REGIONAL FOCUS GROUP WORKSHOP

From Forestry Residues to Bioplastics

CROATIA

Transforming forestry waste streams into high-value PHA bioplastics

Funded by the European Union · Grant Agreement No 101135166

SYMBIO
MEET YOUR SUSTAINABILITY TARGET

alchemia nova research

Cardiff Metropolitan University

STEEM

Agenda

01 Introduction to SYMBIO Project

02 The Value Chain: Forestry Residues to PHA

03 Material Flow Analysis

04 Economic, Ecological & Social Aspects

05 Ecosystem Map

06 Designing the Implementation Blueprint

07 Validating Croatia’s Ecosystem Map

08 Networking and light Lunch

The SYMBIO Project

WP1

DATA-HUB BUILDING

Explored and analyzed regional resources that trigger symbiotic activities close to the market.

- Quantified biomass availability
- Mapped 12 promising bio-based products and transformation pathways
- Ecosystem mapping

WP2

VALUE-CHAIN DESIGN

Connecting companies in circular value chains based on their specific material flows and available technologies

- 47 prioritised value chains
- selected based on local feedstock supply, conversion technologies, and clear local market demand
- Use of AI-tool VCG.AI

Have a look at VCG-AI:

WP3

BUSINESS MODELLING

Development of a circularity index and reporting system to support companies in building a circular business model

- 11 regional value chains were prioritized via Multi-criteria decision-making analysis (MCDMA)
- Visualization through Material Flow Analysis
- Multi-criteria overview
- Followed by multi-stakeholder workshop
- Policy recommendations

WP4

BUSINESS DEPLOY

Accelerate business case development by measuring social, economic and environmental impact

- LCC, LCA, social and sociological benefits assessment
- Building Synergies with EU projects, networks, initiatives
- Exploitation routes

Pilot regions

Methodology designed, tested and validated in **12 EU pilot regions** selected based on their biological resources, infrastructure and potential for developing close-to-market CBE supply chains.



