum; to these are added the so-called pseudo-cereals (buckwheat, quinoa, amaranth, sesame) although they do not belong to grasses, but to other botanical families.

Almost two-fifths of world grain production is used for animal feed. In the form of whole or ground grains, as green, dried or ensiled plants, as waste (straw, chaff or stalks of maize) and by-products (bran, germs) they are used in the food of all human-raised animal species.

Figure 11.1.Cereal plants

12 . Valorisation of beekeeping by-products

Beekeepers can also obtain other by-products (Figure 12 .1) such as: pollen, pasture, propolis, wax, venom and royal jelly

Honey is the main product of beekeeping, appreciated both for its nutritional properties and for its therapeutic effects.

Beekeeping is a branch of animal husbandry which studies the biology and technology of beekeeping and exploitation, in order to obtain quality bee products and increase seed production in entomophilous agricultural plants (where pollination is done by insects).

13. Valorisation of the wood processing by-products and waste

The forest is a source of raw materials (wood products - working wood and firewood - energy source - but also non-wood products - food source).

Wood is the main product of the forest because it has many uses and uses, including working wood (resonant, for veneer, construction, etc.), firewood and even debris (legs, stumps, leaves) that can be used for various purposes (chopping, unique pieces of furniture, tools, accessories, etc.)

The bark is used to fertilize the soil, as a combustible material, to obtain products such as tannins, waxes and furfural

Figure 13.1. Wood wastes (Owoyemi et al., 2016)

Sawdust ways of valorisation

- Obtaining compost
- Valorisation of packaging and pallets:
  - by reuse after repair
  - by recycling
- Degreasing of metal parts
- Litter for animals
- Obtaining inferior quality charcoal
- Smoking meat and fish
- Nutrient substrate for growing cultivated mushrooms (eg Pleurotus ostreatus).
- Obtaining sawdust briquettes

By-products of the forest industry, like bark and peat, contain bioactive molecules with potential applications in medicines, cosmetics, industrial chemicals and plant protection products.

Renewable energy and Natural Resources

By
University of Bacau

NATURAL RESOURCES VALORISATION
RENEWABLE ENERGY SOURCES IN RURAL AREA
(UBc contribution)

Solar energy/ Wind energy/ Biomass/ Geothermal energy/ Hydropower

Renewable energy and circular economy

THE CONNECTION BETWEEN CIRCULAR ECONOMY, BIOECONOMY AND RENEWABLE RESOURCES OF ENERGY

The circular economy is an economic model which comes from the biosphere, where everything can become a resource for the next level of the trophic chain.

The basic principles of the circular economy are:
- the wastes are raw materials;
- resilience through diversity;
- energy from Renewables sources;
- think from a systems perspective.

The European Commission defines the bioeconomy as *the production of renewable biological resources and the conversion of these resources and waste streams into value added products, such as food, feed, bio-based products and bioenergy.*

The two concepts, the circular economy and the bioeconomy, are distinct from several points of view, but in principle have common goals: efficient use of non-renewable sources - a combination of reduction, reuse and recycling activities respectively the use of renewable sources in an intelligent and efficient way.

An important objective resulting from the principles of the two models is development and support for rural areas by adding value to goods that are produced by the agricultural, forestry, fisheries or waste sectors.

http://multitraces.ub.ro

Renewable energy and circular economy

A BRIEF INTRODUCTION ABOUT ENERGY RESOURCES

The word ***energy*** comes from the Greek ενέργεια (***working***). In Latin – ***energia*** (***activity***).

The concept of ***energy*** is fundamental due to the connection between matter and motion - production and transformation of different forms of matter movement.

Primary energy consists of all the energy that is in the original source. Primary energy is the energy that has not undergone any process of conversion or transformation.

Primary energy →
- **conventional** - finite sources (***crude oil, coal, natural gas and nuclear fuels***)
- **renewable** sources - continuously generated by natural systems (***hydraulic, solar, wind, geothermal, tidal, wave, biomass***).

Gross theoretical potential - the energy that would become available through the conversion into useful energy of all natural renewable flows, with an efficiency of 100%.

Technical potential - the share of the gross theoretical potential that can be converted into useful energy, taking into account the level of technological development and the possibility of its use by human society.

Economic potential - the share of the technical potential that can be converted into useful energy, taking into account economic profitability.

