Exploring the Potential of Bio-based Materials in the Emerging Circular Economy

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Bio-polymers overview

Cristina Crespo, ITA (Spain)

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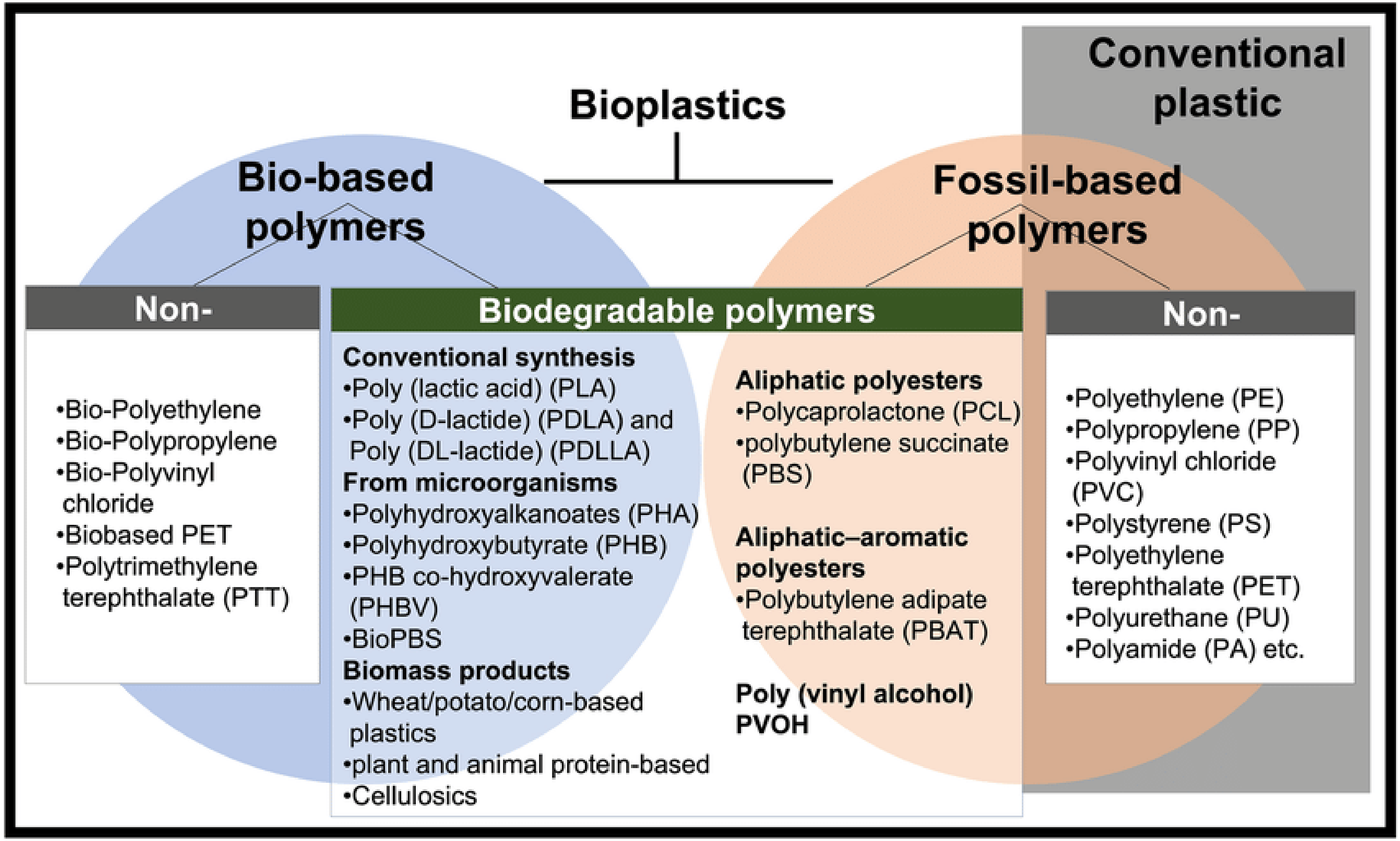
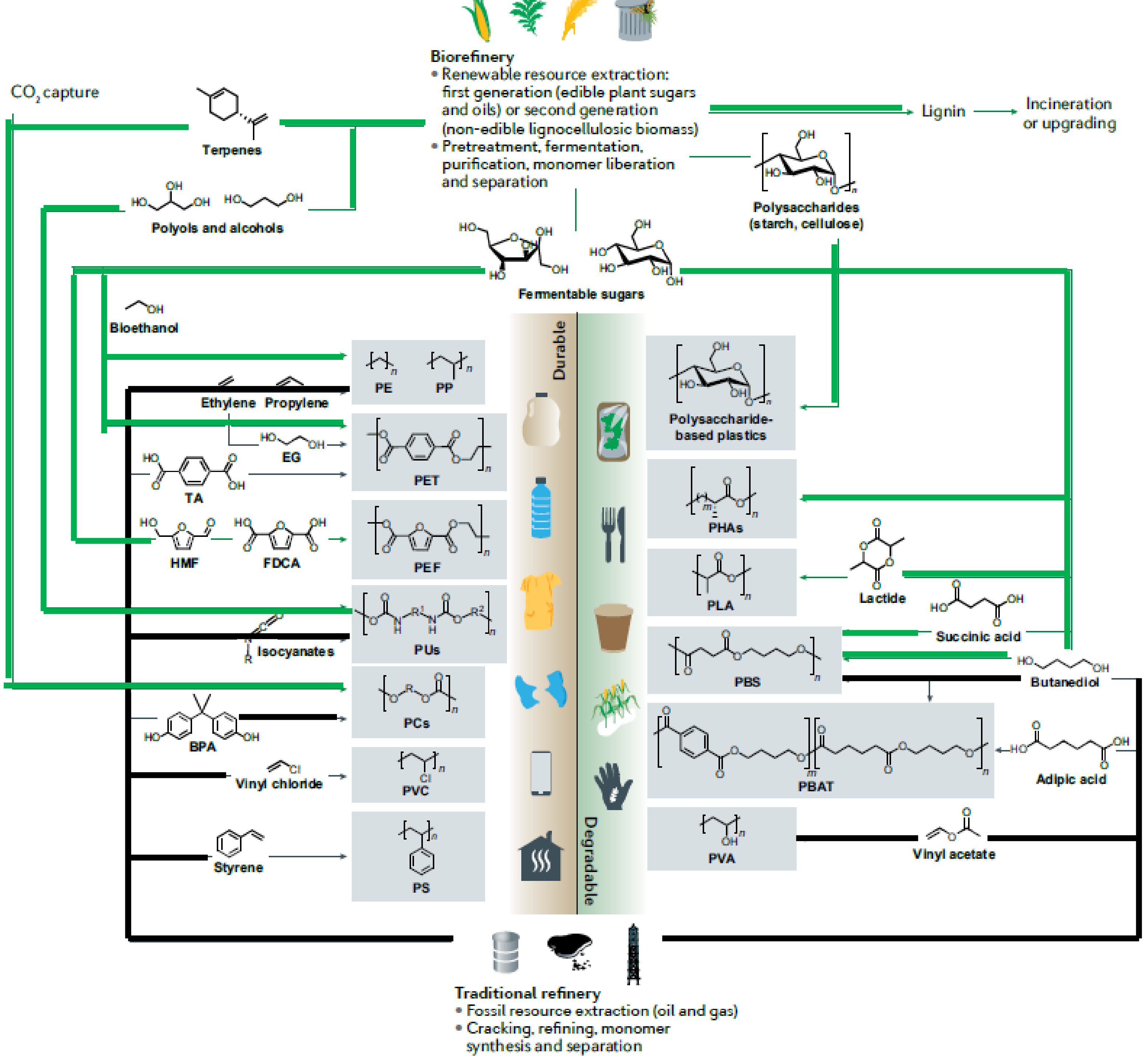


Conventional plastic
Bioplastics
Bio-based polymers
Fossil-based polymers
Non-
Biodegradable polymers
Non-
•Bio-Polyethylene
•Bio-Polypropylene
•Bio-Polyvinyl chloride
•Biobased PET
•Polytrimethylene terephthalate (PTT)
Conventional synthesis
•Poly (lactic acid) (PLA)
•Poly (D-lactide) (PDLA) and Poly (DL-lactide) (PDLLA)
From microorganisms
•Polyhydroxyalkanoates (PHA)
•Polyhydroxybutyrate (PHB)
•PHB co-hydroxyvalerate (PHBV)
•BioPBS
Biomass products
•Wheat/potato/corn-based plastics
•plant and animal protein-based
•Cellulosics
Aliphatic polyesters
•Polycaprolactone (PCL)
•polybutylene succinate (PBS)
Aliphatic–aromatic polyesters
•Polybutylene adipate terephthalate (PBAT)
Poly (vinyl alcohol) PVOH
•Polyethylene (PE)
•Polypropylene (PP)
•Polyvinyl chloride (PVC)
•Polystyrene (PS)
•Polyethylene terephthalate (PET)
•Polyurethane (PU)
•Polyamide (PA) etc.



J.-G. Rosenboom, R. Langer, y G. Traverso, «Bioplastics for a circular economy», *Nat. Rev. Mater.*, vol. 7, n.º 2, Art. n.º 2, feb. 2022, doi: 10.1038/s41578-021-00407-8.

Why bio-plastic

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Why bio-plastic

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Bio-plastic?

Low CO_2 emission

More expensive

No resource depletion

Lower mechanical properties in case of biodegradable

Potentially biodegradable

Less variety

Biodegradable polymers

PLA
PHA
Regenerated
Celullose
PCL

....

Lower properties that oil based

Technical biobased polymers

Bio-PE
Bio-PP
Bio-PA
.....