Austria

Carinthia



Belgium

Brussels Capital, Wallonia, Flanders



Croatia



Italy

Lombardy, Piedmont, Veneto, Friuli-Venezia Giulia, Emilia-Romagna

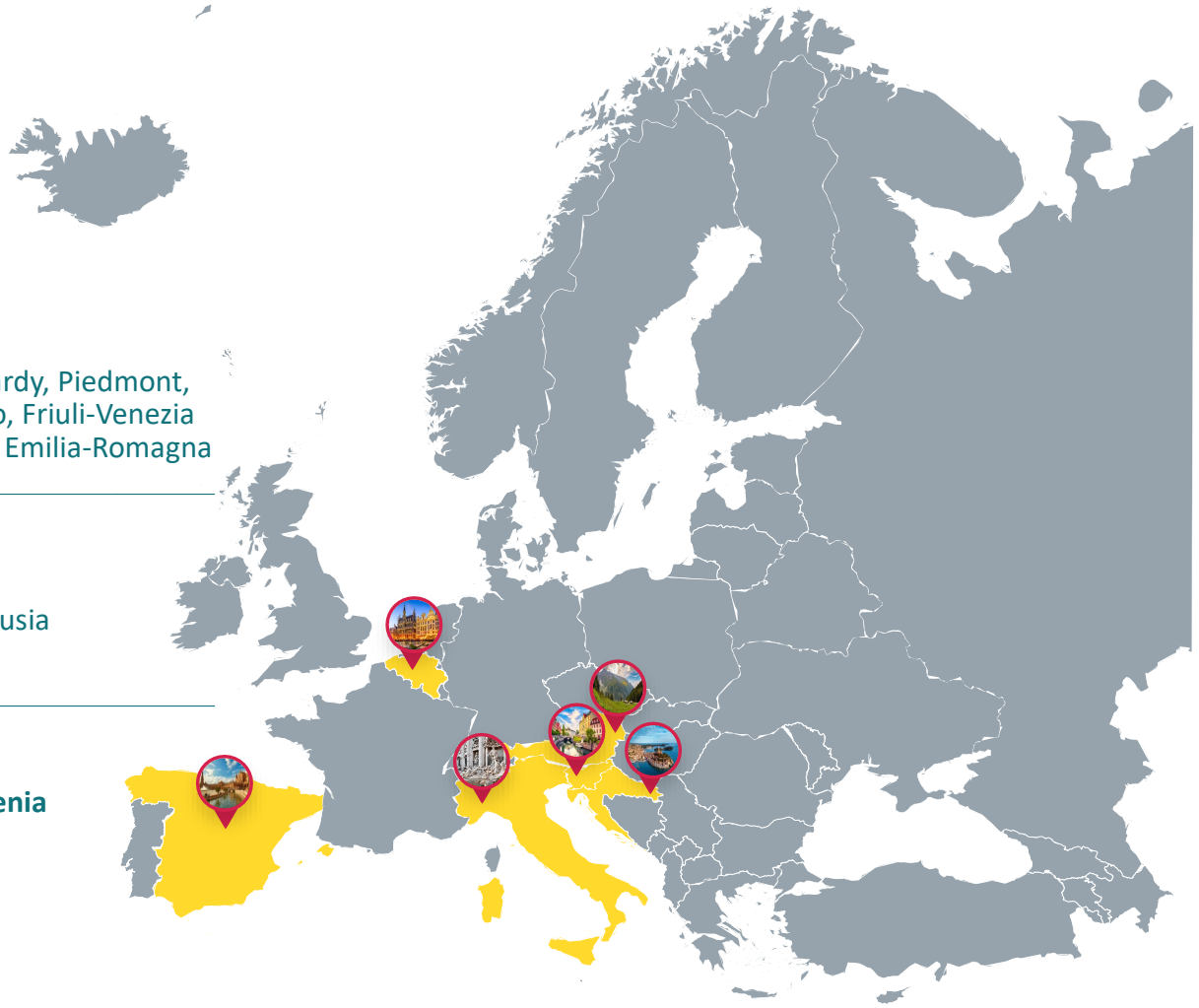


Spain

Andalusia



Slovenia



Strategic Decision-Making

Multi-Criteria Decision Analysis (MCDMA)

- Integrates **environmental, economic & social criteria**
- Enables **transparent comparison** of options
- **Ranks value chains** based on overall **performance**

Material Flow Analysis (MFA)

- Quantifies **material inputs and outputs**
- **Visualises resource flows** through the system
- Assesses **circularity and resource efficiency**
- Applicable for **ESRS E5 corporate reporting**

Multi-Stakeholder Focus Groups

- Brings together **all actors across the value chain**
- Identifies **barriers, enablers** and financing options
- Validates **implementation potential** in practice

Combining data, sustainability metrics, and stakeholder insight to guide strategic decisions.

The PHA Value Chain: From Forest to Bioplastic

1

Feedstock

Forestry residues — sawdust, bark, wood chips (39% of wood processed)