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Renewable energy and circular economy

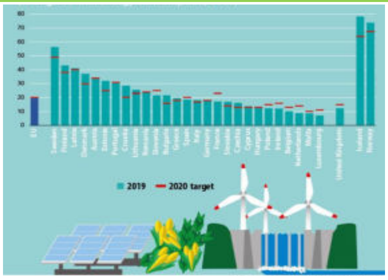

Fig.1. Share of energy from renewable sources, 2019 (% of gross final energy consumption), Source, Euroatat

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Renewable energy and circular economy

The share of energy from renewable sources in gross final energy consumption, 2010-2019 for ***Greece, Spain, Italy and Romania***, in %:

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Greece	10.1	11.2	13.7	15.3	15.7	15.7	15.4	17.3	18.1	19.7
Spain	13.8	13.2	14.3	15.3	16.2	16.3	17.4	17.6	17.5	18.4
Italy	13.0	12.9	15.4	16.7	17.1	17.5	17.4	18.3	17.8	18.2
Romania	22.8	21.2	22.8	23.9	24.8	24.8	25.0	24.5	23.9	24.3

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Solar energy

The sun - the most important source of energy on Earth. In one second the Sun radiates more energy in space than mankind has consumed since its appearance on earth: 3.86x1026 J.

The value accepted of the solar constant is approximately 1360 W/m^2, representing an average annual value, measured with the help of scientific research satellites. The Earth's atmosphere and Earth's surface interact with solar radiation, producing a series of transformations of solar radiation.

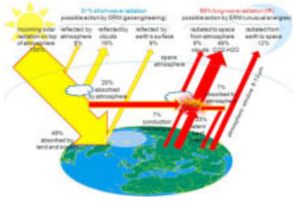

Fig. 2. Principal energy fluxes, Source, https://www.sciencedirect.com

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Solar energy

The mechanisms by which the intensity of solar radiation changes as it passes through the atmosphere, are ***absorption and diffusion***.
X radiation and part of the ***ultraviolet radiation*** are almost completely absorbed (retained, filtered) in the atmosphere.
A part of solar radiation is reflected by the Earth 's atmosphere or some of its components (the air molecules and certain categories of clouds). By reflection, some of the solar radiation is dissipated, the mechanism of this process is called Rayleigh diffusion, and this phenomenon represents the radiation of the celestial vault.
Direct radiation is the component of atmosphere radiation that is neither reflected nor scattered, and which directly reaches the surface. This is the component that produces shadows.
Global radiation from the Sun, on a horizontal surface at ground level in one serene day, represents the sum of direct radiation, diffuse radiation and reflected radiation.
Direct solar radiation depends on the orientation of the receiving surface.
Diffuse solar radiation can be considered the same,

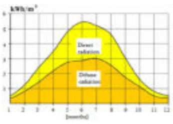

Fig.3. The ratio between diffuse and direct radiation. Source, http://www.termo.utcluj.ro

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Solar energy

The solar radiation that reaches the Earth consists of:
- visible radiation from 0.38 to 0.78 microns,
- ultraviolet (UV) radiation from 0.28 to 0.38 microns,
- infrared (IR) radiation from 0.78 to 2.5 microns.

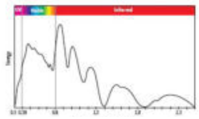


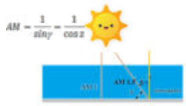
Fig. 4. The overall spectrum of solar radiation according to EN 410

According to the standards, the photovoltaic modules are evaluated for an air mass index - AM of 1.5.
It quantifies the reduction in the power of light as it passes through the atmosphere and is absorbed by air and dust.

AM has the value 0 (before entering the Earth's atmosphere), in which case the irradiance is the solar constant, respectively 1360 W / m².

AM =1 corresponds to a trajectory perpendicular to the Earth's surface (the shortest path of radiation, through the atmosphere, to the Earth's surface).

AM =1.5 attests that the path of radiation through the Earth's atmosphere is 50% longer than for AM =1, which corresponds an angle $\gamma = 41.8°$



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Solar energy
Aspects related to the conversion of solar energy into other forms of energy

Tthe solar energy can be converted into other forms of energy in 4 ways:
1. Photomechanical energy conversion;
2. Photothermal conversion;
3. Photochemical conversion;
4. Photoelectric conversion.

Photomechanical energy conversion is applied in the field of space energy. The solar sail motor is a new application common to satellites. After the satellite or spacecraft reaches interstellar space, due to the interaction between photons and large reflecting surfaces, propulsion occurs through the impulse given by the photons to the interaction.

Photothermal conversion determines the climatic and meteorological conditions in various geographical areas, the formation and the preservation of the water cycle on the earth, an essential phenomenon for the existence of life on the planet. Photothermal conversion has many practical and industrial applications.

Photochemical conversion (along with photothermal conversion) use the solar energy in two ways: directly by light excitations of the molecules of a body, or indirectly through plants (photosynthesis) or the transformation of animal manure. Lately, the fuel cell sector has developed a lot as industrial applications.

Photoelectric conversion has multiple applications in both terrestrial and space energy. The direct conversion of solar energy into electricity is done by photovoltaic effect, with the help of photovoltaic cells.

