LUCIA GARDOSSI

- Professoressa presso l'Università di Trieste. Cofondatrice dello spin-off SPRIN SpA. Coordinatrice del progetto EU-Russia "IRENE." 2013-2019: Advisory Group EU per H2020-SC2. 2017. Oltre a essere nel direttivo del Cluster SPRING, dal 2019 è membro del Gruppo di Coordinamento per la Bioeconomia - Presidenza del Consiglio dei Ministri. Autrice di oltre 100 pubblicazioni e 4 brevetti.

SPRING

Sustainable Processes and Resources for Innovation and National Growth

CIRCOLARITÀ E ECODESIGN

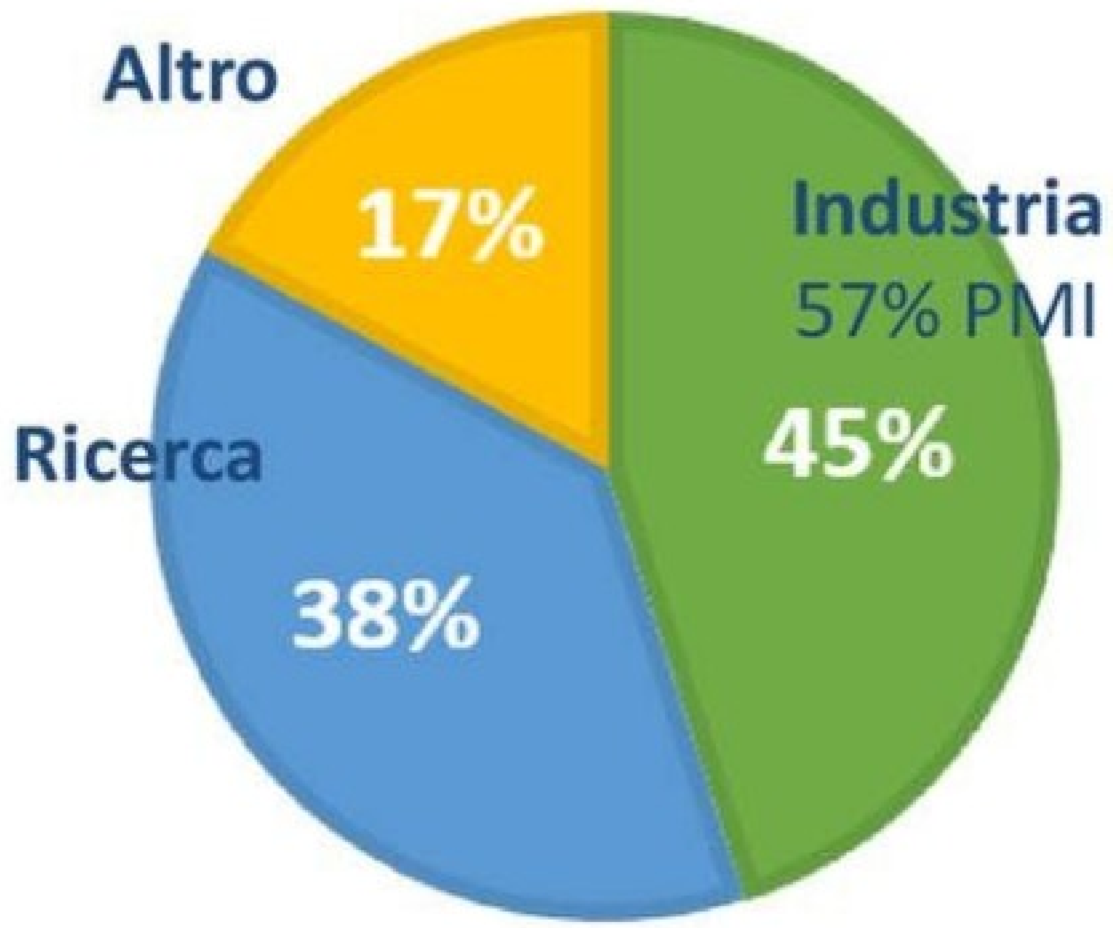
Il Cluster Tecnologico Nazionale sulla Chimica Verde

SPRING

2014

MINISTERO DELL'ISTRUZIONE, DELL'UNIVERSITÀ E DELLA RICERCA

123SOCI



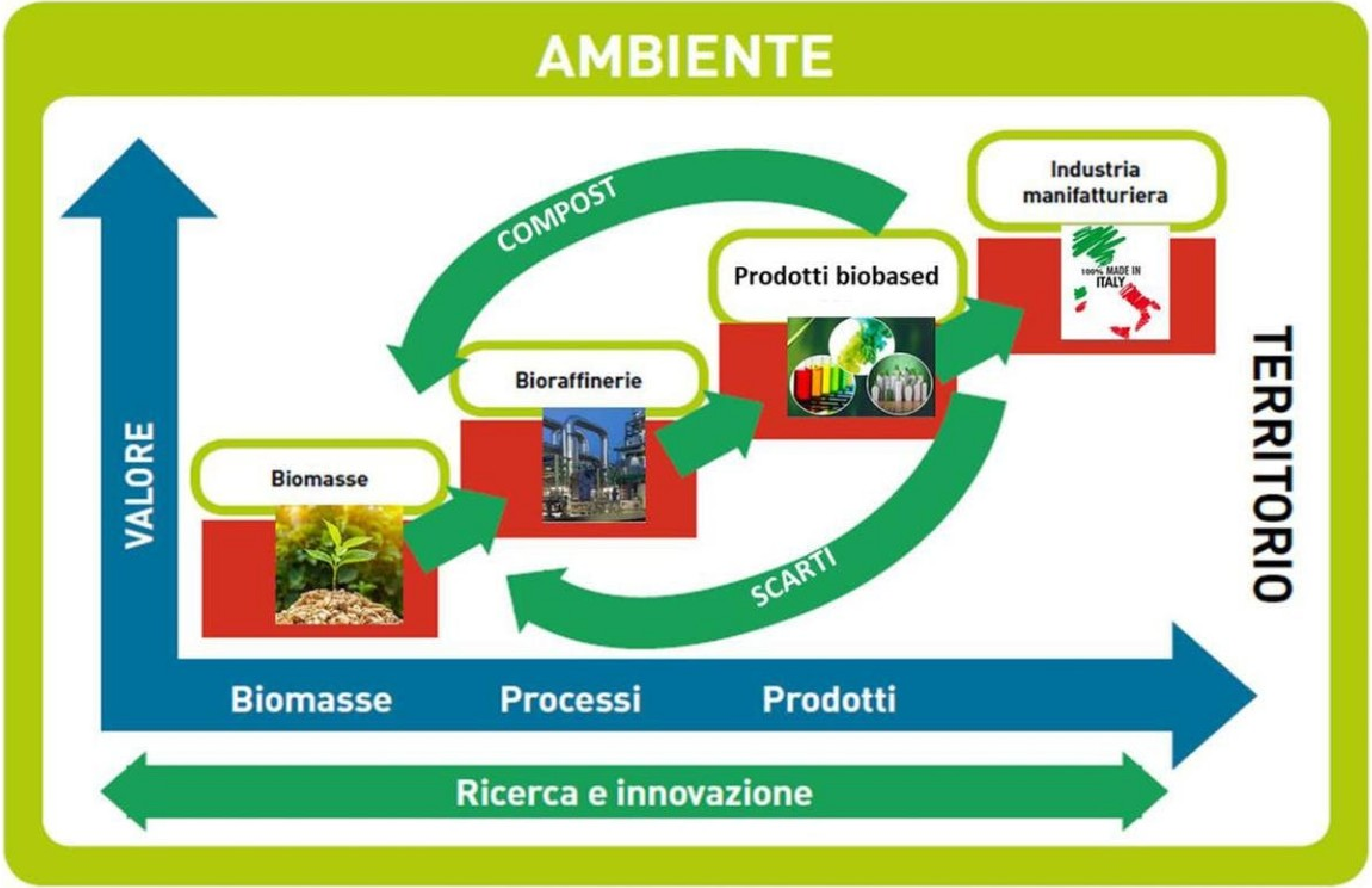
PRESENZA REGIONALE

SPRING

- Basilicata
- Campania
- Emilia Romagna
- Friuli Venezia Giulia
- Liguria
- Lombardia
- Piemonte
- Puglia
- Sardegna
- Umbria
- **Sicilia** – *in fase di adesione*
- Toscana
- Veneto
- Provincia Autonoma di Trento