2

Biorefinery

Pre-treatment

Fermentation

Downstream

PHA powder

3

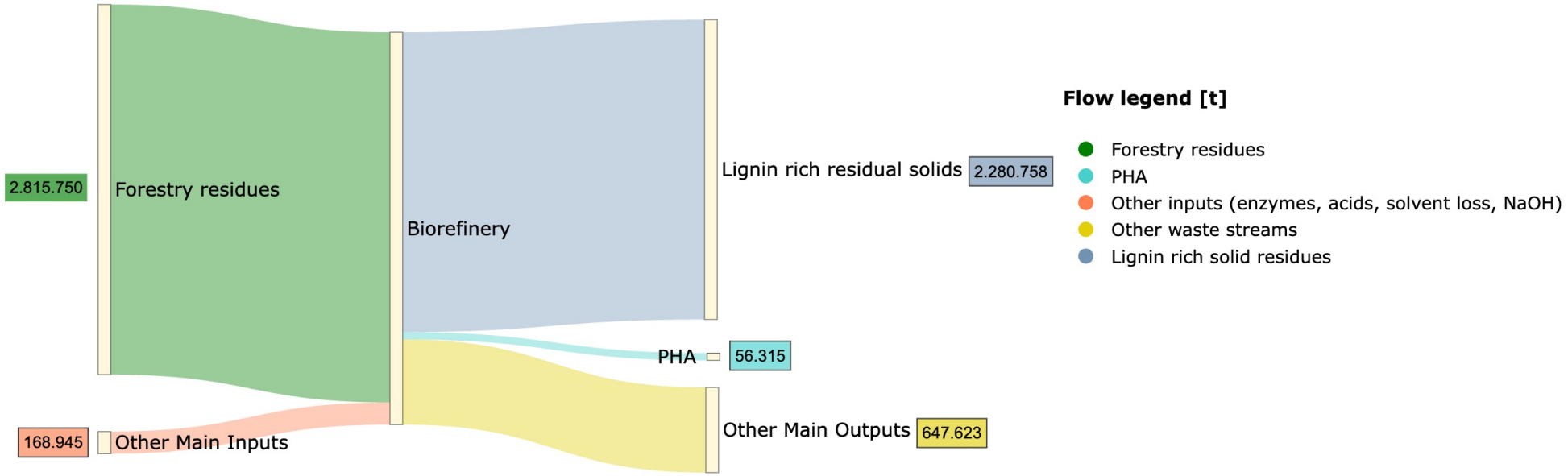
Market uptake

Compounding & Processing

- Packaging
- Biomedicine
- Automotive Industry
- Textiles
- Agriculture
- Cosmetics

Polyhydroxyalkanoates (PHA) are a class of **biobased, biodegradable and biocompatible polymers** synthesized by numerous microorganisms as a carbon and energy storage material. These biopolymers exhibit properties similar to conventional plastics while being **environmentally friendly**, making them increasingly vital in addressing plastic pollution.

Material flow analysis



Transforming **2.82 Mt** of **regional forestry residues into 56 kt of biodegradable PHA** annually, while **valorizing 81% lignin-rich side streams** for full circularity

Economic Reality: Opportunities vs Challenges

MARKET INSIGHTS

USD 64.41M	PHA Market size 2026
29.40%	Forecasted CAGR (2026-2034)
USD 64.41M - USD 504.88	Market size projected to grow from 2026 to 2034
47%	Market share in Europe 2025

THE COST CHALLENGE

PHA production costs remain a major challenge:

- Currently 3-12x higher then fossil-based plastics

Price comparison:

- Conventional polyethylene (PE): USD 1,250 per ton
- PHA: between USD 4,000 and 15,000 per ton

Key cost drivers in PHA production:

- Raw material acquisition
- Pretreatment of biomass
- Downstream: extraction and purification

ECONOMIC ENABLERS

- **Secondary lignocellulosic residues** as low-cost feedstock can reduce substrate costs by 40-50% compared to refined sugars
- **Advanced processes** like Solid-State Fermentation and Solid-State Enzymatic Hydrolisis increase yield and reduce water and energy consumption
- **Integrated Biorefinery Models**: Implementing a ”zero-waste” cascade approach increases revenue

Integrated Biorefinery: Maximising Local Value

High-value applications of lignin-rich residues

~81%

of total output are lignin residues

Aromatic Platform Chemicals
Lignin → adipic acid, nylon precursors & other aromatic building blocks

PHA Composite Reinforcement
Lignin as filler/reinforcement → enhances structural properties & reduces raw material costs

Renewable Energy Generation
Residual solids → on-site heat & power → reduces fossil fuel dependency & operational costs

Biochar Production
Pyrolysis → biochar for energy/carbon sequestration → potential carbon credit revenue

Diversified Revenue Streams
Co-products reduce waste burden & create multiple income sources → essential for long-term profitability

Environmental Profile

ECOLOGICAL BENEFITS

Universal Biodegradability
Fully decomposes in soil & marine systems → water, CO_2, biomass. Zero persistent microplastics.

Carbon Neutrality
CO_2 released during degradation was absorbed during tree growth — closed carbon cycle.

Waste Valorization
Transforms low-cost sawmill residues & harvest leftovers into high-value material.

No Food Competition
2nd-generation feedstock — no land/resource conflict with food systems.

ECOLOGICAL RISKS

Soil Health & Biodiversity
Excessive residue removal depletes soil organic matter, threatening long-term forest productivity & ecosystem functions.

Process Intensity
Conventional submerged fermentation demands high water volumes & significant dilution to manage inhibitors.