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Solar energy
Aspects related to the conversion of solar energy into other forms of energy

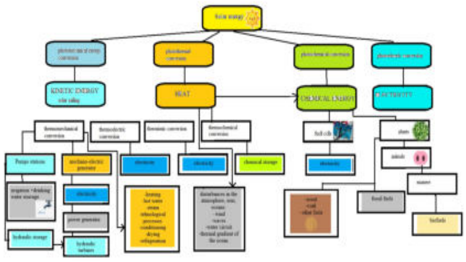

Fig.5. The conversion of solar energy in other forms of energy

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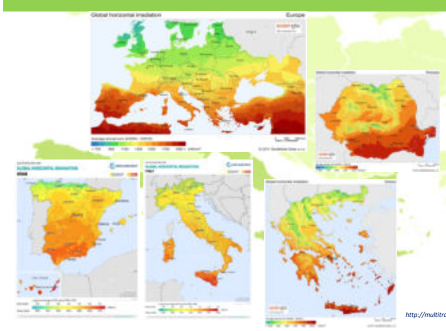
Solar energy



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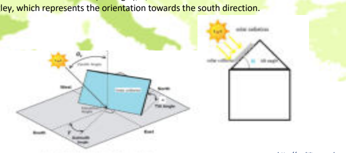
Solar energy
Solar thermal energy

Capturing the sunlight for heat production

There are two major categories:
- ***CSP - Concentrating Sun Power*** - solar energy is concentrated by using mirrors or lenses and used to increase the temperature of a thermal agent, subsequently used for electricity production, in an industrial scale system;
- ***LPC - Low Power Collectors*** - generally intended for small - scale use, generally for obtaining hot water (low power domestic or industrial applications).

For the rural area of great importance are the various types of low power collectors.
For a highest possible efficiency, the orientation of the collectors position towards the Sun must be correct.
The position of the solar collectors is defined by two angles:
- the angle of inclination to the horizontal (tilt angle), α,
- the azimuth angleγ, which represents the orientation towards the south direction.



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Solar energy
Solar thermal energy

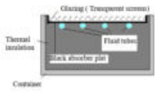
For residential applications, the most common solar collectors are:

- Flat solar collectors;
- Vacuum tubes solar collectors;
- Heat pipe solar collectors.

The flat solar collector

- *open circuit* - the heat transfer fluid from the consumer's installation is the same as the one circulating through the panel pipes - radiator principle;
- *closed circuit* - the primary circuit (corresponding to the solar panel) is separated from the secondary circuit by the consumer through a heat exchanger.

The solar radiation absorbed by a collector per unit of absorption surface is equal to the difference between the incident solar radiation and the optical losses. The heat losses of the collector in the environment by conduction, convection, and radiation are determined as the product of the heat transfer coefficient U_L and the difference between the average temperature of the absorbent plate ***Tp*** and the temperature of the environment ***Ta***. At steady state the useful energy output of an surface collector ***Ac*** is given by the difference between the absorbed solar radiation and the heat loss.



$$Q_u = A_c \times [I - U_L \times (T_p - T_a)]$$

Solar energy
Solar thermal energy

Vacuum tubes solar collectors

Battery-mounted glass tubes. Heat pipe collectors have a wing-shaped Cu pipe with an absorbent element inside. These types of collectors have been on the market for over 25 years and are of several types:

- Tube-welded absorption surface,
- Absorption surface not welded to the tube;

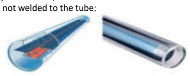
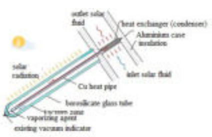


Fig.10. Tube-welded absorption surface (left), Absorption surface not welded to the tube (right)

Fig.11. Collector with completely vacuum tube, b. Collectorwith a not completely vacuum tube

Solar energy
Solar thermal energy

Heat pipe evacuated tubes collector



At the top of the panel is an insulated metal cylindrical tank, which holds the vacuum glass tubes. The tubes have double walls, between them being a vacuum. Due to the vacuum, the heat transfer to the environment is reduced. Inside the outer walls of the glass tubes is an absorbent material that increases the ability to capture solar radiation. In the cylindrical metal tank, the warmer water, with a lower density, will rise to the top, and the water with a lower temperature will remain at the bottom of the tank and will flow through the glass tubes, will receive heat from the Sun. It will heat up and becoming less dense it will climb into the tank at the top (the thermosyphon effect).