Same properties that oil based

Challenges

Biodegradable polymers

Enhancement of final properties:
Mechanical, durability, process conditions

Sorting and Recycling process

Social acceptance

Price

Technical biobased polymers

Price

Production capacity

The AMBIANCE project

Dr. Gemma Ibarz-Ric

Project Coordinator – ITA (Spain)

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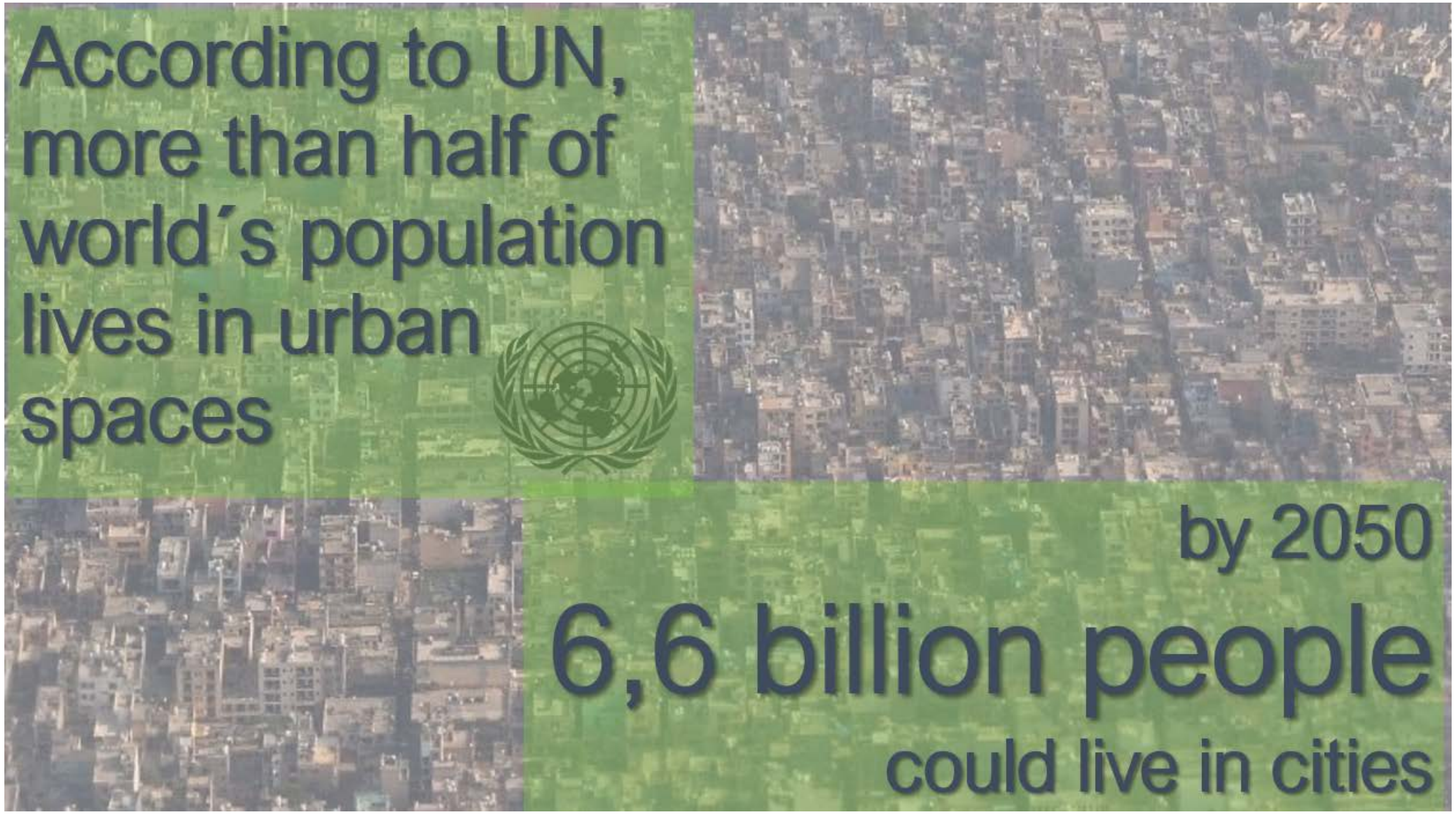
The concept


According to UN, more than half of world´s population lives in urban spaces
by 2050
6,6 billion people
could live in cities

Policies addressing urban sustainable development

THE GLOBAL GOALS
For Sustainable Development

European Commission

Make cities inclusive, safe, resilient and sustainable

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The figures

Project 101058406 (AMBIANCE)
Responsible unit: HADEA/B/03

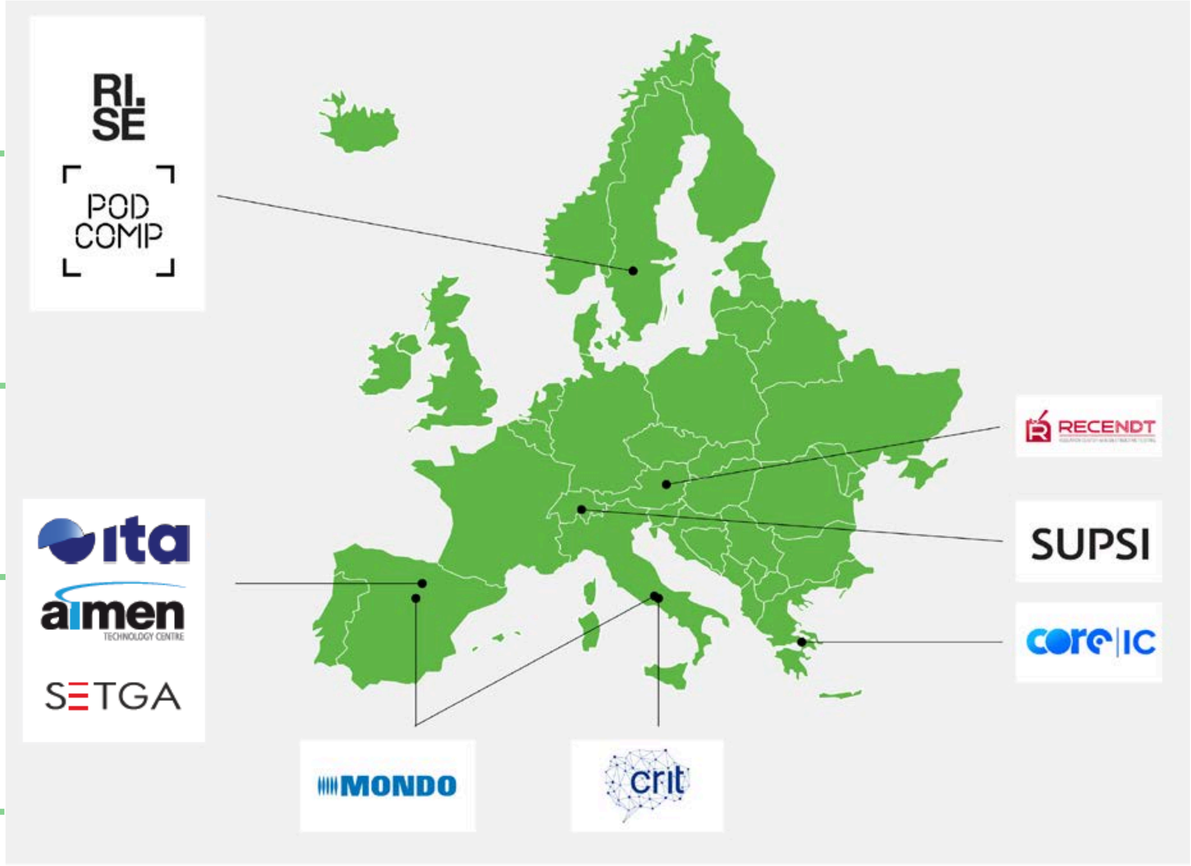
Duration: 48 months

Project Start 01/06/2022

Grant amount: 4,57 M €

10 Partners

6 Countries



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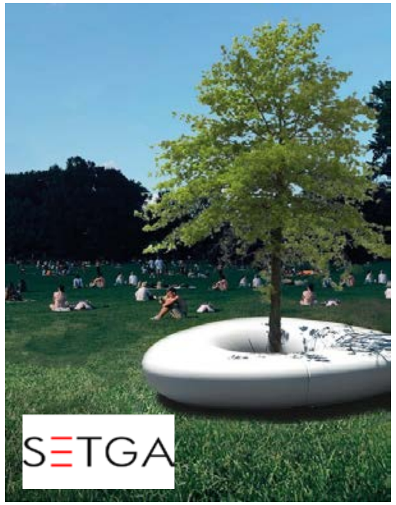
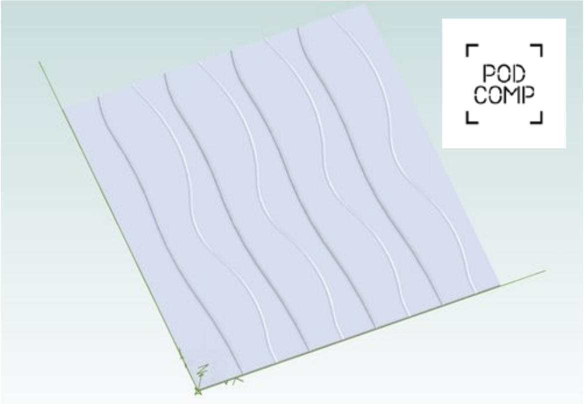
Products to develop

- Recyclable artificial turf from bio-thermoplastics and bio-materials of natural origin