Chimica verde - Innovazioni di prodotto e di processo relative alle **bioraffinerie**, alla produzione e all'utilizzo di prodotti **biobased**, biomateriali e combustibili nuovi o innovativi da **biomasse** forestali o agricole dedicate e da sottoprodotti e **scarti** della loro produzione, nonché da **sottoprodotti** e scarti della produzione e lavorazione della filiera animale

SPRING



AMBIENTE

VALORE

Biomasse

Bioraffinerie

Prodotti biobased

Industria manifatturiera

100% MADE IN ITALY

COMPOST

SCARTI

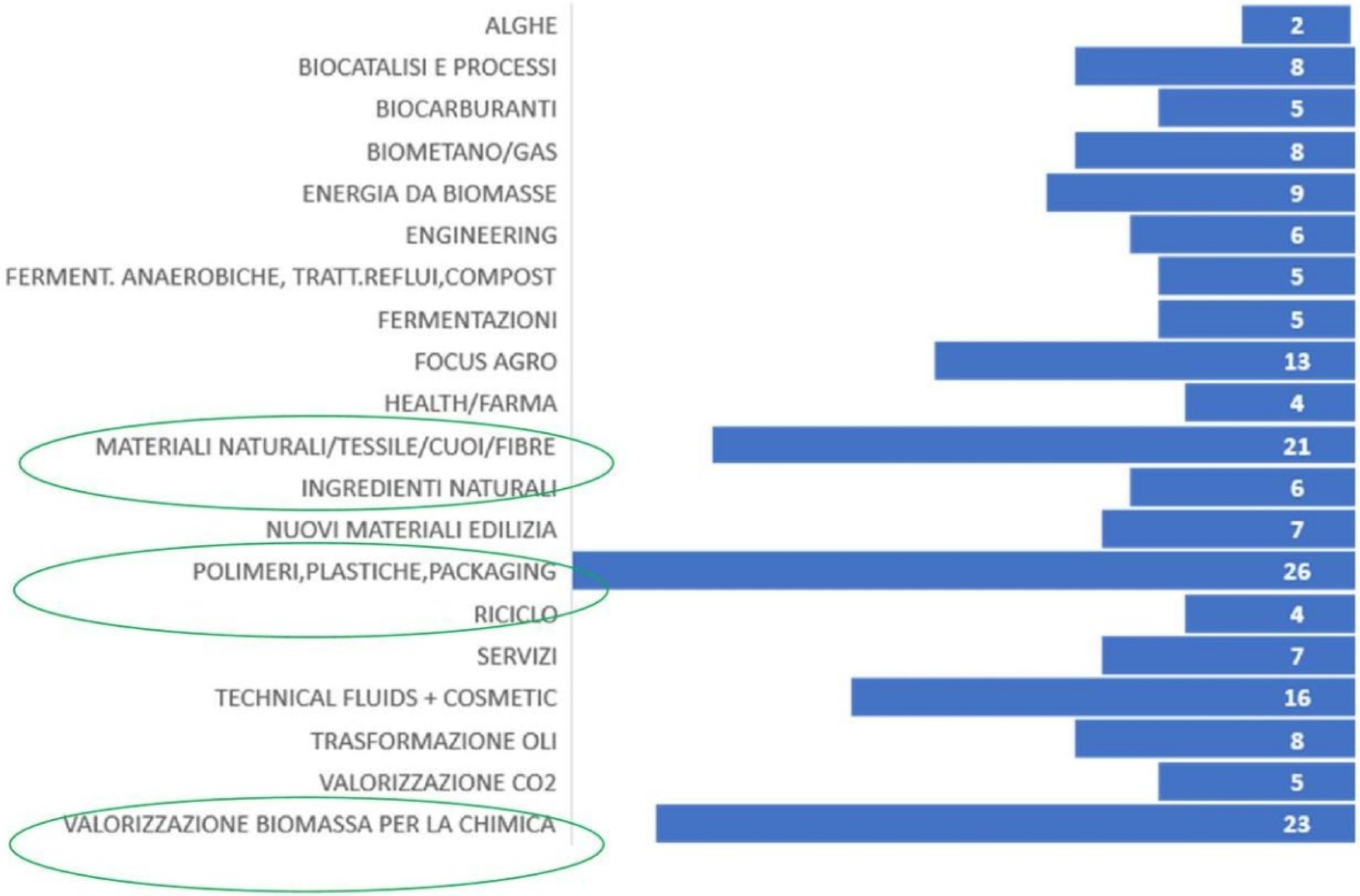
TERRITORIO

Biomasse **Processi** **Prodotti**

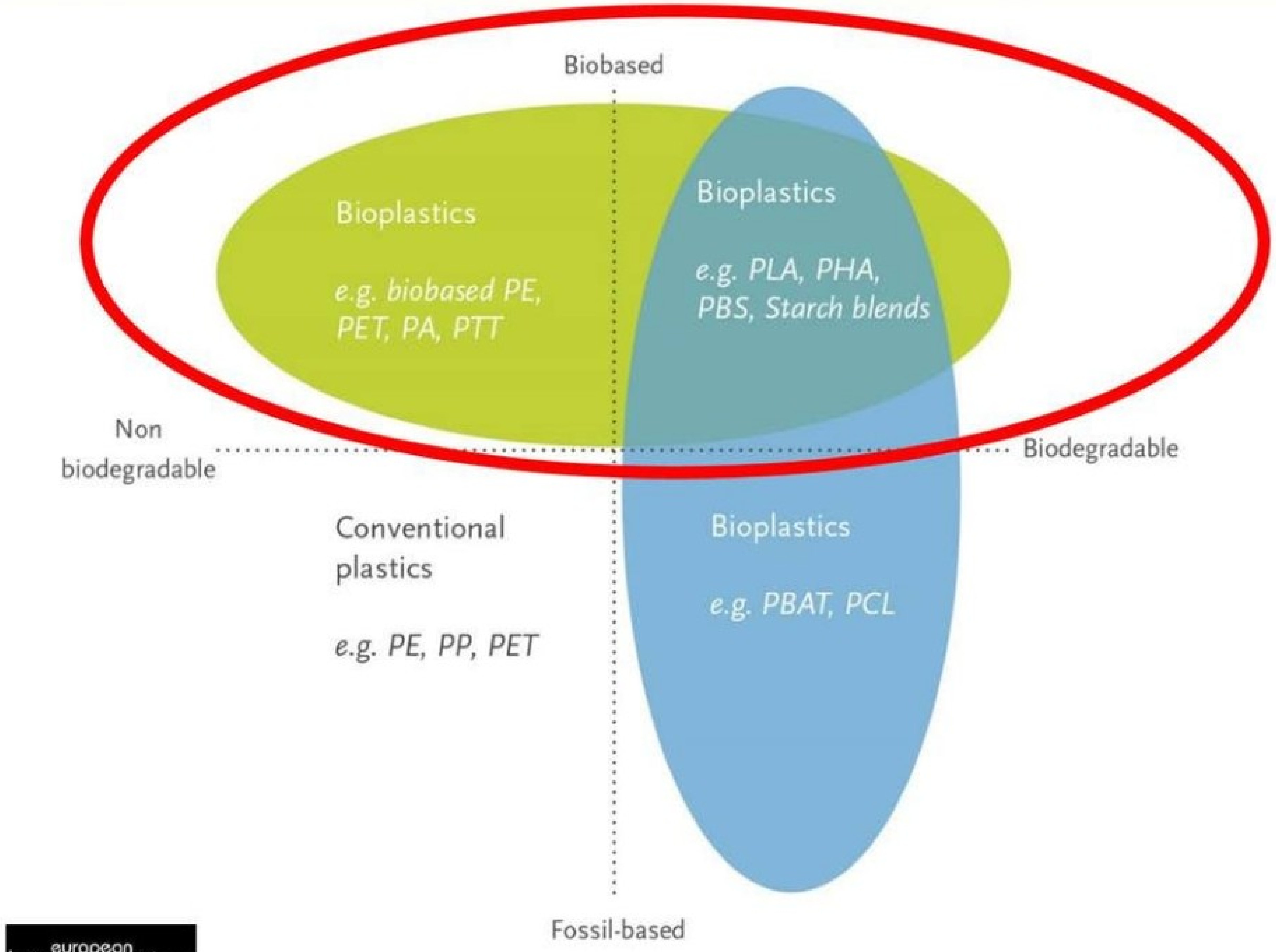
Ricerca e innovazione

SPRING

Focus tematici Soci Industriali



Chimica e biotecnologie per le nuove plastiche bio-based



Biobased

Bioplastics

e.g. biobased PE, PET, PA, PTT