Solar energy
Solar thermal energy

Examples of heat production systems using solar collectors for rural houses

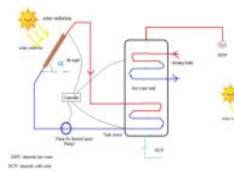


Fig.13. Schematic diagram for solar domestic hot water system

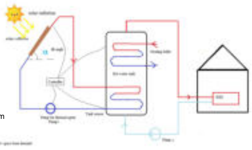


Fig.14. Schematic diagram scheme for solar heating system

Solar energy
Solar power

Solar power is the conversion of the sunlight into electricity (the photoelectric conversion). This conversion can take place indirectly using concentrated solar power, directly using photovoltaic panels or combination. Concentrated solar power systems use lenses or mirrors and solar tracking systems to focus a large area of sunlight into a small beam. Photovoltaic cells convert light into an electric current using the photovoltaic effect

Agrivoltaic *(agriculture – photovoltaic)* is a new term, used for the first time by Adolf Goetzberger and Armin Zastrow in 1981 and established in vocabulary in 2011. This word means co-developing the same area of land for both photovoltaic power as well as for agriculture.

Fig.15. Agrivoltaic beekeeping project in Spain

Photovoltaic cell – operation principle

The word photovoltaic consists of the Greek word for light and the name of the physicist Allesandro Volta. This word refers to the direct transformation of sunlight into electricity through solar cells. Solar cells are the main components of a photovoltaic panel system.

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Solar energy
Solar power

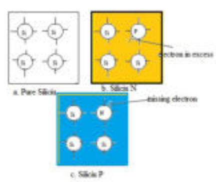


Fig.16. The schematic of Siliciu atom (4 electrons on the outer layer)

The cell consists of two or more semiconductor layers between 0.001 and 0.2 mm thick, doped with certain chemical elements to form "p" and "n" junctions.

Structura celulei PV este similară cu cea a unei diode. Când stratul de siliciu este expus la lumină, va avea loc o „agitație" a electronilor din material și va fi generat un curent electric.

$E_f = h \times \nu$ h=6.62607015×10^{-34} J·s (Planck constant;)
v - photon's frequency.

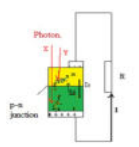


Fig.17. Simplified diagram of a photovoltaic cell

Solar energy
Solar power

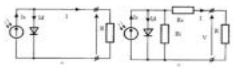


Fig.17. The electrically equivalent diagrams of the photovoltaic cell a. simplified diagram, b, complete diagram

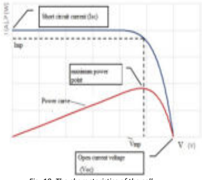


Fig. 18. The characteristics of the cell

The standard test conditions:
•Solar irradiance 1000 W/m^2,
•-airmass AM=1.5,
•Temperature of the cell 25^{0}C.

Solar energy
Solar power

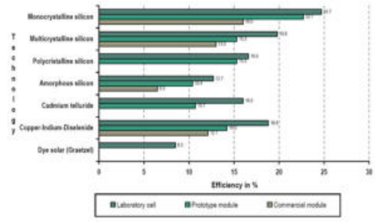
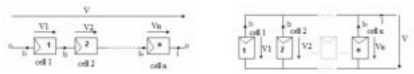


Fig. 19. Efficiency of photovoltaic cells depending on the manufacturing technology.

Solar energy
Solar power

The connecting of photovoltaic cells



V=V1+V2+….+Vn , [V]
I=I1=I2=….=In, [A]

V=V1=V2=….=Vn , [V]
I=I1+I2+….+In, [A]

Fig.20. The series/paralel connected photovoltaic cells

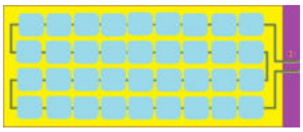


Fig.21. 36 Cells Photovoltaic PanelFig.2.28. 36 Cells Photovoltaic Panel

Solar energy
Solar power

Some examples of PV panels systems for rural area

The photovoltaic systems are divided into two large groups:

- ***Off-grid PV systems or stand-alone PV systems***;

These systems feed consumers which are not connected to the main electrical grid. These systems are used in areas without electricity (small rural areas) and can generate the power and run the appliances by themselves. In principle, the energy produced by the PV panels is stored in the batteries, and from there it is provided with the help of an inverter DC-AC, to household users at 220 V

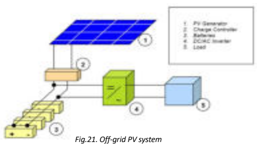
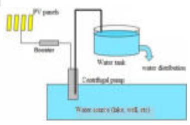


Fig.21. Off-grid PV system



Solar energy
Solar power

- ***On-grid PV systems***

The on-grid PV systems or grid-connected PV systems are used in areas with electricity. In principle, the energy produced by solar panels is delivered in the national grid and at the same time used for home applications.

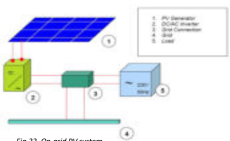


Fig.22. On-grid PV system

- ***Hybrid systems*** - independent of the electrical distribution network. Consist of a photoelectric generator, associated with a wind turbine or generator set with an internal combustion engine, or both. Biogas is also used.