- Street furniture made by 3D printing from bio-based materials



- Decorative panels using agricultural waste streams

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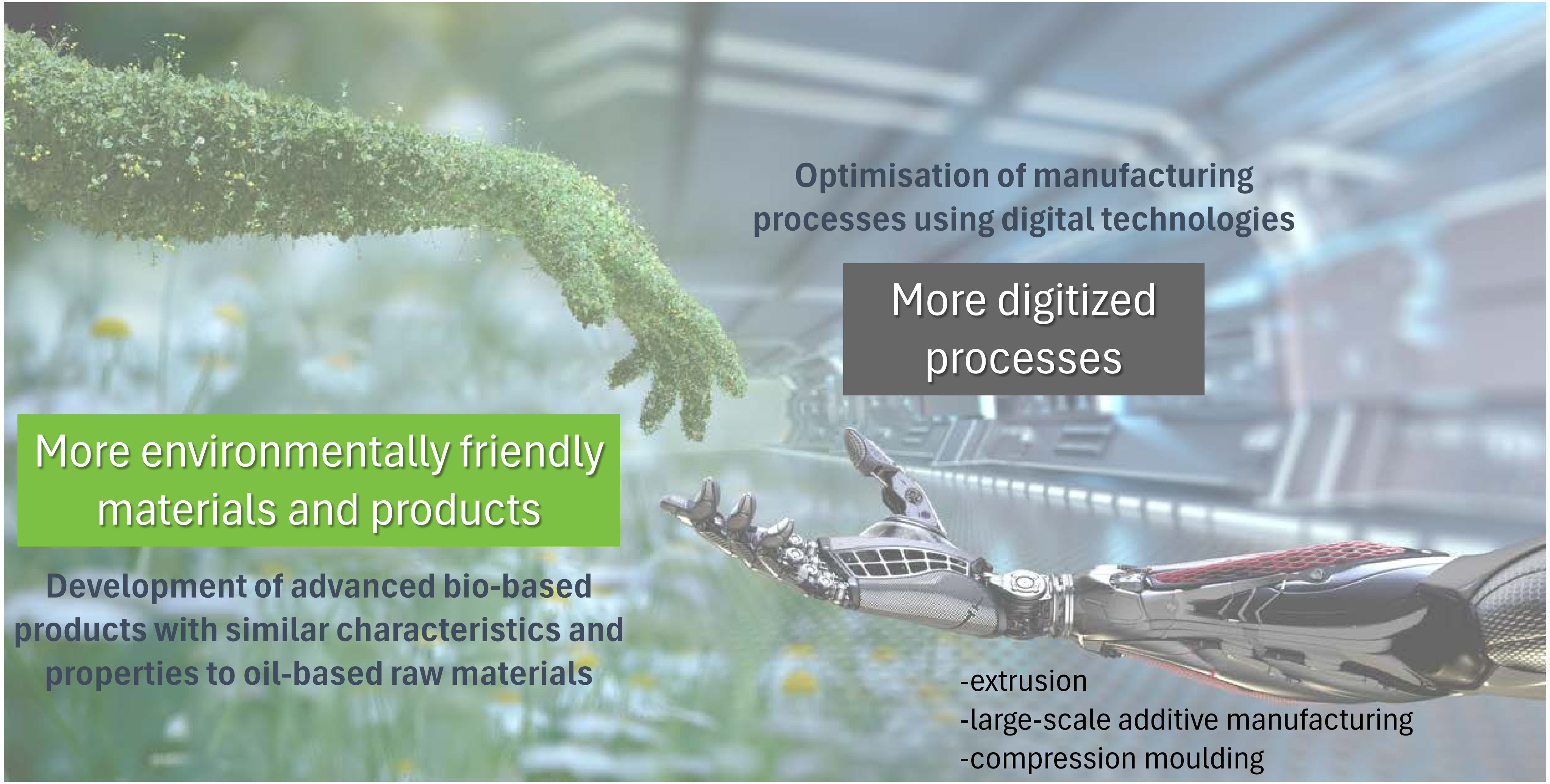
Our approach: objectives



The AMBIANCE challenges

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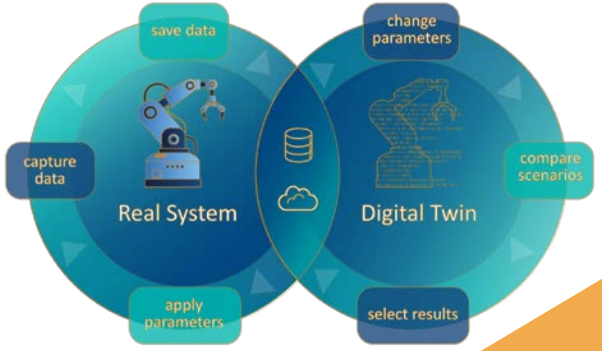
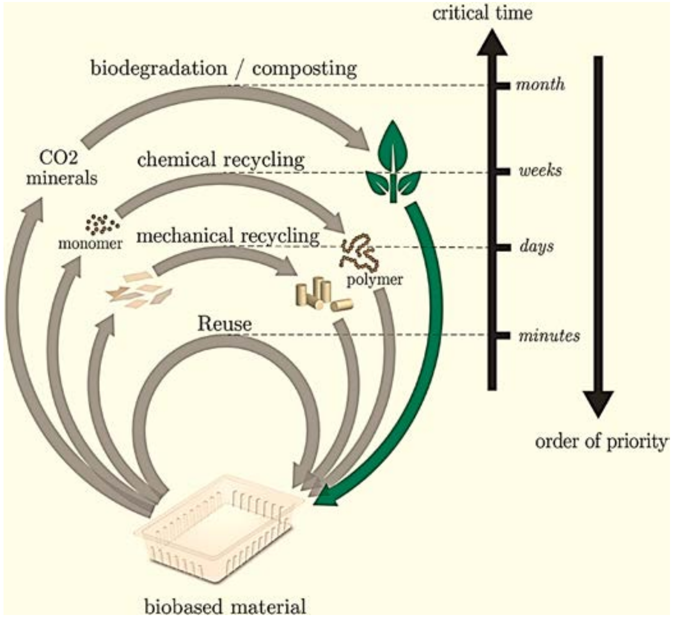
The challenges

1.-
Resistance to Weathering: Rain, Wind, Frost _ LONG LIFESPAN

2.-End of life: Recyclability /reuse

3.- Implementation of digital models (data, physical) in fabrication





The results

1.-
Resistance to Weathering: Rain, Wind, Frost _ LONG LIFESPAN

No discoloration of PLA under harsh weathering conditions

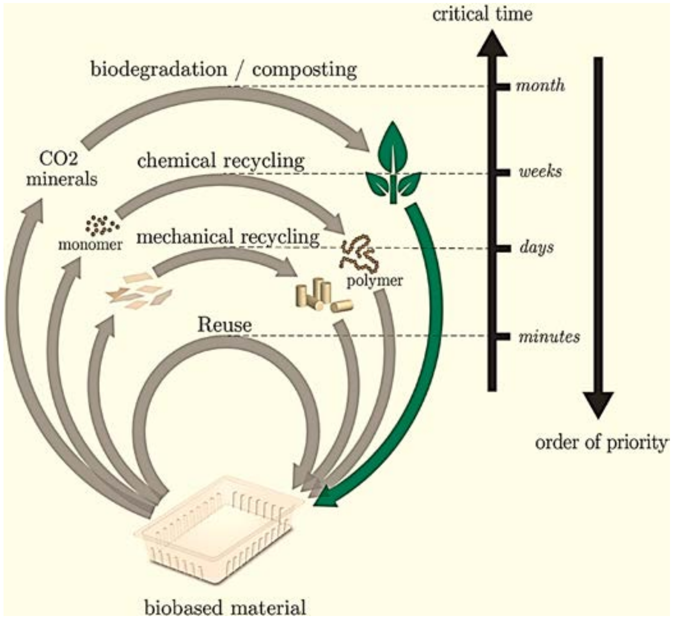
Slight colour deviation after exposure

750 h vs 1 year (real exposure)

Good visual matching between climatic chamber and real exposure

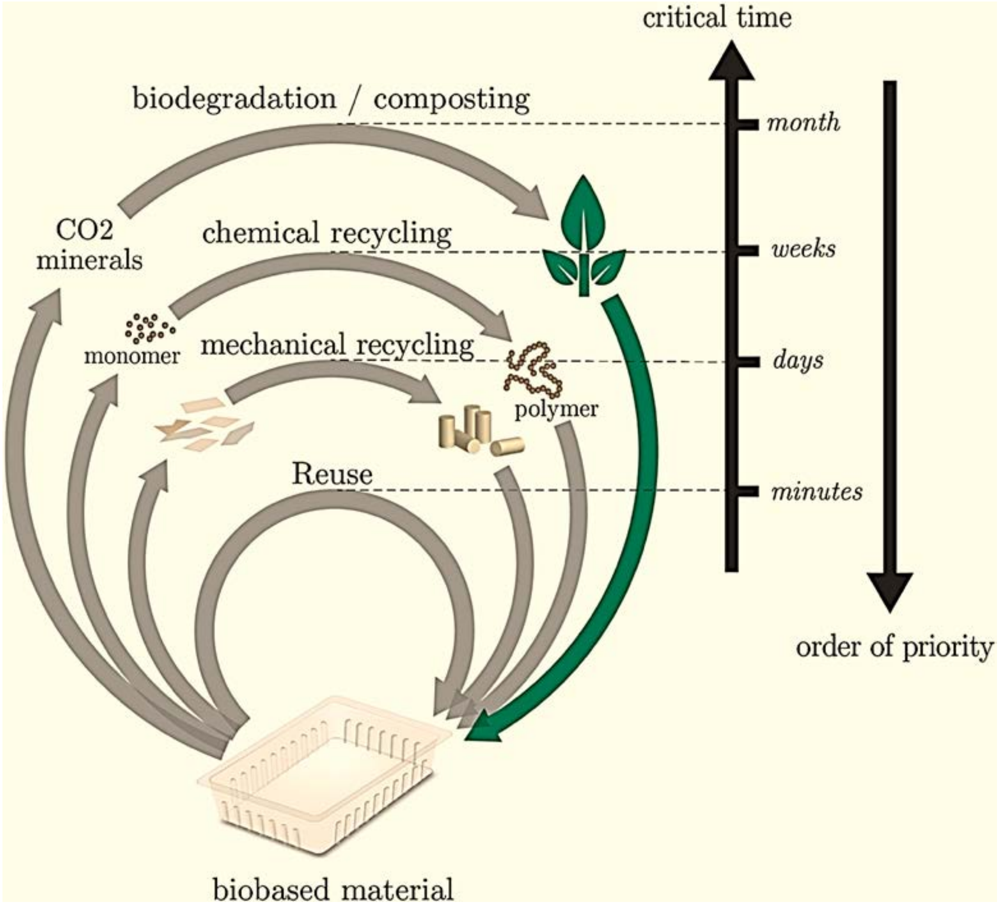
The results

2.-End of life: Recyclability /reuse



End of life scenario: extend the loop

Refurbishment
Reuse/Repair
Mechanical / Chemical Recycling
Biodegradation and composting