Bioplastics

e.g. PLA, PHA, PBS, Starch blends

Non biodegradable

Biodegradable

Conventional plastics

e.g. PE, PP, PET

Bioplastics

e.g. PBAT, PCL

Fossil-based

european bioplastics

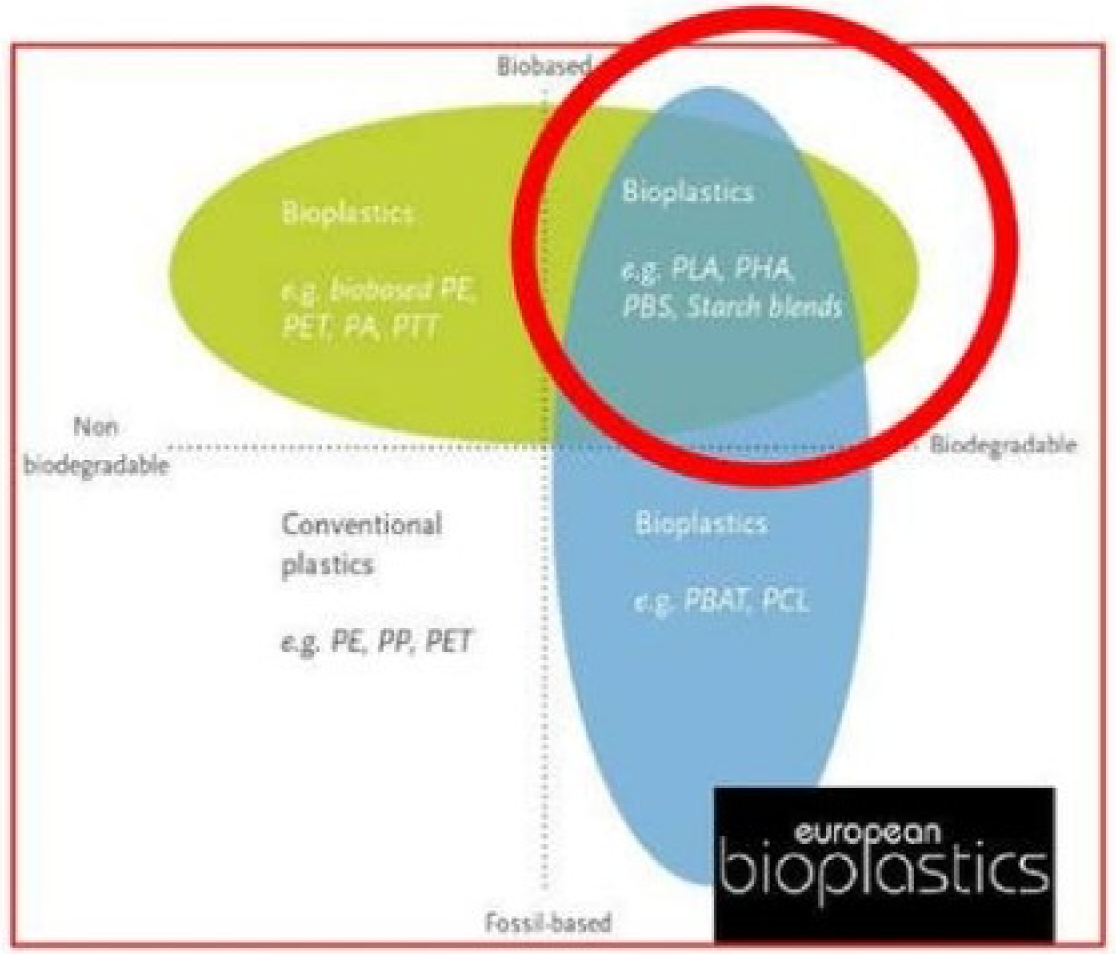
https://www.european-bioplastics.org/

Biopolimeri naturali biosintetizzati e derivati

Polisaccaridi	**Polimeri a base amido**	Componente di plastiche biodegradabili e compostabili
	Cellulosa e derivati	Il tipo di modifica chimica influisce sulla biodegradabilità
	Chitosano	Biodegradabile

Polimeri bio-ingegnerizzati biosintetizzati

Poliesteri	**Poliidrossialcanoati**	Biodegradabili, compostabili



🟩 **Biodegradabile/compostabile**

🟨 **Biodegradabile solo in condizioni controllate**

Polimeri sintetizzati a partire da monomeri bio-based o combinazioni di monomeri rinnovabili e fossili