Renewable energy and circular economy

Fig. 23. Hybrid system from campus of Vasile Alecsandri University

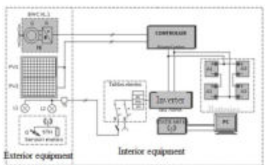


Fig. 24. The diagram of hybrid system the, Vasile Alecsandri University

Wind energy

Wind energy is the most rapidly expanding source of energy in the world.
The main advantages of wind power are:
- Lack of pollutant emissions and greenhouse gases,
- Does not require any combustion process to obtain this form of energy;
- Does not involve the generation of waste;

The cost per unit of energy (€/MWh) produced with this technology has declined substantially in recent years, making it competitive with traditional generators in most of the electricity markets worldwide.

Technical aspects of wind energy:
- the wind intensity and the wind speed variation in time
- the variation in wind speed with altitude
- the wind direction

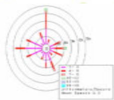


Fig. 25. Example of the wind rose diagram

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Wind energy

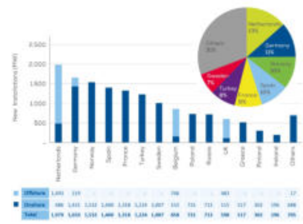

Fig. 26. New wind installations in Europe, 2019

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Wind energy

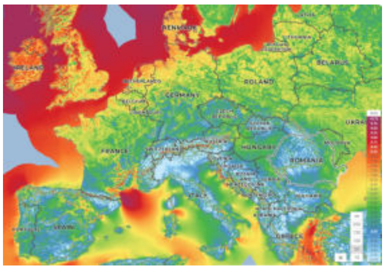

Fig.27. The wind map for Europe at a height of 50 m

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Wind energy

In rural environment are two possible types of wind installations, mainly:
- the development of wind farms, which can be connected to the network and which can provide electricity for a community made up of several families
- a small wind turbine that would provide energy needs for a home. This can be combined with other energy producing systems.

The types of small wind turbines
- ***Small vertical axis turbines (VAWT – "vertical-axis wind turbine")***
  - ✓ Marilyn Wind Turbine
  - ✓ Darrieus wind turbine
  - ✓ Lentz turbine
  - ✓ Savonius wind turbine

Fig. 28. Small vertical axis turbines
From the left: Marylin turbine, Darrieus-Savonius, Lentz turbine, Savonius turbine

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Wind energy

- ***Small horizontal axis turbines (HAWT – "horizontal-axis wind turbine")***

Category

❖ Number of bladed:
- quick turbines, which can have 2-3 blades;
- slow turbines, which have multiple blades, their number can be from 3-18.

❖ The placement of the blade:
- placed blade against the wind - "upwind" (first encounters wind blades and nacelle then),
- located downwind paddle - "downwind" (wind meets first nacelle and blades then).

❖ Depending on the equipment used in the conversion process
- with speed multiplier (gearbox), equipment that connects the hub of the wind turbine and electric generator;
- without speed multiplier, the hub of the turbine shaft is coupled directly to the generator

Fig. 29. Wind turbines with many

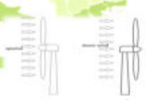

Fig. 30. The location of the turbine blades relative to the direction of the wind: a. upwind turbine, b. downwind turbine

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Wind energy

Wind energy conversion system with horizontal axis turbine

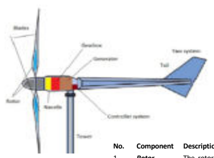

Fig. 31. Components of small horizontal axis wind turbine

No.	Component	Description
1	***Rotor***	The rotor is formed from the main-shaft and its blades. The blades made from composite materials mixed with fiberglass have an aerodynamic shape.
2	***Generator***	The generator transforms mechanical energy of rotational into electricity.
3	***Gearbox***	The gearbox serves in adjusting the rotation speed of the rotor. It is used in small wind turbines with outputs greater than 10 kW.
4	***Nacelle***	In the nacelle are mounted the generator and the gearbox.
5	***Yaw system***	The yaw system assures the orientation of the nacelle to the wind direction.
6	***Controller***	The electronic control system monitors the overall operation of the turbine
7	***Tower***	The tower supports the guidance system, the nacelle and the rotor of the wind turbine.

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Wind energy

The batteries for wind or hybrids system are of a special construction regarding the free maintenance and the fact that it supports a large number of charge-discharge cycles.

The most common types of storage batteries in photovoltaic systems, wind systems and hybrid systems are lead-acid batteries. Recently, there have been developed Li-Ion batteries and nickel - cadmium (Ni-Cd) batteries for high capacity. Lead-acid batteries continue to be the main option for energy storage, having the advantage of price and availability.