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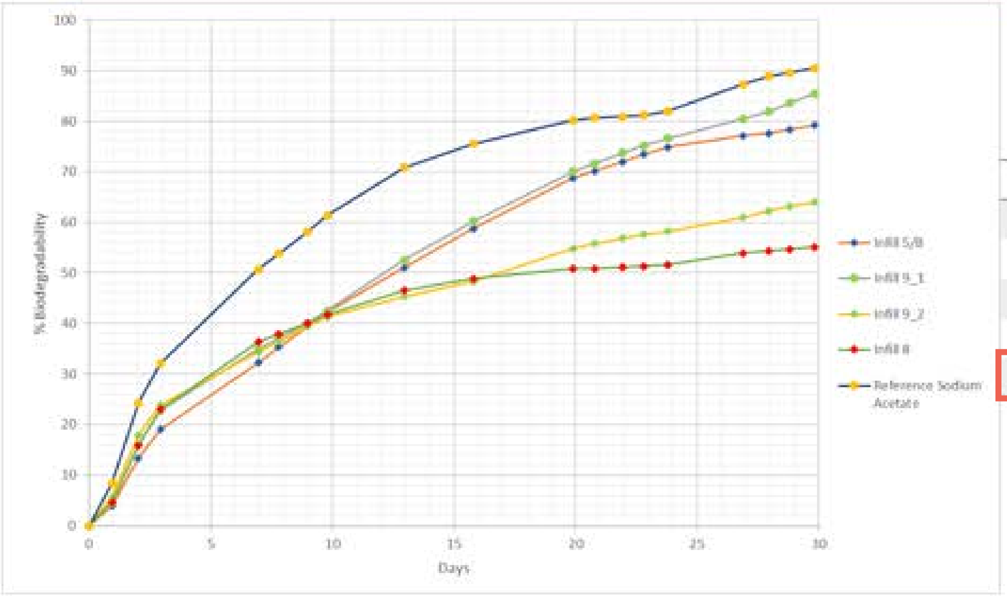
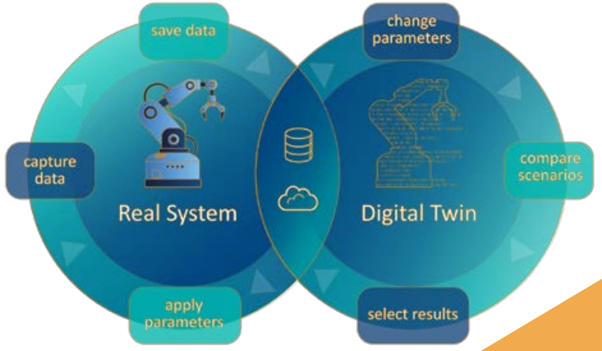
New biobased infills from artificial turf show high rates of biodegradability

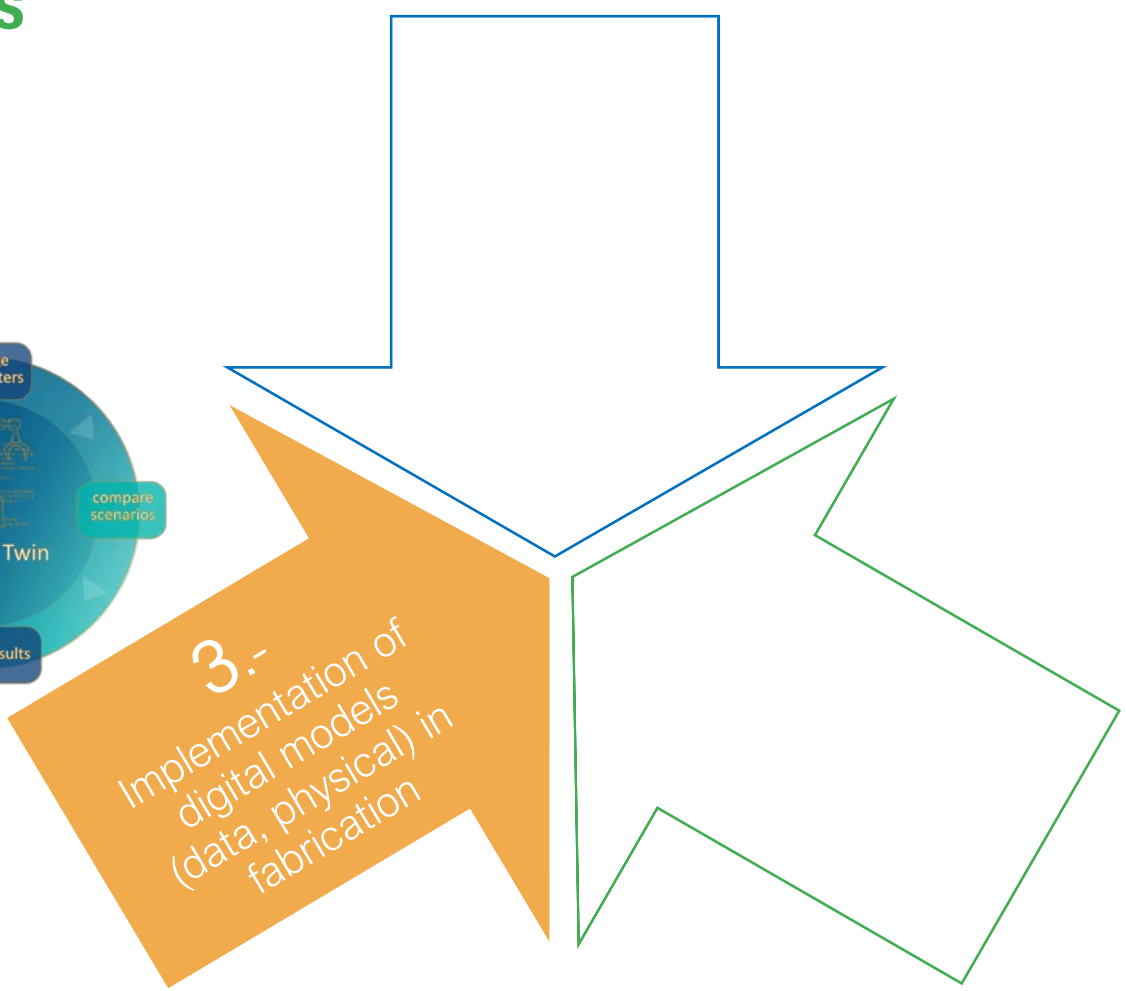


% Biodegradability	
Sample	Day 28
Sodium acetate	88,92
Infill 8	54,37
Infill 9	72,10
Infill 5/B	77,58

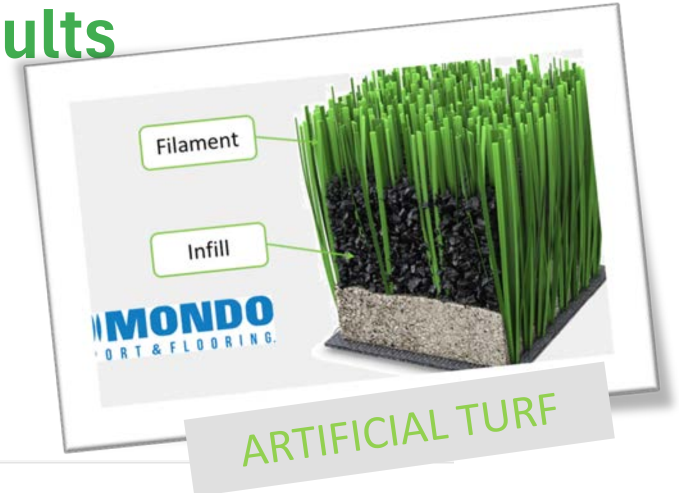
Accelerated test in 28 days

The results


save data
change parameters
capture data
Real System
Digital Twin
compare scenarios
apply parameters
select results