Poly(L-lactide) -PLLA	Polyester. Thermoplastic. Processable by extrusion, injection molding, blow molding. Degradable by hydrolysis rather than microbial attack. Industrially compostable Crystallinity can be controlled by co-polymerization of selected ratios of L- to D-stereoisomers of lactic acid or lactide. Mechanical, thermal and barrier propertie justify applications in food packaging. Used for medical applications and drug delivery because of its biocompatibility.
Poly(trimethylene terephthalate) - PTT*	Polyester. Same properties as fossil-based PTT. Scarcely biodegradable. Semi crystalline thermoplastic, easily molded or thermoformed and spun into fibres. Goo tensile and flexural strength, excellent flow and surface finish. Used in textiles and engineering applications (automotive parts, mobile phone housings.
Poly(ethylene terephthalate)-PET*	Polyester. Same properties as the fossil-based PET. High-performance plastic used for engineering applications, fibres, films, bottles.
Poly(1,4-butylene succinate) - PBS	Polyester. Biodegradable in soil and biocompostable. Its T_m of 115 °C and tensile strength of 30–35 MPa make PBS suitable for applications in packaging as a alternative to polyolefins.
Poly(ethylene succinate) - PES	Moderately biodegradable. Good oxygen barrier and elongation properties. Used for film applications.
Poly(ethylene furanoate) - PEF	Polyester. Durable, good oxygen barrier. T_m of 211 °C and T_g of 86 °C. Suitable for packaging, in the food and beverage industry.
Poly(trimethylene furanoate) - PTF	Polyester. Not biodegradable. T_m of 172 °C, T_g of 57 °C, good oxygen barrier properties. Employed in light weighting packaging.
Poly(butylene furanoate) - PBF	Polyester. T_m of 172 °C, T_g of 44 °C. Potential replacer of PET and PBT.
Poly(1,4-butylene adipate-*co*-1,4-butylene terephthalate) - PBAT	Polyester. Biodegradable. Used in blends with PLA and fibers due to low thermo-mechanical properties. Obtained from fossil feedstock or bio-tereftalic acid
Unsaturated polyester resins - UPR	Properties varies according the percentage of unsaturated diacid (e.g. itaconic acid) and the curing procedure. Applied in waterborne UV-curable coatings for wood and flooring industry.
Polyamides containing four carbons - 4C PAs: 4; 4.6 and 4.10	Not biodegradable. 4C PAs match properties of fossil-based PAs 6 and 6.6, such as thermal durability and mechanical strength, with a Tm above 250°C. All 4C PA have higher dielectric strength and higher retention of tensile properties as compared to PA 6.6. PA 4.10 has low moisture uptake. Applications range from wate management to cable coating, food contact products and automotive.
Polyamides with longer chains. PAs: 6.10; 10.10; 11 and 12	Long chain carbon monomers confer flexibility to these polymers, which find application in fuel lines in cars, offshore pipelines, gas distribution piping systems electronics, sports equipment, furniture and automobile components.
Polyethylene – PE* (from bio-ethanol)	Polyolefin. Same properties of fossil-based PE. Not biodegradable, recyclable through dedicated infrastructures. Thermoplastic. High Density PE (more crystalline finds applications in construction sector. Low Density Polyethylene is used in packaging. Ultrahigh Molecular Weight Polyethylene has applications in medical device and bulletproof vests.
Polypropylene - PP*	Polyolefin. Same properties as the fossil PP. Not biodegradable, non-polar. Partially crystalline thermoplastic with low density. Used in a large variety of application and in packaging.
Poly(methyl methacrylate)–PMMA	Not biodegradable. Lightweight material used as glass replacement in automotive for shatterproof and UV resistant properties.
Ethylene propylene diene monomer – EPDM (synthetic rubber)	Not biodegradable. Good resistance to hot water and polar solvents but poorly resistant to aromatic and aliphatic hydrocarbons. Chlorine-free synthetic rubber use for technical clothing, elastomers with shock absorption. Ozone and thermal resistant. Electrical insulation properties. Used also for automotive applications.
Polyurethanes -PURs	Produced through the reaction of a diisocyanate with a polyol. Microbial degradation depends on the chemical structure. Often blended with polyethers to increas flexibility or extensibility. Used as de-halogenated flame retardant foams, paints, powder coatings, medical devices (blood contacting applications). Biodegradabl polyurethane scaffolds have been used in tissue regeneration.
Poly(furfuryl alcohol) - PFA	Not biodegradable. Synthesized from bio-based furfuryl alcohol (FA) deriving from sugars. Used in the fabrication of nanoporous carbons structures for molecula sieve adsorbents, membranes and as a component for electrochemical and electronic devices.
Acrylonitrile butadiene styrene - ABS	Obtained from butadiene rubber dispersed in a matrix of styrene-acrylonitrile copolymer. Not biodegradable. Thermoplastic, used to make light, rigid, moulde products such as pipes, automotive parts. Used also for its flame retardant properties.
Polyacrylic superabsorbent polymers - PA-SA	Its high swelling capacity is tuneable by controlling the degree of crosslinking. Its biodegradation in soil can be improved under conditions that maximize solubilisation Find applications in personal disposable hygiene products, such diapers and sanitary napkins.
Poly(itaconic acid) - PIA	Due to the presence of a vinyl moiety, itaconic acid is structurally similar to acrylic and methacrylic acid, providing a suitable bio-based alternative t poly(meth)acrylates via radical polymerization to yield poly(itaconic acid) (PIA). Applications include fibers, coatings, adhesives, thickeners, binders. As co-monome itaconic acid gives glass-ionomer dental cement.
Polyvinyl chloride – PVC*	Not biodegradable and poorly chemically degradable. Same properties as fossil-based PVC. Used in construction profile applications, bottles and non-food packaging. When made more flexible by the addition of plasticizers, it is used in electrical cable insulation, imitation leather, flooring and as rubber replacer.