Types:

- ***VRLA*** - Valve-Regulated Lead-Acid Batteries - encapsulated batteries
- ***GB-*** Gel Batteries - sealed at the factory, use sulphuric acid turned into a gel form (they do not leak or spill), easily transported and require no maintenance.
- ***AGM*** (Absorbed Glass Mat) lead-acid batteries, sulphuric liquid acid electrolyte is absorbed into mats fibers glass so they would not leak, even if cracked.
- ***OPzS*** (liquid electrolyte) or ***OPzV*** (gel)- are tubular plate batteries, also called gel batteries, made especially for off-grid applications and have excellent deep discharge characteristics. The positive plates in tubular cells are made of rods protected in a 'tubular' sleeve – not a flat plate – which gives them an exceptionally long life cycle.

The power inverters transform stored energy from the batteries or from generated energy DC current from the wind turbine at 12, 24 or 48V into alternating current at the necessary voltage and frequency.
There are two types of inverters:

- ***grid-tie*** inverters and
- ***stand-alone*** inverters.

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Wind energy

Small wind electric systems used in rural areas

- *Household installations* - a domestic system of production and use of direct and alternating current using a small wind turbine

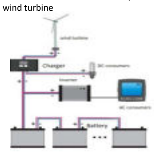

Fig. 32. Simple system of using wind energy for a residential house.

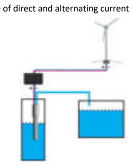

Fig.33 Water-pumping windmills

- *Water-pumping installations* - used in areas where water is in limited quantities, but there is ground water in depth and wind blows regularly.

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Biomass

The **biomass** is the biodegradable part of products, waste and residues from agriculture, including plant and animal substances, forestry and related industries, as well as the biodegradable part of industrial and urban waste. From an energetic standpoint, biomass is the most abundant renewable resource on the planet. It includes absolutely all the organic matter produced by the metabolic processes of living organisms. Biomass is the first form of energy used by man, with the discovery of fire.

General data:
•total mass (including humidity) - over 2,000 billion tons ;
•total mass of terrestrial plants – 1,800 billion tons;
•total mass of the forest – 1,600 billion tons;
•the amount of energy accumulated in the terrestrial biomass - 25,000 * 10^{18} J;
•annual biomass increase - 400,000 million tons;
•speed of energy accumulation by terrestrial biomass;3000 * 10^{18} J per year (95TWt);
• total annual consumption of all types of energy - 400 * 10^{18} J per year (22TWt);
• biomass energy use - 55 * 10^{18} J per year (1.7TWt).

There are five basic categories of material:
•Vergin forestry, arboricultural activities, wood processing,
•energy crops: high yield crops grown specifically for energy applications,
•agricultural residues: residues from agriculture harvesting or processing,
• food waste, from food and drink manufacture, preparation and processing, and post-consumer waste,
•industrial waste and co-products from manufacturing and industrial processes.

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Biomass

The biomass categories:

•***Primary biomass*** - produced by agriculture and forestry. It includes energy crops and agricultural crops such as short rotation trees, grasses and aquatic plants.
•***Secondary biomass***: biomass such as straw, stover and crop residues that is generated as a result of harvesting and processing of primary biomass such as lumber, pulpwood, and grains. It also includes processing residues and by-product streams from food, feed, fibre and materials production.
•***Tertiary biomass***: post-consumer residue streams from urban activities such as fats, greases, oils, construction and demolition debris/wood, as well as animal manure and other by-products from concentrated animal feed operations.

Forms of biomass energy recovery (biofuels)

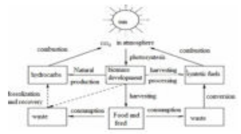

Fig. 34. Biomass transformation

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Biomass

Biomass transformation

Forms of biomass energy recovery :

- ***direct combustion*** with thermal energy generation.
- ***pyrolysis combustion***, with singaz generation (CO + H2).
- fermentation, with generation of biogas (CH4) or bioethanol (CH3-CH2-OH) - in case of fermentation of sugar products; biogas can be burned directly, and bioethanol, mixed with gasoline, can be used in internal combustion engines.
- ***chemical transformation*** of vegetable oil biomass by treatment with an alcohol and generation of esters, for example methyl esters (biodiesel) and glycerol. In the next step, the purified biodiesel can burn in diesel engines.
- ***enzymatic degradation*** of biomass with ethanol or biodiesel. Cellulose can be enzymatically degraded to its carbohydrate-derived monomers, which can then be fermented to ethanol.

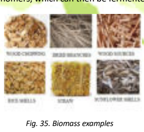

Fig. 35. Biomass examples

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Biomass

Wood waste - renewable energy source in rural area

All materials with ligno-cellulosic structure (wood, straw, wood sawdust, paper, wood fibers) are important energy resources.

