CAFIPLA

D7.12 GUIDELINE FOR SUCCESSFUL INTEGRATION OF THE TECHNOLOGY PLATFORM

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This project has received funding from the Bio-based Industries Joint Undertaking (JU) under the European Union's Horizon 2020 research and innovation programme under grant agreement No 887115. The JU receives support from the European Union's Horizon 2020 research and innovation programme and the Bio-based Industries Consortium.

Bio·based Industries Consortium

Horizon 2020 European Union Funding for Research & Innovation

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COLOPHON

Bio-based research and innovation action	
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DISCLAIMER

This deliverable has been prepared in the context of the project CAFIPLA funded from the Bio Based Industries Joint Undertaking (JU) under grant agreement No 887115. The JU receives support from the European Union's Horizon 2020 research and innovation programme and the Bio-Based Industries Consortium.

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EXECUTIVE SUMMARY

The deliverable *D7.12 Guideline for successful integration of the technology platform* provides a comprehensive outline to implement the CAFIPLA concept on a regional level to help unlocking the potential of biowaste as a resource of a circular European bioeconomy and create novel bioeconomic value chains across sectors.

SECTION 1 demonstrates that the utilisation of biobased raw materials, especially biowaste, plays a key role to promote emission reductions on an urban level and highlights the relevance of biowaste recycling to advance the circular bioeconomy by closing material cycles. Current challenges, new approaches as well as policy recommendations in biowaste valorisation are described.

SECTION 2 describes how the platform approach of CAFIPLA facilitates tailored biowaste valorisation and provides a comprehensive description of key requirements for the implementation of the CAFIPLA technology, such as biomass supply and technical feasibility.

SECTION 3 outlines the economic potential of CAFIPLA-based value chains in the bioeconomy and highlights the flexibility of exploitation options based on the CAFIPLA technology.

SECTION 4 pinpoints main chances and challenges along the CAFIPLA value chain such as upstream processing, the conversion of platform products as well as markets and end-products. Furthermore, the results of an overarching PESTEL analysis are presented to facilitate technology implementation considering a broad range of influencing factors.

SECTION 5 summarises the main findings of this deliverable and puts them into the context of different implementation strategies, such as the integration into existing biorefinery or waste treatment sites as well as stand-alone options, thereby demonstrating an extensive implementation potential of the CAFIPLA technology.

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ABBREVIATONS

Abbreviation	Description
AD	Anaerobic digestion
CAP	Carboxylic acid platform
DBFZ	Deutsches Biomasseforschungszentrum gGmbH
DSP	Downstream processing
ECHA	European Chemicals Agency
FM	Fluid matter
FRD	Fibres Recherche Développement
FRP	Fibre recovery platform
MCCA	Medium-chain carboxylic acid
MP	Microbial protein
NADES	Natural deep eutectic solvents
OMSW	Organic municipal solid waste
OWS RF	Organic Waste Systems Research Foundation

Abbreviation	Description
PHA	Polyhydroxyalkanoate
REACH	Registration, Evaluation, Authorisation and Restriction of Chemicals
REMD	Renewable Energy and Material Directive
RED	Renewable Energy Directive
SCCA	Short-chain carboxylic acid
TSS	Total suspended solids
VFA	Volatile fatty acid
WFD	Waste Framework Directive
UGent	University of Ghent

GUIDELINE TO SUCCESSFULLY IMPLEMENTING THE CAFIPLA TECHNOLOGY FOR RECYCLING OF MIXED BIOGENIC WASTE

Bioeconomy expansion and rising demand for biobased raw materials

Biomass availability	CAFIPLA technology	Economic potential	Legislative frameworks
Assessment of underutilised organic waste streams suitable for CAFIPLA e.g. OMSW, green waste, by-products and residues	TRL5 pilot process integrating CAP and FRP to produce carboxylic acids and recovered fibres from organic waste	New biowaste-based value added product portfolio with high market potentials in diverse application fields	Biowaste legislations to facilitate its material use, strengthen market demand and provide low risk investment opportunities

Unlocking biowaste as resource for bioeconomic value chains

OMSW = Organic municipal solid waste; CAP = Carboxylic acid platform; FRP = Fibre recovery platform