Pretreatment Impact
Energy- and chemical-intensive pretreatment can offset carbon benefits if the process is not carefully optimized.

KEY CONSIDERATION

Mobilization Safeguards
Sustainable retention thresholds must ensure sufficient biomass remains to protect soil & nutrient cycling.

Social & Regulatory Landscape

RED III & Waste Directives	Policy Drivers	Skills & Infrastructure Gap	Social Opportunity
The 2023 Renewable Energy Directive allows wood residues for biorefining but restricts whole-tree use to safeguard biodiversity and soil quality.	Value chain development is currently driven by EU packaging legislation and regional bioeconomy strategies not yet by genuine commercial market pull.	Significant shortages in bio-processing scale-up and advanced fermentation engineering in Croatia hinder the transition from pilot to industrial scale.	A domestic biorefinery extends the forestry value chain locally, creating skilled jobs and retaining economic value within Croatian regions.

Why Ecosystems Matter for Bio-based Value Chains

1. Bio-based value chains depend on strong regional innovation ecosystems.

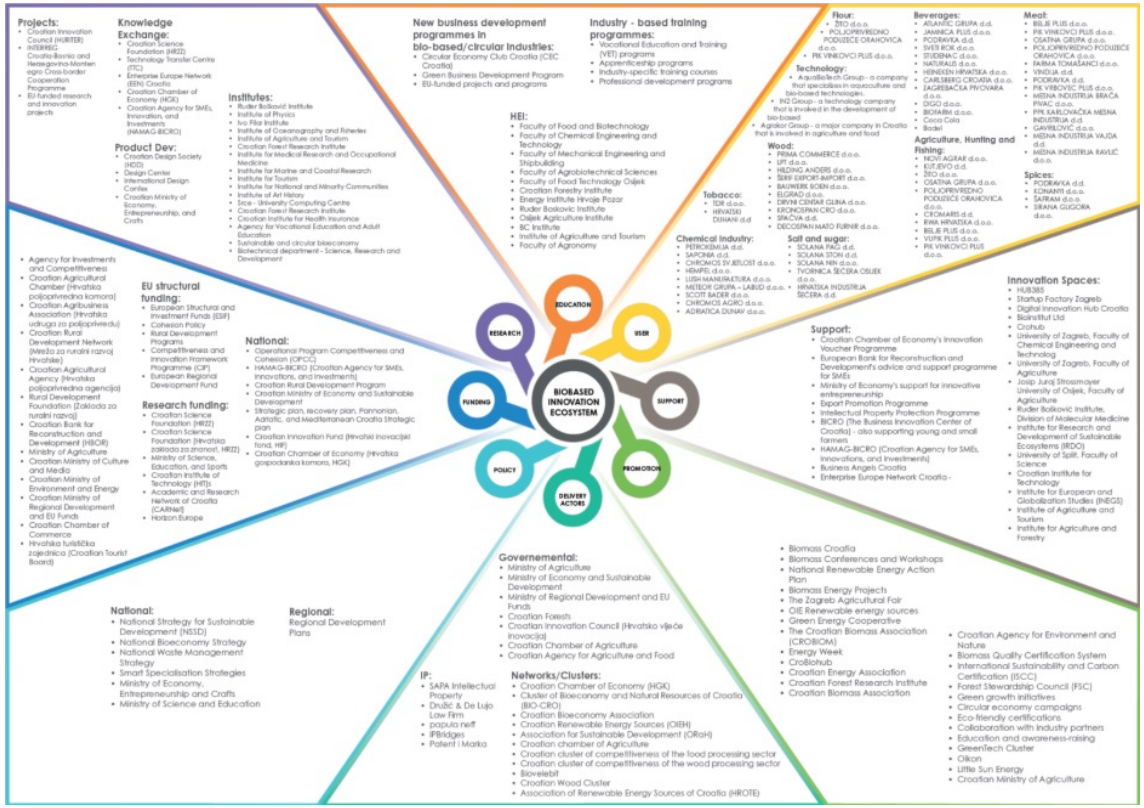
2. Industrial symbiosis requires coordination between businesses, research, policy and funding actors.