Disadvantage:

- very low density - difficulties in handling, transport, storage - increased costs,
- large variations in the humidity of the material - difficulties in the operation and regulation of the processes in the power plants in which they are used.

Solution:

- drying and compression of the material (densification) at very high pressures - woody biofuels with a uniform structure, (pellets and briquettes). Ș

Advantages of wood biomass densification:

- increasing the density of the compressed material (from 80-150 kg / m3 for straw or 200 kg / m3 for wood sawdust up to 600-700 kg / m3 for the final product);
- higher calorific value and a homogeneous structure of compressed products;
- low moisture content (less than 10%).

Calorific values for wood waste

Combustible	Net calorific value [GJ/tonă]	Net calorific value [kWh/kg]	Density Kg/m³	Energy/volum MJ/m³	Energy/volum kWh/m³
Wood sources (30% maximum umidity)	12.4	3.5	250	3100	870
Wood choping (20% maximum umidity)	14.7	4.1	350-500	5200-7400	1400-2000
wood (solid –very dry)	19	5.3	400-600	7600-11400	2100-3200
Wood pellets	17	4.8	650	11000	3100
Energy willow (25% maximum umidity)	13	3.6	140-180	1800-2300	500-650

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Biomass

Pellets

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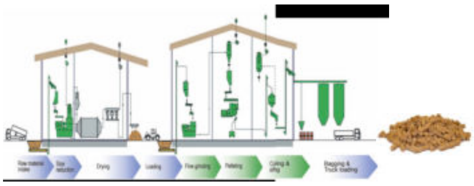


Fig.36. The pelletizing process

Biomass

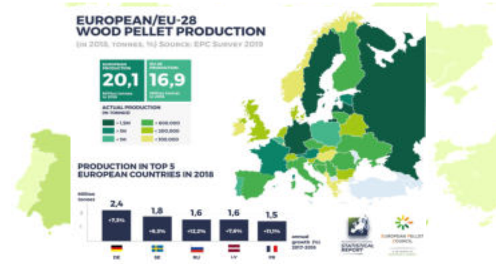


Fig.37. The wood pellet productiion in uropa/Eu-28 in 2018,

Source: https://epc.bioenergyeurope.org/about-pellets/pellets-statistics/european-production/

Biomass

In rural areas, biomass for heating is traditionally used in stoves where wood logs or briquettes are burned to make heat at a decentralized level and with a low efficiency of up to 45%. In addition to stoves, small boilers can use similar types of fuel for small central heating units in the household. These systems can use small fuels, such as pellets or wood chips, which allow automatic feeding. In recent years, with the development of modern power plants using wood pellets, the efficiency of these systems has increased to almost 90%. Medium-sized central heating systems in small grids use fuels that allow automatic feeding, such as pellets or wood chips, and typically use hot water boilers to produce heat with up to 90% efficiency. Larger central heating systems and industrial plants powered by solid biomass typically use cogeneration technologies for heating.

Biomass can be converted to **biogas** through a process called anaerobic digestion (AD). This is a staged biological process in which various types of microorganisms decompose digestible biomass in the absence of oxygen. Biomass is converted to biogas, which contains mainly methane (CH4) and carbon dioxide (CO2) and much smaller amounts of hydrogen (H2) and hydrogen sulfide (H2S). At the end of the process, the remaining digestate is often rich in nutrients such as ammonium and phosphate and can be used as fertilizer. Methane-producing microorganisms are found in various places in nature, such as the stomachs of ruminants (cattle). To initiate the process of anaerobic digestion in a biogas plant, an inoculum (cow dung) can be introduced into the raw material.

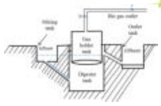
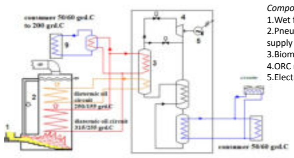


Fig.38. Scheme of a biogas plant

Biomass

Biomass burning and energy production. Micro- cogeneration plant

CHP or cogeneration is a process of energy transformation in which useful electricity and heat are produced simultaneously, in a single process



Components parts:

1.Wet fuel silo
2.Pneumatic transport installation for boiler supply
3.Biomass boiler
4.ORC module (Organic Ranking Circuit)
5.Electrical generator

Fig.39. Thermal scheme for the cogeneration plant

Cogeneration advantages:

- energy efficiencies above 80%,
- primary fuel economy,
- less pollution and the possibility of controlling and reducing pollutants,
- low cost for energy produced in cogeneration plants.

Geothermal energy

The Earth has a and a metallic hot and liquid inner core consisting of molten sheath core generating the magnetic field. The temperature of the earth increases with depth, in the inner core reaching more than 4500°C [39]. But the core does not only generate the earth's magnetic field, it also generates heat, which can be used as a renewable energy source.