3.-
Implementation of digital models (data, physical) in fabrication

Initial data acquisition, monitoring and analysis of results



Test setup

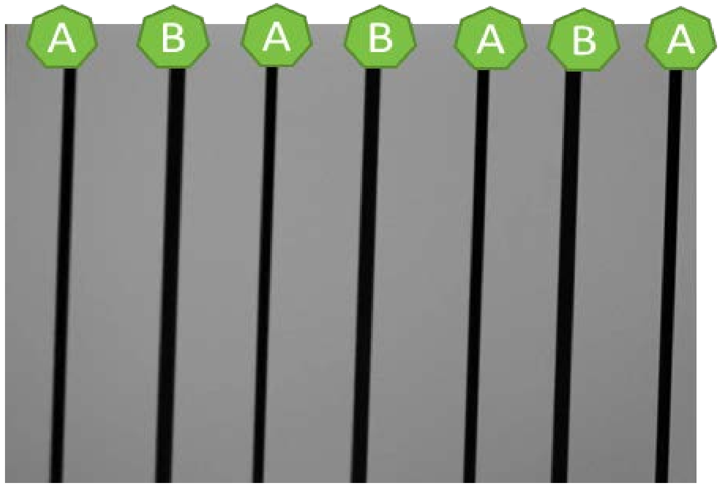
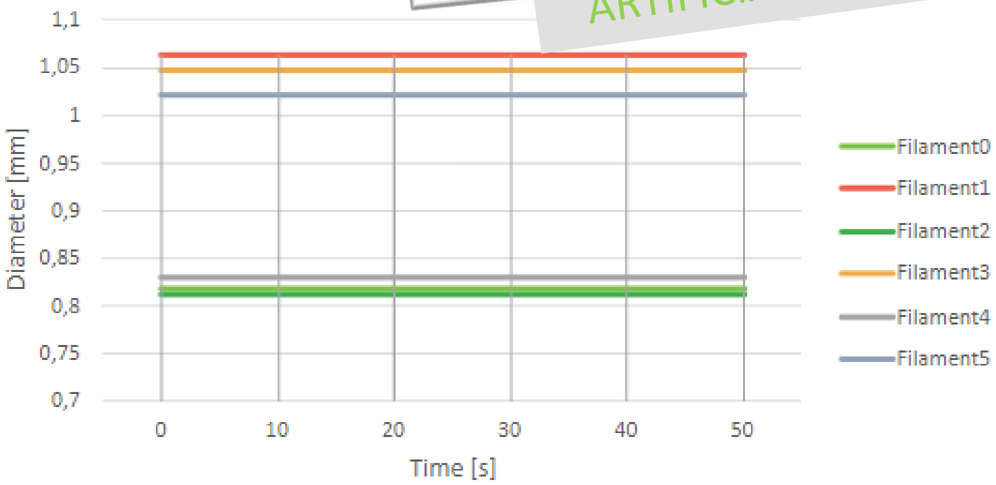
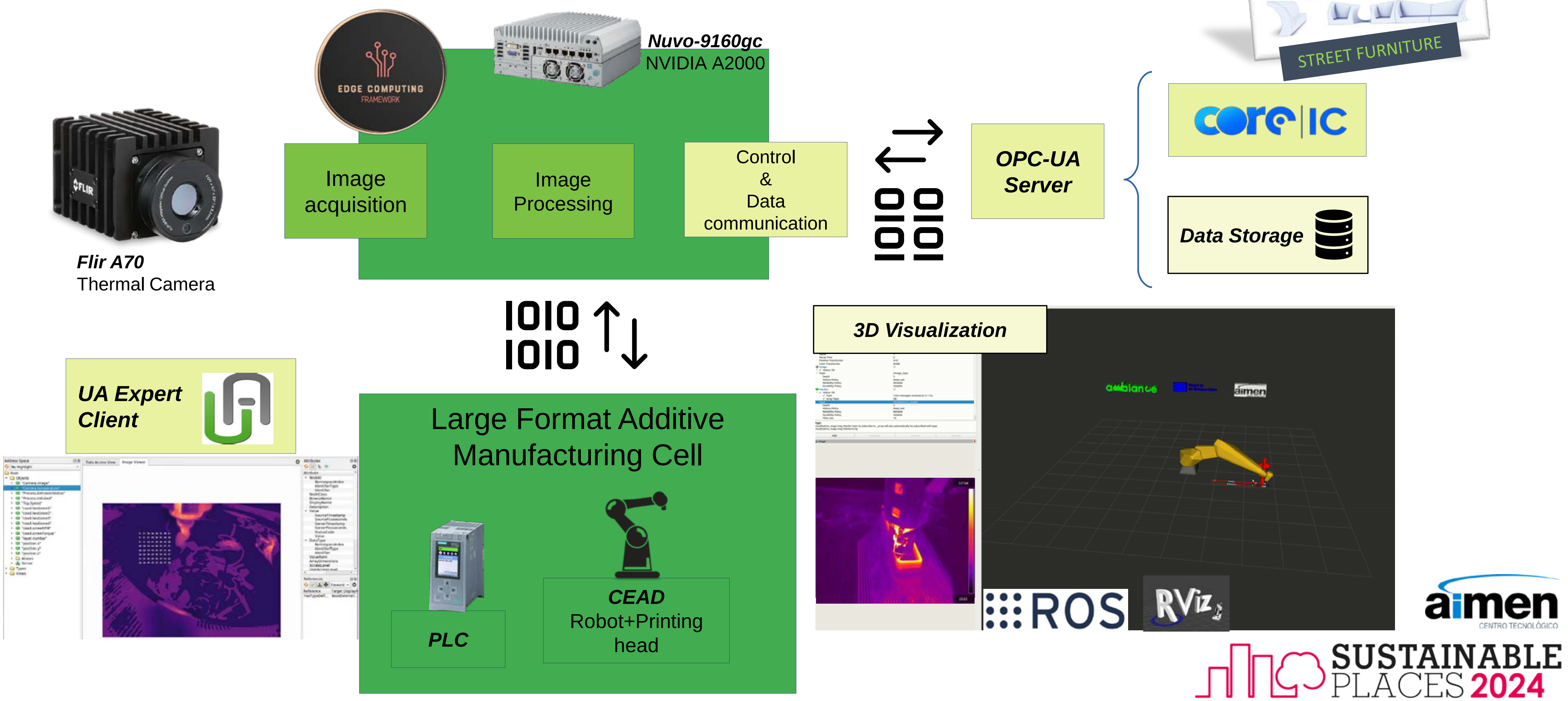


Image of filaments



Measurement
of filaments profiles

Real time temperature monitoring during FPF deposition



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SETGA Use Case

Alba Campillo, SETGA

Jesus Saavedra, SETGA

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35 YEARS

OF SHARED HISTORY

- SETGA, a manufacturer of lighting equipment and street furniture with more than 35 years of experience, located in Pontevedra, in Galicia, Spain.

SETGA's presence in 16 countries is the result of **renouncing industrial globalisation** to respond to local particularities.

Proximity and sustainability go hand in hand in a business commitment that has been able to adapt to the needs of the new times, making clear its **environmental and social commitment to the environment.**

Looking to the future with the energy of the beginning

SETGA Lighting Examples

City of Amsterdam

SETGA
Lighting Examples

Burgo Bridge, Pontevedra

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SETGA Lighting Examples

Gran Vía, Madrid

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SETGA in AMBIANCE Project and GOAL

- SETGA's and AMBIANCE's challenge, to manufacture new products with Bioplastics of vegetable origin as raw materials. Manufacturing process using large format additive manufacturing.

- SETGA implements Use Case 2, manufacture of urban furniture. We are also responsible for the execution of the final exhibition of the project in the city of Pontevedra, Galicia, Spain. We are currently in the design phase.

The initiative.
The origin of the Project.

- The bioplastic material shall be processed and shaped properly.
- The raw material for the additive manufacturing process shall be in pellet form.



**Final product requirements.
Raw Material Prescriptions.**

- Street furniture must withstand the inclement weather. Solar radiation can affect the colour or surface finish of materials, but it must not affect their performance.
- Our conventional benches are made of steel, aluminium and wood.
- Furniture made from AMBIANCE raw materials must meet these requirements: Resistance and Stability, good behaviour against UV radiation and against moisture and water, ...

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AMBIANCE manufacturing process.

Large Format Additive Manufacturing.

- In the AMBIANCE project, the manufacturing process is another innovative challenge. Large-format additive manufacturing will make it possible to produce elements of large dimensions and with very complex geometries.

- The process is carried out by means of an anthropomorphic robot incorporating a CEAD head for extruding the thermoplastic pellets and for depositing the polymer bead. The robot can move on a rail. The system therefore has 7 axes of movement. Working dimensions of 3 metres long, 1.2 metres wide and 1.8 metres. CEAD heated printing table.

- This configuration allows different manufacturing strategies. Not available on other conventional systems.

Design and geometry of the parts.

- The manufacturing process allows great flexibility in the manufacture of parts, which allows great design freedom and their usefulness for specific or special applications.

Design and geometry of the parts.

- Very personalized, very specific and unique products.
- Products for temporary, ephemeral applications. Being able to recover the raw material of the pieces.
- Possibility of colouring the material itself to have different finishes and avoid the application of surface coatings.

LCA and SETGA use case

Marco Pirotta - SUPSI

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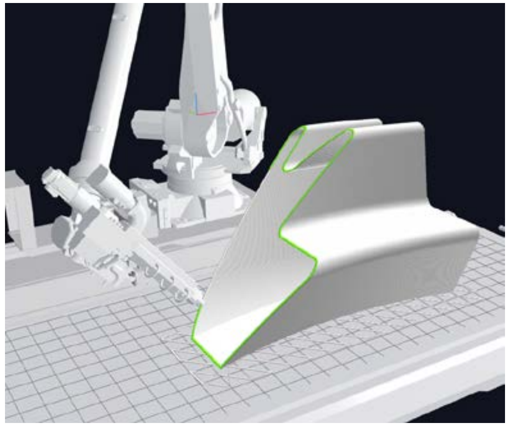
SETGA Use Case

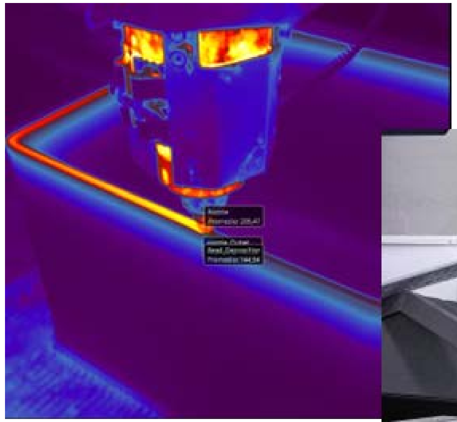
As-Is Scenario:

- Benches using wood and steel
- Traditional production technology

To Be Scenario:

- Bio-based polymer for 3D Printing
- 3D printing FDM



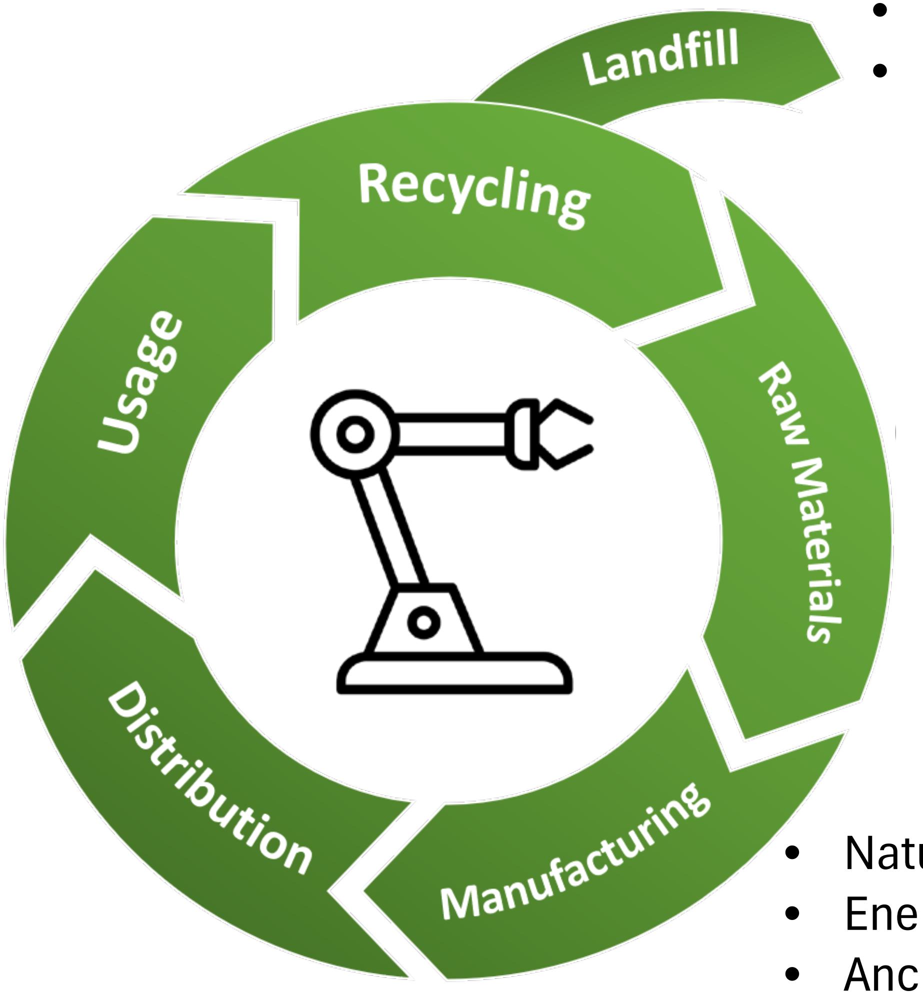


What are the problems in such an LCA?

Is the new bio-plastic better?

Life Cycle Approach

- Energy
- Resources
- Processing equipment (allocated)
- Credits for recycling/reuse



- Consumables/ancillary
- Energy

- Materials extraction, processing, transportation
- Natural Resources
- Chemicals & industrial resources
- Energy

- Fuels
- Energy
- Transportation means

- Natural Resources
- Energy
- Ancillary resources
- Production equipment

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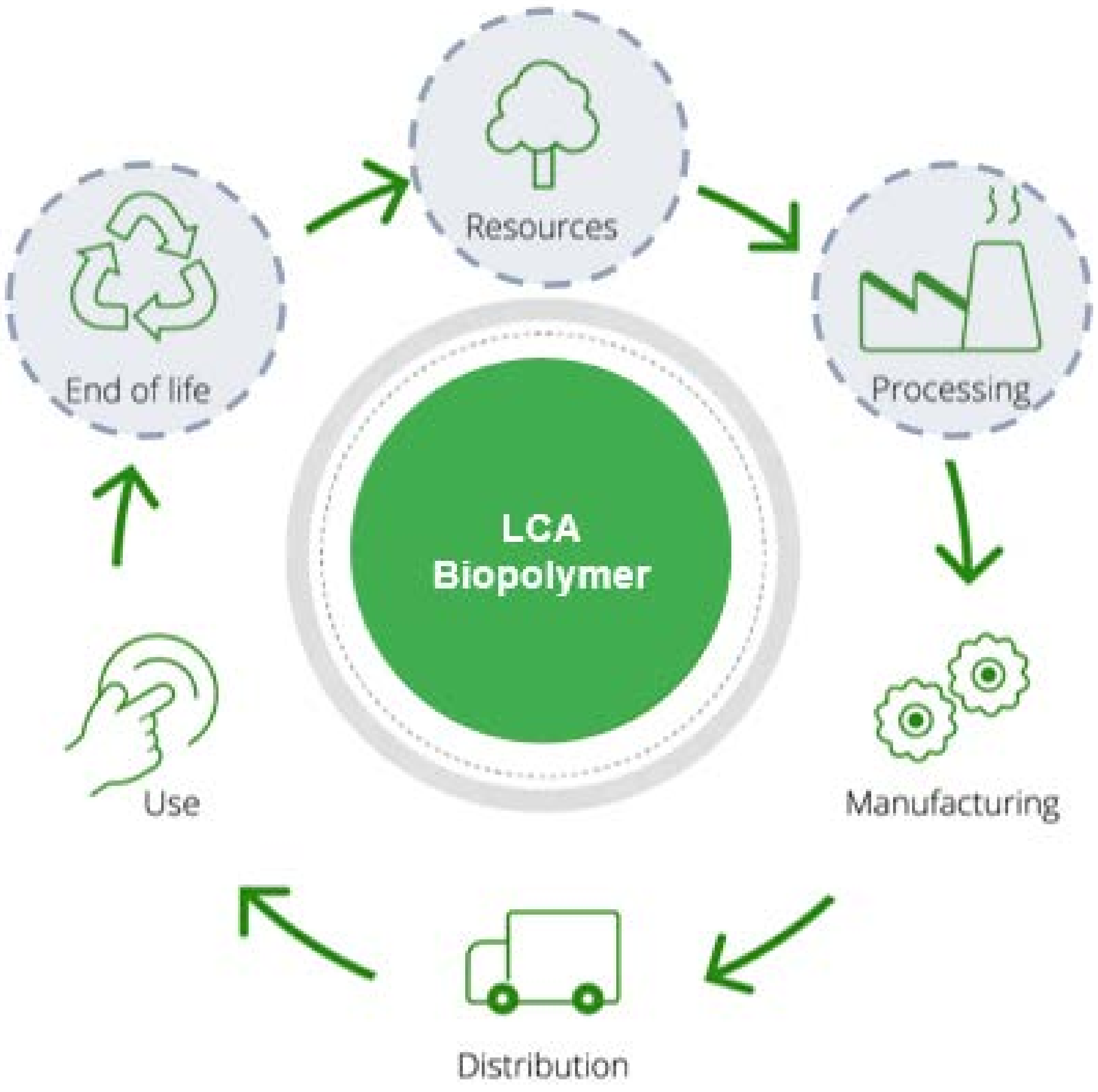
LCA in Biopolymer context

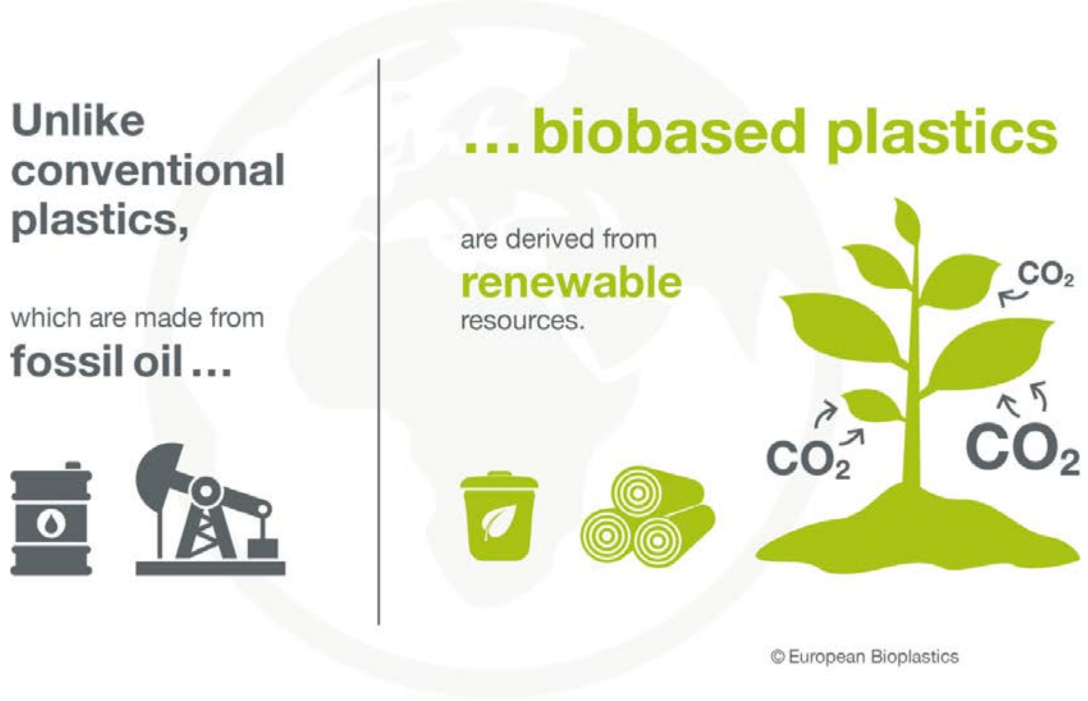
LCA for biopolymers, several unique considerations and peculiarities need to be kept in mind:

- Raw material impact
- Agricultural Practises
- Land Use Change
- Energy sources
- The process of manufacturing the polymer
- Biodegradability and EoL Options



LCA in Biopolymer context

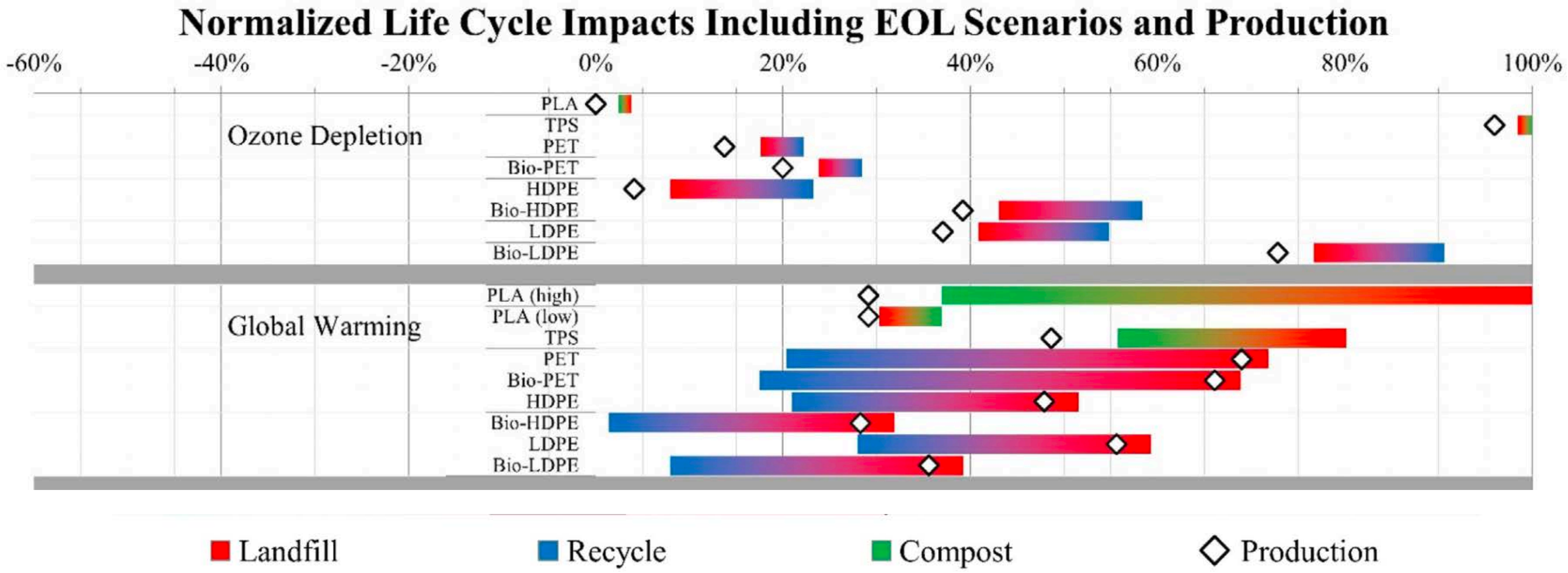
The Environmental Impacts of Biopolymers, especially bioplastics, are usually **lower regarding Climate Change, Global Warming Potential** (Kg CO2 emission) and dependence on fossil fuels, but **are not always lower** compared to the traditional polymer derived from fossil fuels.



End of Life phase

The impact related to the End-of-Life of the Biopolymer can differ significantly considering the disposal strategy.

The main problem is related to the **limited End-of-Life Options** and **Waste management** strategy compared to the traditional polymer.

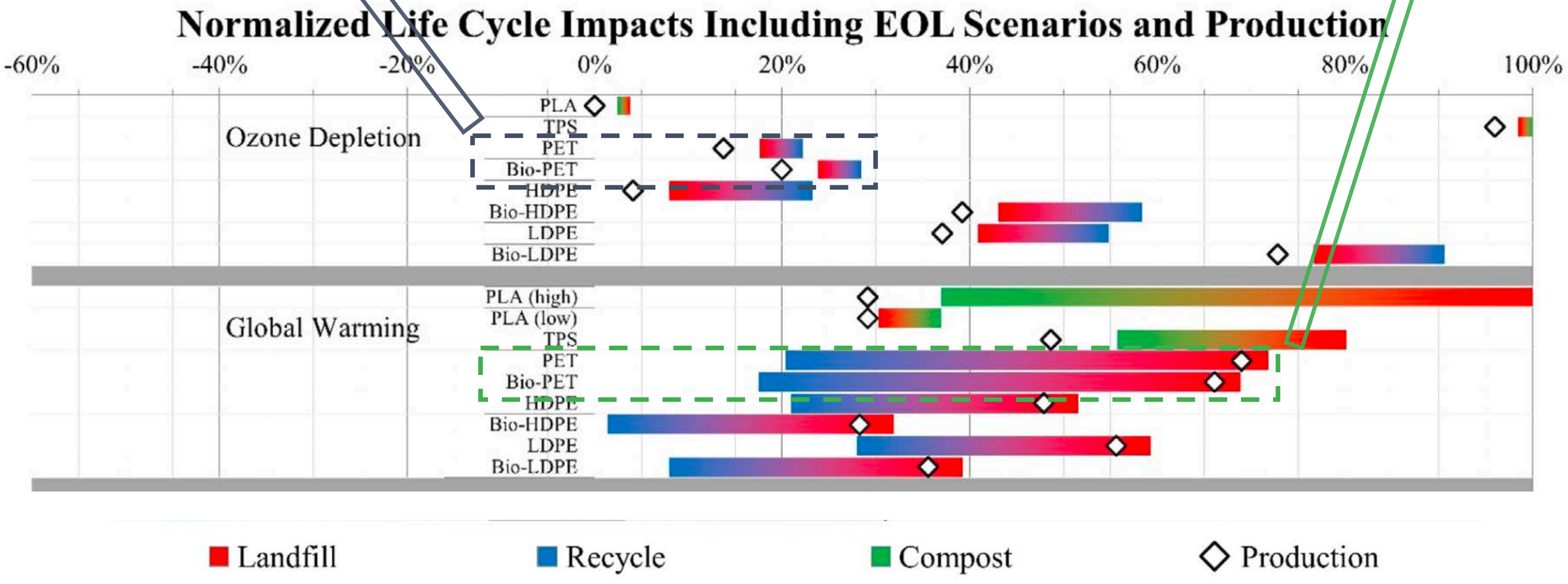


Source: *Hottle et all (2017). Biopolymer production and end of life comparisons using life cycle assessment*

End of Life phase

Tradition PET has a **lower** impact in the Ozone Depletion indicator when compared to the Bio alternative, both in the production and EoL phases

Tradition PET has a **higher** impact in the Global Warming indicator when compared to the Bio alternative, both in the production and EoL phases.
The total impact of EoL phase is highly influenced by the type of EoL



Challenge – Standardisation

Challenge:

- Biodegradation Rates
- Energy Consumption and Emissions
- Recycling and End-of-Life Management
- Dynamic LCA Modeling
- Inventory data missing

Reference framework or standard? →

Actual Standards:

EN 16760

EN 16751

Literature research

Challenges in standardization

Elena Mocchio – UNI, BIORECER

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BioReCer

Biological Resources Certifications Schemes

STANDARDIZATION: A TOOL FOR R&I

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The BioReCer Project receives funding from the Horizon Europe Framework Programme under the Grant Agreement Number 101060684

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ABOUT UNI – ITALIAN STANDARDISATION BODY

- Set up in 1921, UNI is a private, **not-for-profit association**
- Entitled to develop standards and best practices ("prassi di riferimento") in Italy covering all industrial, trade and service sectors (except for the electric and electronic one)
- An open platform working together with all stakeholders: industries, professionals, sectorial associations, public bodies, research centers, academia
- Recognized by **EU Regulation 1025/2012** on European Standardisation and the Italian Legislative Decree 223/2017
- Represents Italy in European and International standardization contexts

CEN - European Committee for Standardization

CEN Members · CEN Affiliates · EU neighbouring countries

- ✓ Provides a **multistakeholder platform** for the development of **European Standards** and other technical documents in relation to various kinds of products, materials, services and processes
- ✓ Help to ensure that the system **respects the WTO principles of transparency, openness, coherence, consensus**
- ✓ Based on the **national pillars**, which are the National Standardization Bodies or the members of CEN
- ✓ Supports the **EU Legislator** on specific requests

34 National Standardization bodies + CEN Affiliates (eg. ExtraUE, EFTA, international organizations)

BioReCer

BUDGET	PARTNERS	COUNTRIES	DURATION	STAKEHOLDERS
5,713,200 €	16	7	36 Months	16

About BioReCer

BioReCer (Biological Resources Certifications Schemes) aims at assessing and complementing current certification schemes for biological resources according to the new EU sustainability goals to enhance bio-based circular systems.

This will be achieved by including new criteria that align with EU taxonomy and EU corporate due diligence regulations into guidelines for certifying biological resources' sustainability, origin, tracking and traceability (T&T), and by ensuring applicability at EU and global scale.

By promoting the sustainability and trade of biological resources, BioReCer will increase the added value, use, as well as social acceptance of bio-based products.