3. Ecosystems enable collaboration, knowledge transfer, investment and scale-up of circular bio-based solutions.

4.
- Businesses and value-chain actors form the core of the ecosystem.
- Supporting actors include research institutions, education providers and innovation support organisations.
- Policy, funding bodies, networks and promotion agencies create enabling conditions for innovation.

Croatia’s Bioeconomy Innovation Ecosystem – Snapshot

- **Research:** Ruđer Bošković Institute, Croatian Forest Research Institute, University of Zagreb.
- **Support & Innovation:** HAMAG-BICRO, ZICER Innovation Centre, Crohub startup platform.
- **Networks:** Croatian Chamber of Economy, CROBIOM Biomass Association, Green Energy Cooperative.
- **Policy & Funding:** EU Green Deal alignment, National Development Strategy 2030, EU Structural Funds.



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Key Drivers and Challenges in Croatia

Drivers	Challenges
• strong forestry resources, • supportive EU and national policies, • active research landscape.	• limited large-scale biorefinery infrastructure • fragmented support landscape, • need stronger collaboration between research, industry and innovation support

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Co-creation session

You are now invited to share insights and co-develop solutions to help forming industrial symbiosis in the bioeconomy

Generating an Implementation Blueprint

1

Step 1. Actors and Flows (15 min)

On the poster:

- Draw the main **material flow**
  - You can add additional stages if needed.
- Identify the **lead and side actors (roles)** for each stage of the value chain (Feedstock / Biorefinery / Market)
- Add the **value flow**: who pays whom?

2

Step 2 . Bottlenecks & Enablers (10 min)

On the poster:

- Write critical **bottlenecks** on **RED sticky notes** (e.g. technology gaps, policies, logistics, market demand)
- For each bottleneck, add a **GREEN sticky note** describing what would be **needed to resolve it**
- Add any existing **financing instruments** or funding opportunities you are aware of

3

Step 3 – Key Leverage Point (10 min)

- Ask yourselves: What is the most important next step to move this value chain from concept to implementation?
- As a group, **agree on ONE concrete action** that would have the **biggest impact** on making this value chain happen.
- Write this ONE key action clearly on the poster.

Role assignment per group:

🎙️ Moderator: Leads the discussion, ensures all voices are heard

✍️ Scribe: Fills in the canvas, writes sticky notes

Group Pitches & Discussion

Now each group has **5 minutes** to present their implementation blueprint

1

Core Logic:

What is the core logic of your implementation model? Who drives what?

2

Biggest Bottleneck:

What is the most critical obstacle in your model and why? What would help to solve it?

3

Leverage point:

What single action would make the biggest difference?

4

Cross-group reflection:

Participants can move to the presenting goups poster and place sticky notes after raising disagreements or agreements (red/green).

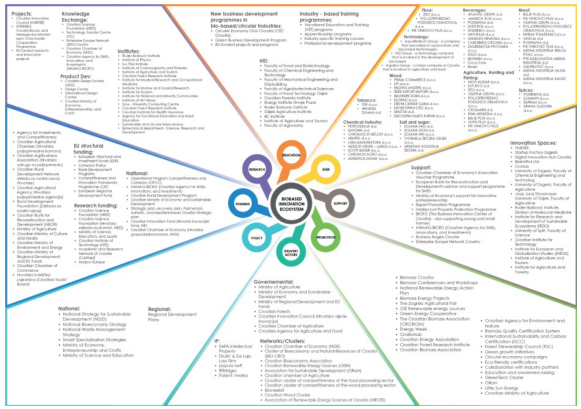
Croatia's Bioeconomy Innovation Ecosystem – Snapshot

This session explores whether the **regional innovation ecosystem is ready to support the bio-based value chains discussed earlier.**

Rather than perfecting the map, we **focus on what enables implementation, what blocks it, and where coordination gaps exist.**

Activity

- Review the ecosystem map and consider the BioLink/value chain discussed earlier.
- Use sticky dots to mark:
  - 🟢 **Enablers** – elements already supporting implementation
  - 🔴 **Bottlenecks** – gaps, barriers, or missing capacities
- Write a short note explaining why it helps or blocks implementation.



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Feedback Survey

Before we move to networking, we would love to take a moment to hear your feedback.