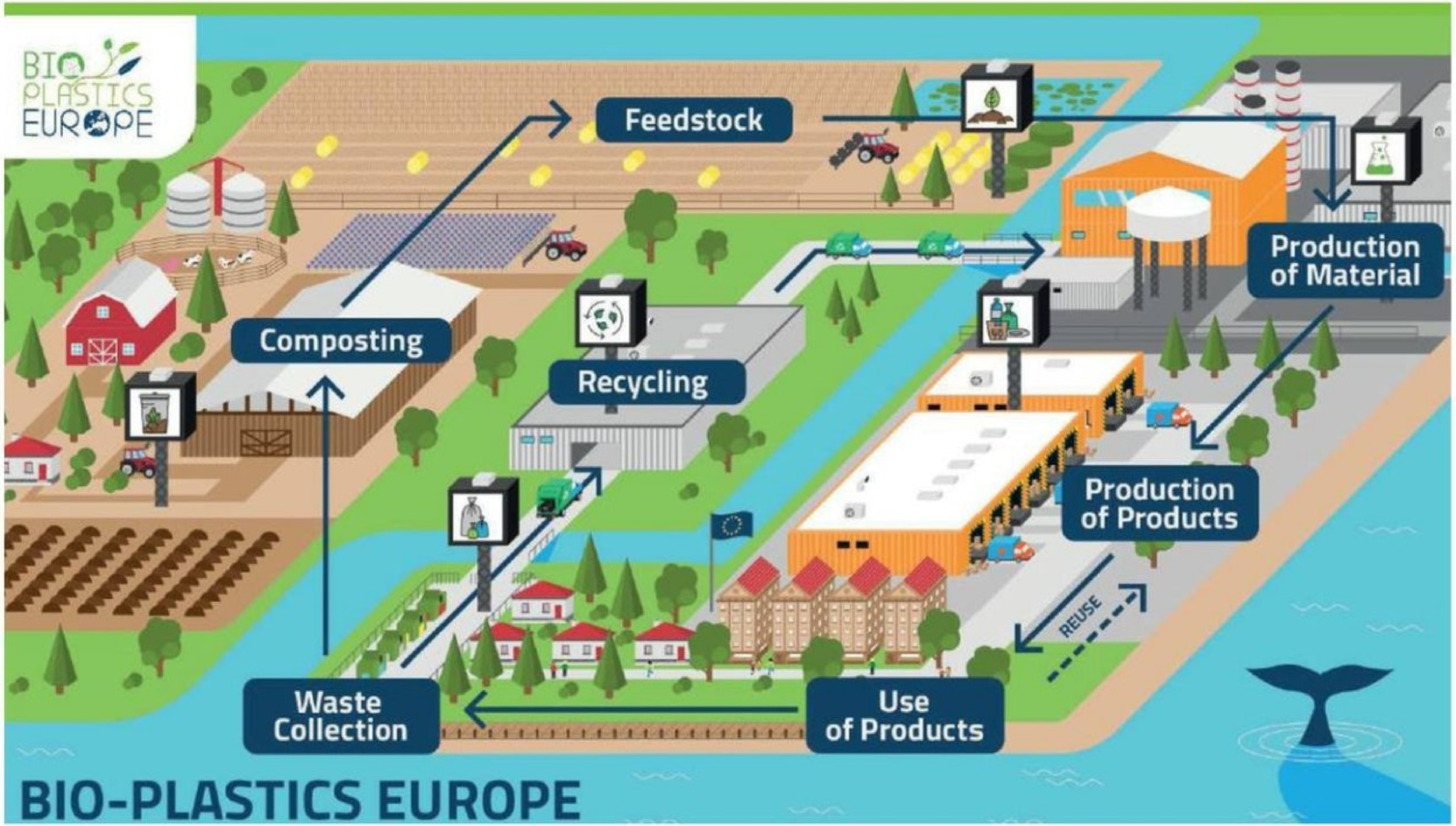



🟩 **Biodegradabile/compostabile**

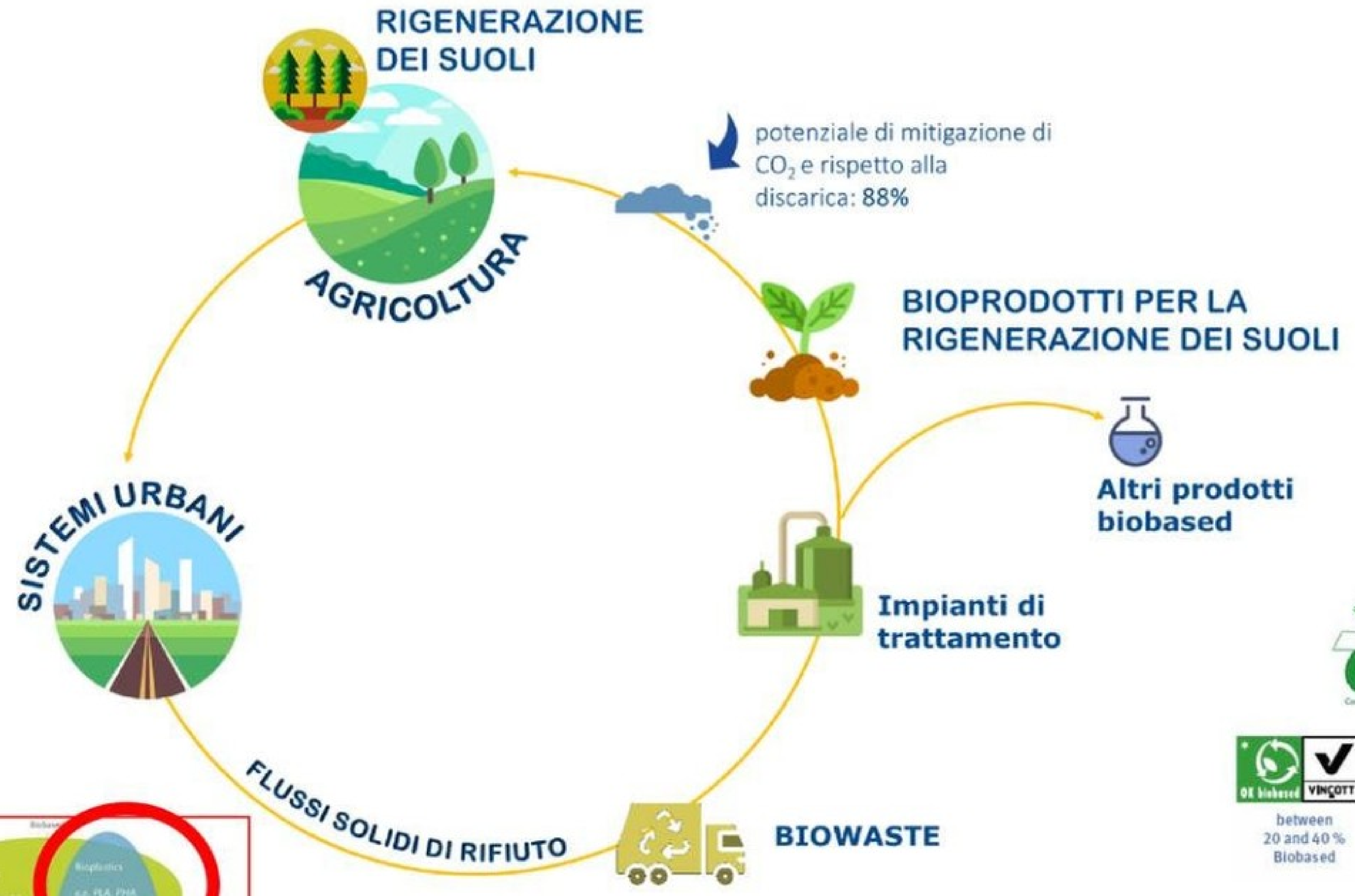
🟨 **Biodegradabile solo in condizioni controllate**

🟧 **Durevole**

Ecodesign:
Quale circolarietà per quale bioplastica?



Quale circolarietà per le plastiche bio-based biodegradabili e compostabili?