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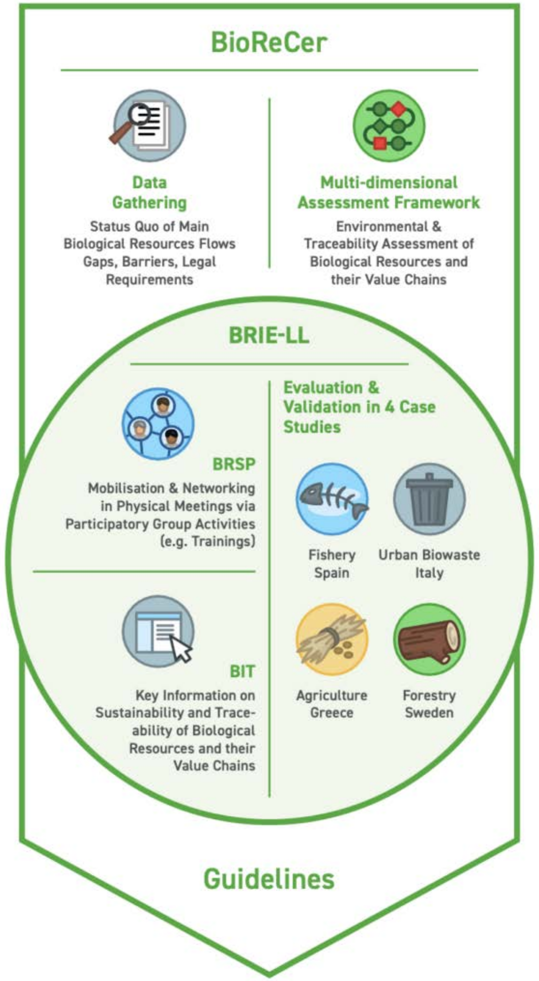

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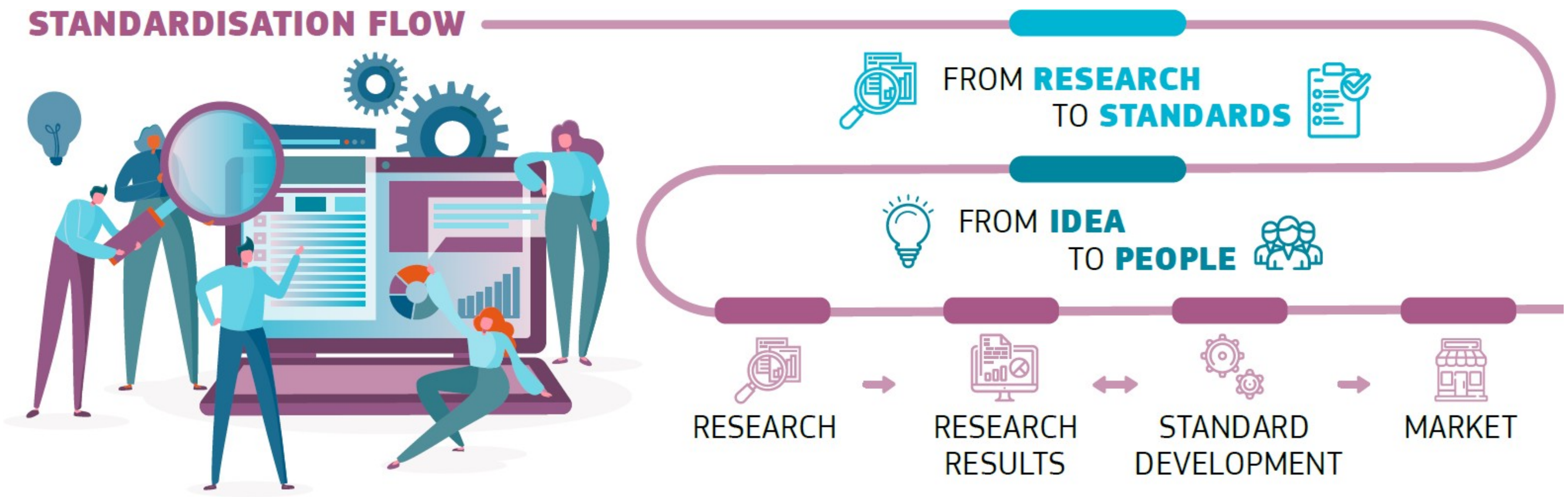
www.biorecer.eu

VALORIZING RESEARCH

Standards are a crucial tool to get the most out of research results. This is because they:

- help researchers to **bring their innovation to the market** by making their results transparent and ensuring high quality
- **build consumer trust** in innovative technology because they guarantee safety and quality
- **codify** the technologies **requirements** and inform both manufacturers and consumers on what to expect
- allow technologies and materials to be **interoperable**



Visit STANDARD+INNOVATION for more info

…PROVIDE OPEN STANDARDS RESEARCH TOOL

Progress until now:

- Number of Standards Mapped: **149**
- Number of Areas Identified: **14**
- Number of Unique Keywords: **175**
- Number of Unique International (ISO) TCs: **35**
- Number of Unique European (EN) TCs: **20**
- Number of Unique National (UNI) TCs: **35**

Click **here** to see how a Standardization Toolkit works

UNI PROJECTS H2020 E HE

BioReCer

UNI
UN MONDO FATTO BENE

EUB SuperHub – European Building Sustainability performance and energy certification Hub

#Edilizia, #Sostenibilità

SCOPRI IL PROGETTO →

TREASURE: leading the TRansion of the European Automotive SUpply chain towards a circulaR futurE

#AI, #Automotive

SCOPRI IL PROGETTO →

CircThread – Building the Digital Thread for Circular Economy Product, Resource & Service Management

#AccessoDati, #EconomiaCircolare

SCOPRI IL PROGETTO →

RECLAIM: RE-manufaCturing and Refurbishment LArge Industrial equipment

#EconomiaCircolare, #Industria4.0, #Remanufactoring

SCOPRI IL PROGETTO →

BIORECER: Biological Resources Certifications Schemes

#Bio-basedMaterials, #Bio-basedPlastics, #Bio-basedProducts, #BioFuels, #Certification, #Standards, #TechnicalCompliace, #Validation, #Verification

SCOPRI IL PROGETTO →

RobétArmé: Human-robot collaborative construction system for shotcrete digitization and automation through advanced perception, cognition, mobility and additive manufacturing skills

#CognitiveRobotPlatform, #Shotcrete

SCOPRI IL PROGETTO →

E-SHyIPS: Ecosystemic knowledge in Standards for Hydrogen Implementation on Passenger Ship

#Idrogeno, #NaviPasseggeri, #TrasportoMarittimo

SCOPRI IL PROGETTO →

ASINA: Anticipating Safety Issues at the Design Stage of NAno Product Development

#Nanotecnologie, #SafetyByDesign

SCOPRI IL PROGETTO →

Project Ô: demonstration of planning and technology tools for a circular, integrated and symbiotic use of water

#EconomiaCircolare, #GestioneAcqua, #PublicUtilities

SCOPRI IL PROGETTO →

STAR4BBS: Sustainability Transition Assessment Rules for Bio-Based Systems

#Bio-basedMaterials, #Bio-basedPlastics, #Bio-basedProducts, #Certification, #Standards, #TechnicalCompliace, #Validation, #Verification

SCOPRI IL PROGETTO →

MOZART Morphing Computerized mats with Embodied Sensing and Artificial Intelligence

#AI, #IntelligentSystems, #MultiAgentSystems, #RoboticAutomaticControl

SCOPRI IL PROGETTO →

BIORADAR: Monitoring system of the environmental and social sustainability and circularity of industrial bio-based systems

#Bio-basedMaterials, #Bio-basedPlastics, #Bio-basedProducts

SCOPRI IL PROGETTO →

…and three more will start in the next months

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Awareness of biopolymers

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Any questions?

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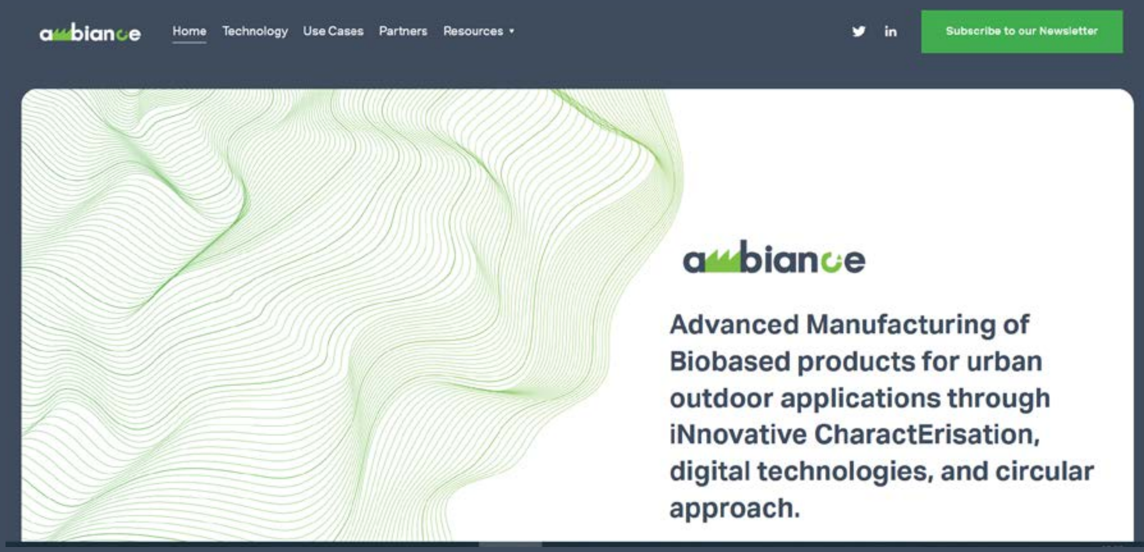

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Stay tuned!

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aimen TECHNOLOGY CENTRE

RISE Research Institutes of Sweden

Scuola universitaria professionale della Svizzera italiana SUPSI

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RECENDT RESEARCH CENTER NON DESTRUCTIVE TESTING

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