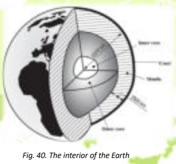


Fig. 40. The interior of the Earth

The high temperature at the boundary of the outer core (liquid), with the mantle, can reach over 4500 °C and due to the high pressure it causes the rocks to melt but also to heat them to the level of the earth's crust, where the water contained in it can reach temperatures higher than 350 °C. Consequently, it can be said that geothermal energy is the thermal energy generated and stored in the earth.

Geothermal energy

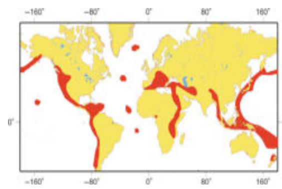


Fig.41. Geothermal regions (in red)

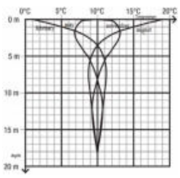


Fig.42. Variation of the temperature in the upper earth crust

Geothermal energy

Example of geothermal power plant

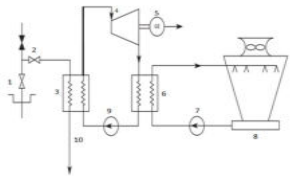


Fig. 43. Binary cycle power plant: 1 –well production, 2 –pressure regulation valve, 3 –heat exchanger, 4 –turbine, 5 –electric generator,6 –condenser, 7 –cooling water pump, 8–cooling tower, 9 –condenser pump, 10 –Injection well.

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Geothermal energy

Ground source heat pumps (GSHP)

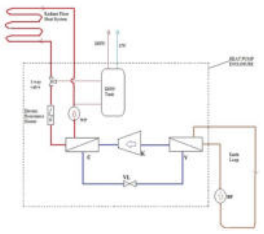

Fig.44. Ground source heat pumpoperating diagram. Component parts: V- evaporator; K- compressor; C- condenser, VL- expansion valve; DHW Tank- boiler for domestic hot water, WP- water circulation pump; BP- brine circulation pump

1. Evaporator (vaporizer) V - the refrigerant fluid absorbs heat from brine from ground loop and evaporates. The evaporator is a heat exchanger.
2. Compressor K- it compresses refrigerant vapors and thus raises their temperature to high values.
3. In condenser C, compressed refrigerant gas is condensed to a liquid and the heat is absorbed by the circulating water in heating system. passes through it and turns into a liquid, which is then introduced into the heating system.
4. Depressurizer (expansion valve) - the above liquid passes through this system which greatly reduces its pressure and thus its temperature. The cycle starts again.

The ground source heat pumps GSHP system has three important components:
- a heat pump;
- a soil connection;
- heating distribution system.

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Geothermal energy

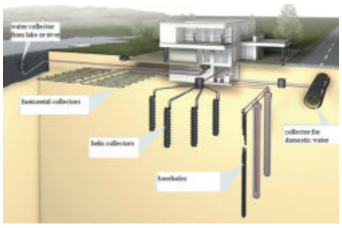

Fig.45. Types of geothermal heat pumps

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Hydropower

Solar energy evaporates seawater producing clouds. When the drops end up having a mass large enough, gravity pulls water back to the Earth's surface in the form of rain. If this rain falls on high ground and reaches the streams and rivers that flow rapidly there is the ability to extract some of their energy by arranging part of their course so that the water passes through a hydraulic turbine that drives an electric generator, using water to produce electricity.

Characteristics of micro hydropower plants:
- They are suitable for low power requirements, decentralized (light industry, private farms and enterprises, rural communities) and for operations outside the main network;
- Requires low voltage distribution networks and possibly sub-regional micro-networks;
- They can be used in private property, in co-ownership or common property, with a semi-skilled labor need and common administration;
- The short period of construction with local materials and the use of the skills of the population in the area, can have a significant impact on the quality of rural life;
- Their flexibility, in terms of adapting to variable loads depending on the tributary flow, makes them a privileged component in any integrated energy system;
- The plants have a very long period of use. Some are over 70 years old and still in working order. Plants ready to be put into operation recently can last even longer and can serve consumers for generations without polluting the atmosphere;
- Investments in micro hydropower plants have proven to be safe and profitable for several decades.

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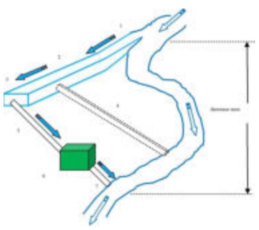
Hydropower



1. the storage system
2. supply channel
3. a stabilization tank
4. overflow channels
5. forced pipe
6. hydro turbine and power plant
7. downstream channel

Fig.46. The components of the micro hydropower plant

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