RIGENERAZIONE DEI SUOLI

AGRICOLTURA

potenziale di mitigazione di CO_2 e rispetto alla discarica: 88%

BIOPRODOTTI PER LA RIGENERAZIONE DEI SUOLI

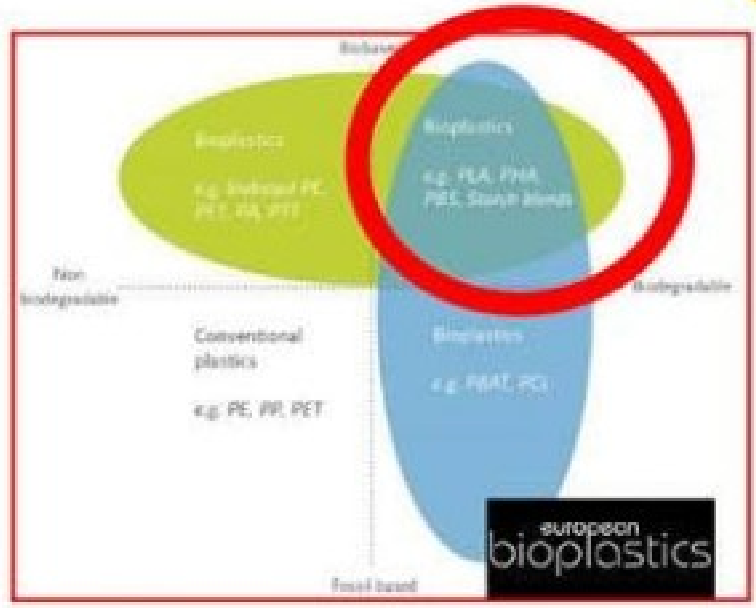
Altri prodotti biobased

Impianti di trattamento

BIOWASTE

FLUSSI SOLIDI DI RIFIUTO

SISTEMI URBANI



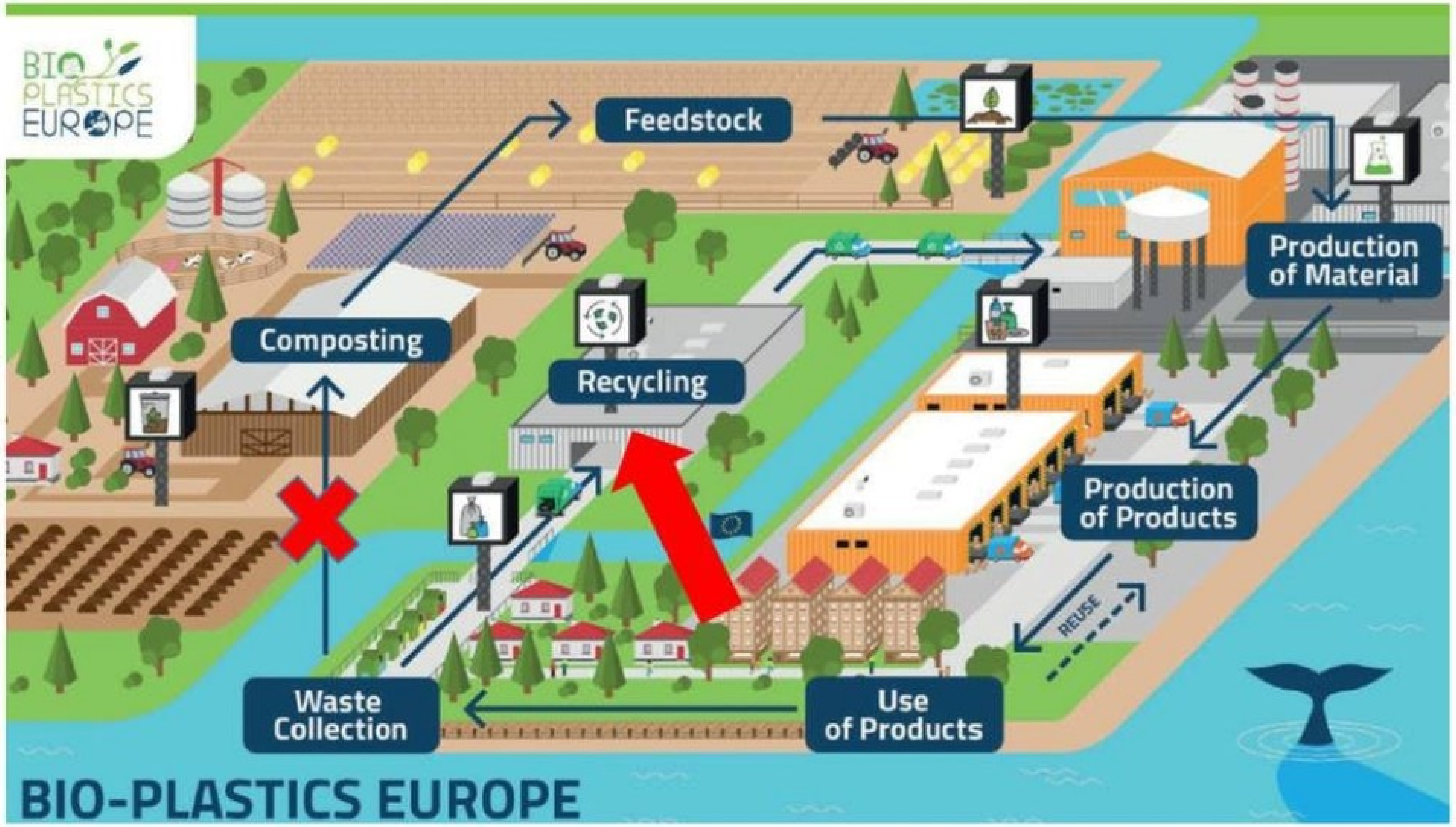
between 20 and 40 % Biobased

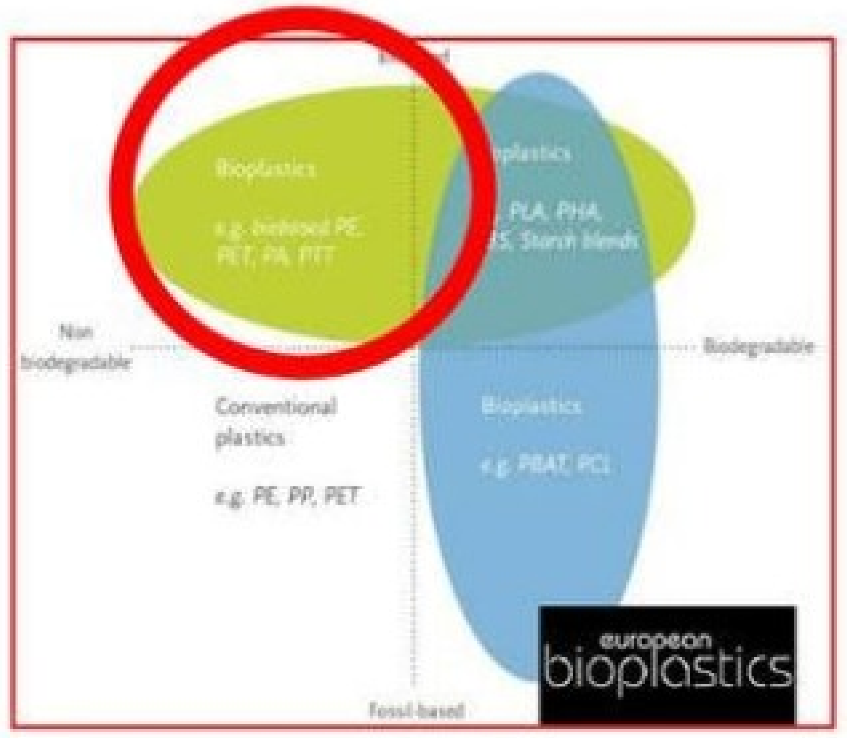
between 40 and 60 % Biobased

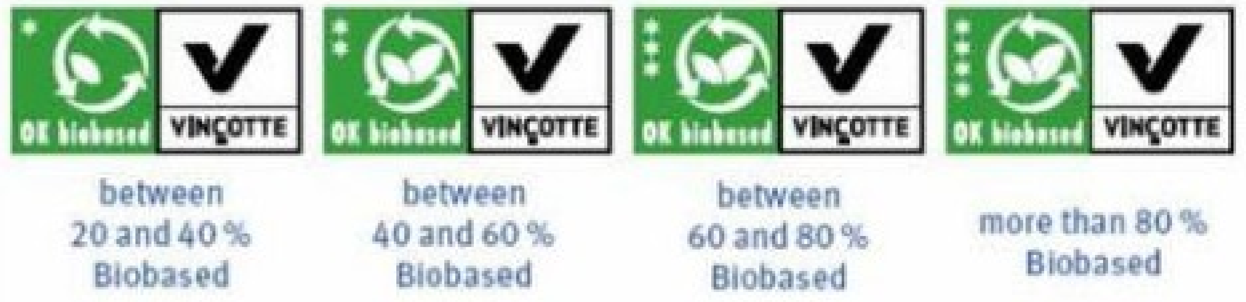
between 60 and 80 % Biobased

more than 80 % Biobased

Quale circolarietà per le plastiche bio-based durevoli e per applicazioni ingegneristiche?

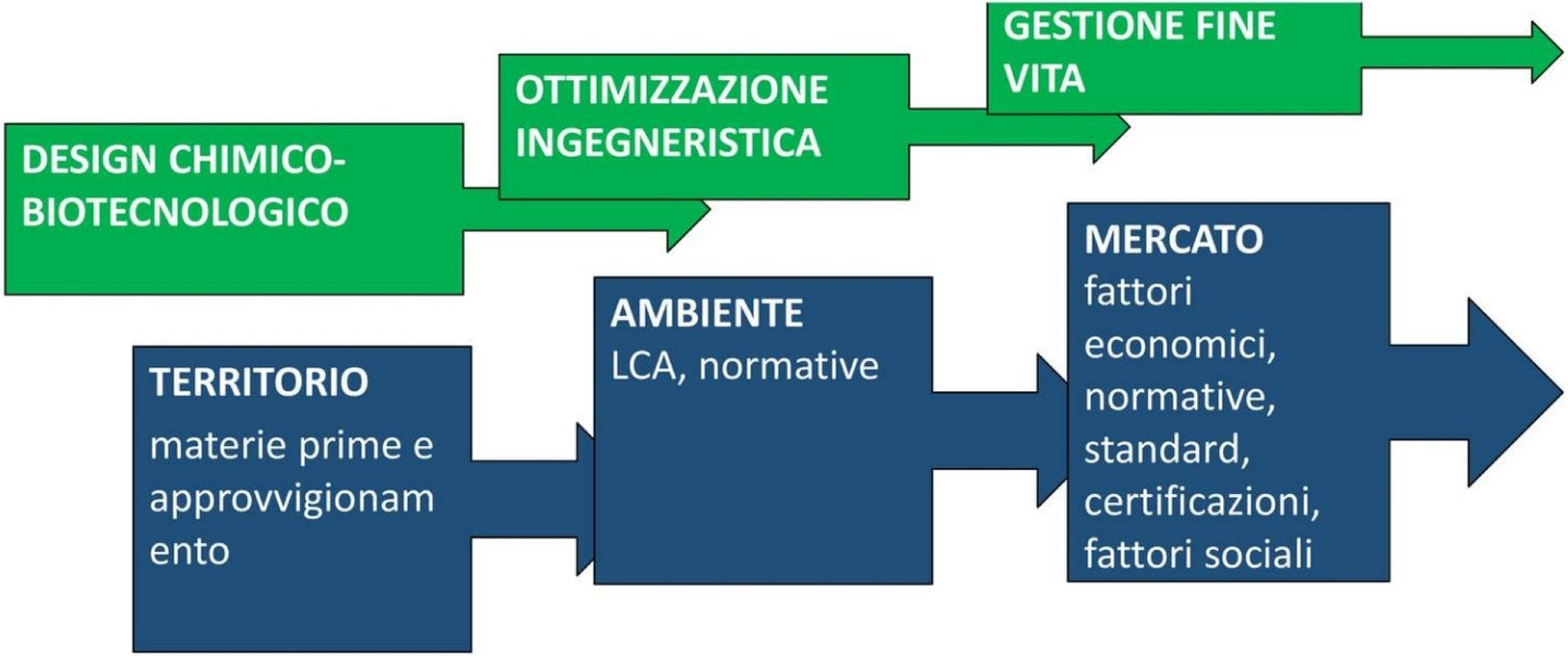






Eco design e circolarità: necessità di un approccio sistemico ed integrato

Passato: *Passaggi successivi ottimizzati singolarmente e che alla fine vengono assemblati ma non necessariamente portano alla soluzione ottimale*



DESIGN CHIMICO-BIOTECNOLOGICO

OTTIMIZZAZIONE INGEGNERISTICA

GESTIONE FINE VITA

TERRITORIO
materie prime e approvvigionamento

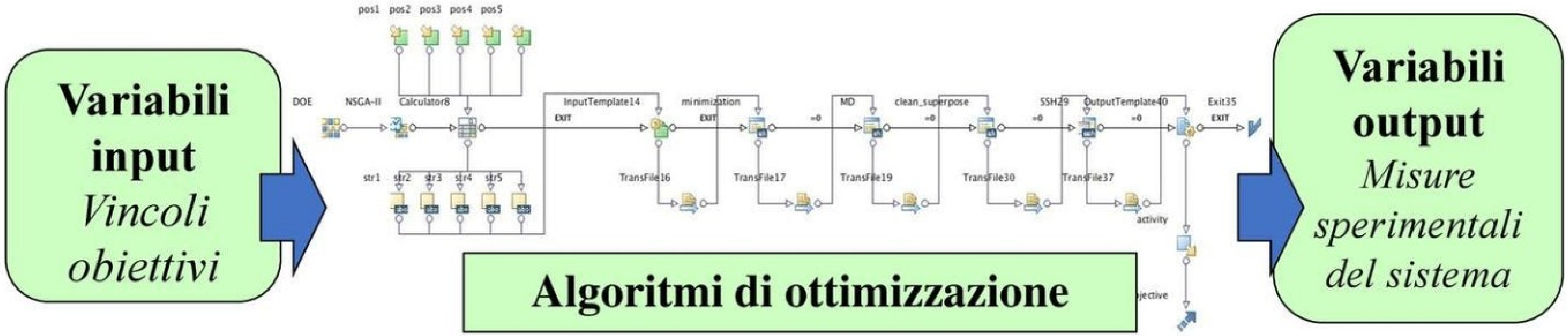
AMBIENTE
LCA, normative

MERCATO
fattori economici, normative, standard, certificazioni, fattori sociali

Eco design e circolarità: approccio sistemico ed integrato

Presente:

Ottimizzazione multi-oggetto mediante algoritmi, modellazione, automazione e machine-learning



Variabili input
Vincoli obiettivi

Algoritmi di ottimizzazione

Variabili output
Misure sperimentali del sistema

- **Simulazioni ripetute**
- **Integrazione e automazione degli strumenti di simulazione**
- **Convergenza fino a identificare le soluzioni migliori sulla base dei vincoli imposti al sistema (machine-learning)**

Digital Twin – Gemelli digitali
Rappresentazione virtuale di un prodotto o processo

Simulare, prevedere e ottimizzare il prodotto
durante tutto il ciclo di vita
e il sistema di produzione
prima di investire in prototipi fisici e risorse.

Sensori installati su oggetti fisici per riflettere qualsiasi modifica alla controparte fisica

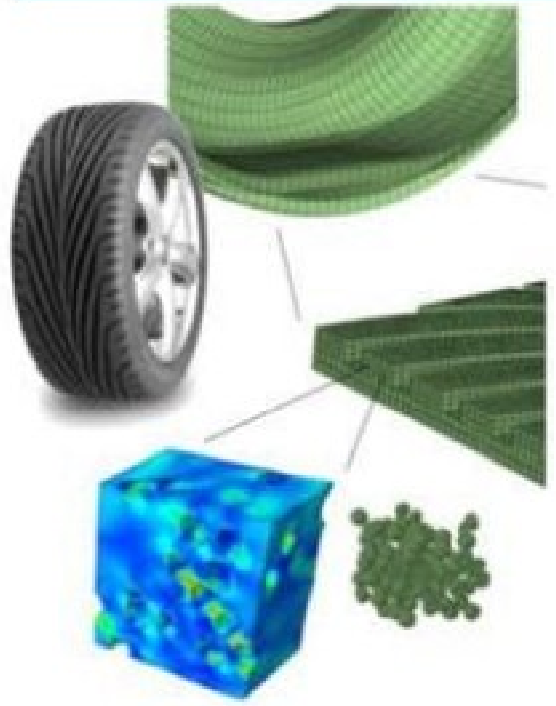
Simulazione + analisi dati + machine learning

Impatto di modifiche di progettazione, scenari di utilizzo, condizioni ambientali, LCA

https://www.plm.automation.siemens.com/global/en/our-story/glossary/digital-twin/24465

A Business Decision Support System for Composite Materials Selection and Design


H2020 COMPOSELECTOR European Research Project



Decision making in composite materials

OPERATIONAL requirements
- Low rolling resistance
- Low noise
- Resistance to wear
- Resistance to ageing
- Resistance to absorbity
- Ability to damp unevenness
- Troublefree operation

ECONOMIC requirements
- Low price
- Availability of materials
- Accessible production technologies

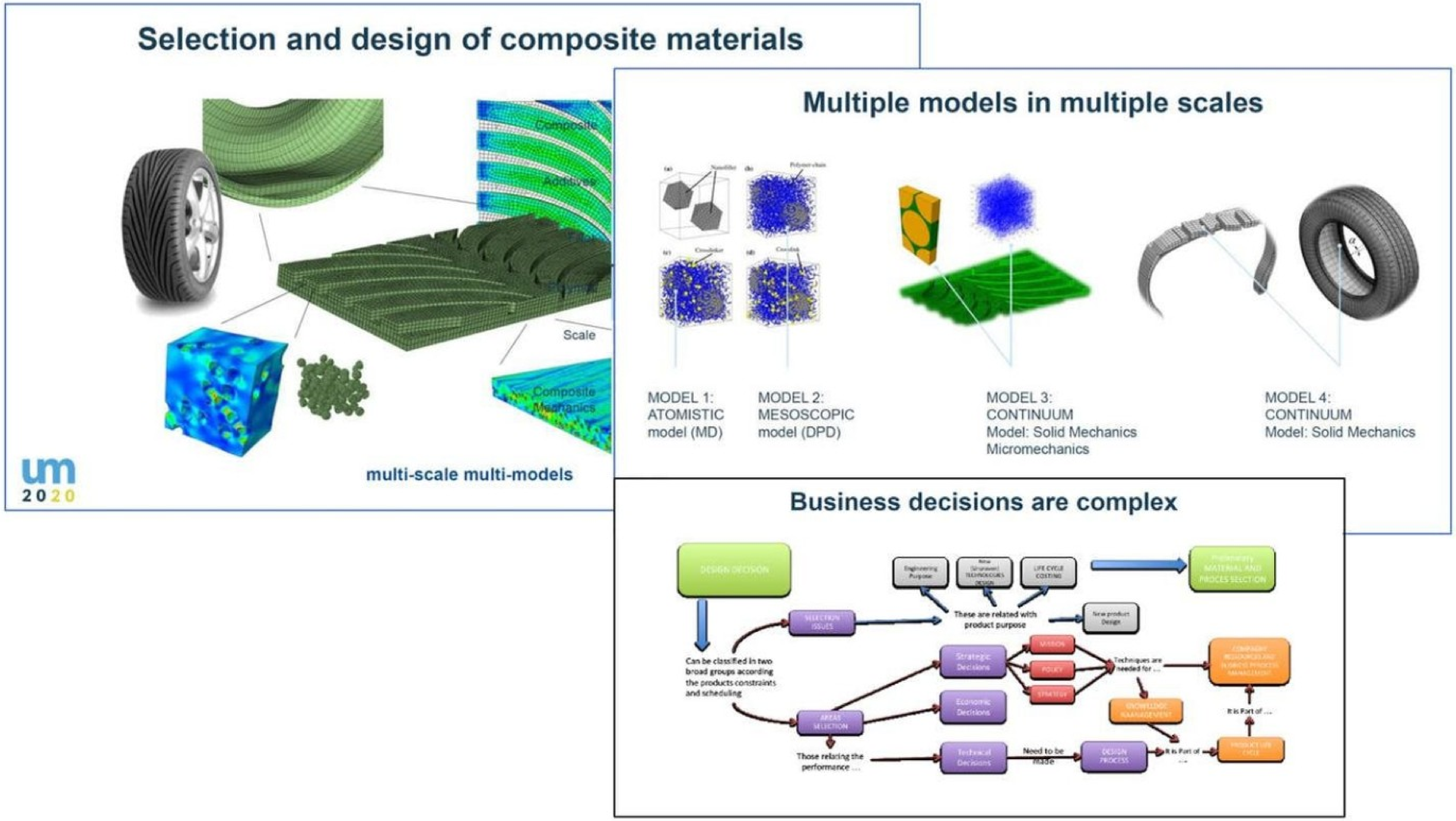
FUNCTIONAL requirements
- Appropriate stress-strain characteristics
- Optimum inflating
- Prevention of aquaplaning
- Optimum adhesive properties
- Static and dynamic balance

MATERIAL requirements
- Long life
- Low mass
- Good mechanical properties
- Ability to be retreaded
- Ability to be recycled
- Resistance to weather conditions

Cortese concessione di **ESTECO Spa** www.esteco.com

A Business Decision Support System for Composite Materials Selection and Design

H2020 COMPOSELECTOR European Research Project



Selection and design of composite materials

multi-scale multi-models

Multiple models in multiple scales

MODEL 1:
ATOMISTIC
model (MD)

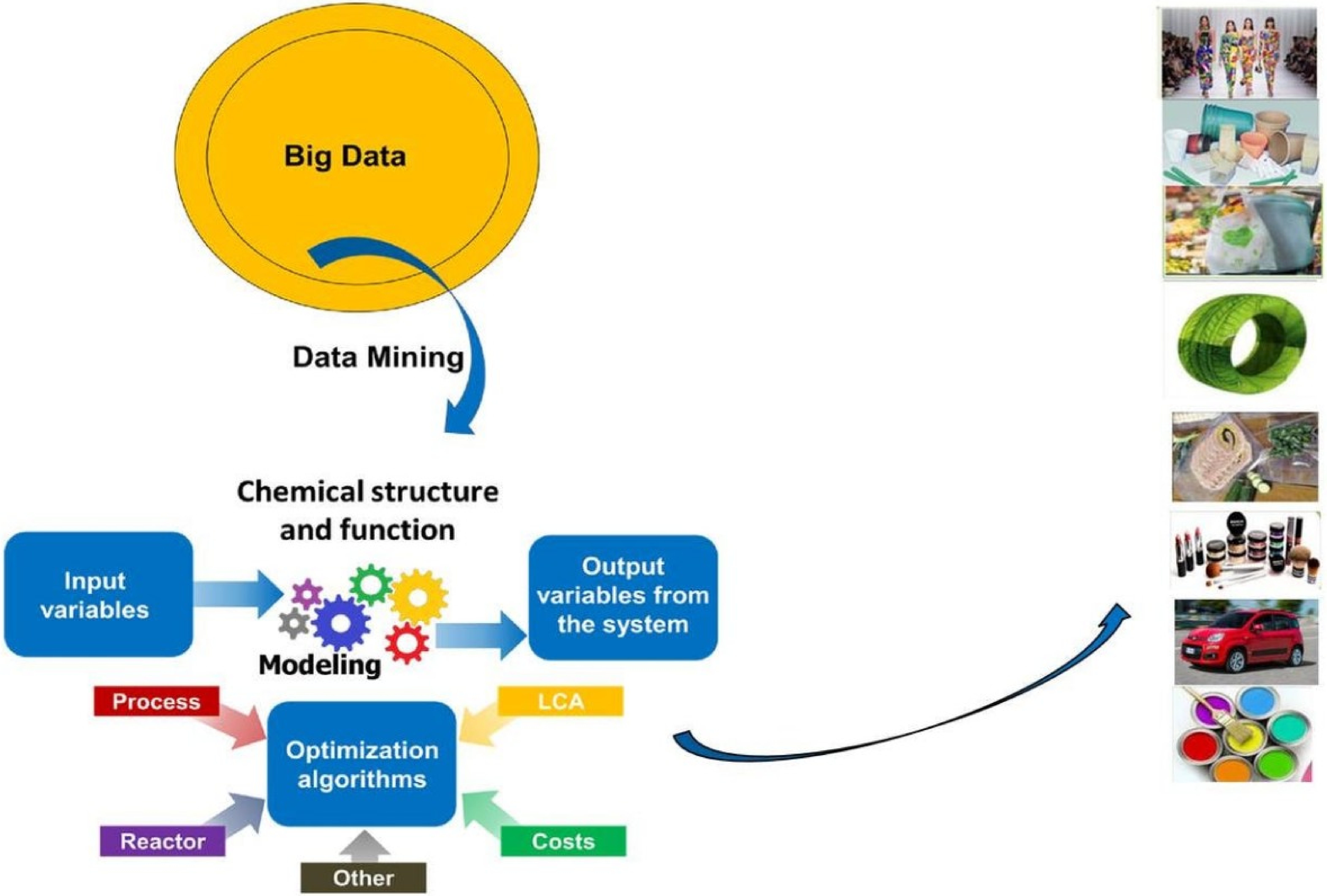
MODEL 2:
MESOSCOPIC
model (DPD)

MODEL 3:
CONTINUUM
Model: Solid Mechanics
Micromechanics

MODEL 4:
CONTINUUM
Model: Solid Mechanics

Business decisions are complex

Eco design per la circolarità



Big Data

Data Mining

Chemical structure and function

Input variables

Modeling

Output variables from the system

Process

LCA

Optimization algorithms

Reactor

Costs

Other

SPRING

Sustainable Processes and Resources
for Innovation and National Growth

Italian Cluster of Green Chemistry

Grazie per l’attenzione!

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