CAFIPLA

SECTION 1
Introduction:
Biowaste Recycling
Towards a Circular Bioeconomy

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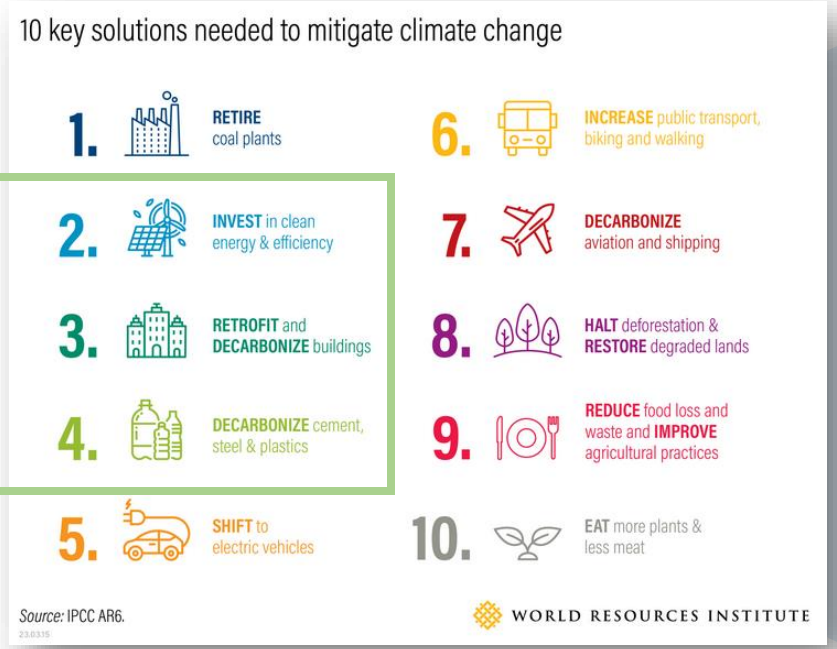
IPCC 6TH ASSESSMENT REPORT EMPHASISES ACTIONS OF URBAN SYSTEMS TO REDUCE EMISSIONS

Derived from [1]

"Mainstreaming effective and equitable climate action will not only reduce losses and damages for nature and people, it will also provide wider benefits. This **Synthesis Report underscores the urgency of taking more ambitious action** and shows that, if we act now, we can still secure a liveable sustainable future for all."

Hoesung Lee, IPCC Chair, Press release, March 2023



Urban systems are critical for achieving deep emissions reductions and advancing climate resilient development, particularly when this involves integrated planning that incorporates physical, natural and social infrastructure.

Deep emissions reductions and integrated adaptation actions are advanced by:

- integrated, inclusive land use planning and decision-making;
- compact urban form by co-locating jobs and housing;
- **reducing or changing urban energy and material consumption**;
- electrification in combination with low emissions sources;
- improved water and **waste management infrastructure**;
- and enhancing **carbon uptake and storage in the urban environment (e.g. bio-based building materials**, permeable surfaces and urban green and blue infrastructure).

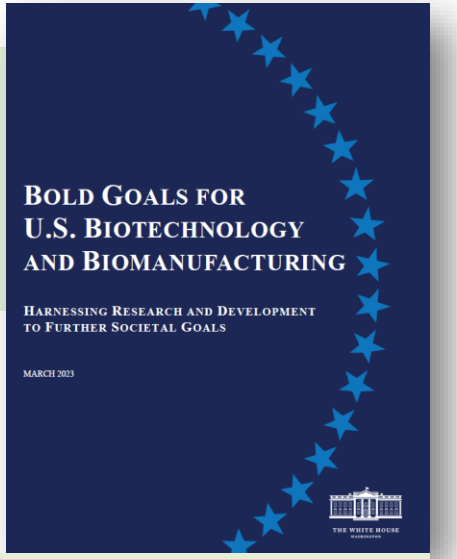
[1] IPCC (2023) Synthesis report of the IPCC sixth assessment report (Longer version)

DEMAND FOR BIOBASED RAW MATERIALS BY BIOBASED INDUSTRIES WILL INCREASE

Derived from [2]

"The world is on the cusp of an **industrial revolution fueled by biotechnology and biomanufacturing**. Emerging biological technologies are and will continue to transform the foundation of our physical world – everything from clothing, to plastics, to fuels, to concrete. Through biomanufacturing, sustainable biomass across the United States can be converted into new products and provide an alternative to petroleum-based production for chemicals, medicines, fuels, materials, and more."

Bold Goals for U.S. Biotechnology and Biomanufacturing - Introduction



Goal 1.1: Expand Feedstock Availability – In 20 years, collect and process 1.2 billion metric tons of conversion-ready, purpose-grown plants and waste-derived feedstocks and utilize >60 million metric tons of exhaust gas CO_2 suitable for conversion to fuels and products, while minimizing emissions, water use, habitat conversion, and other sustainability challenges.

Goal 2.1: Develop Low-Carbon-Intensity Chemicals and Materials – In 5 years, produce >20 commercially viable bioproducts with >70% reduced lifecycle GHG emissions over current production practices.

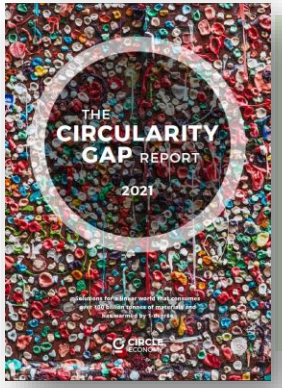
Goal 2.2: Spur a Circular Economy for Materials – In 20 years, demonstrate and deploy cost-effective and sustainable routes to convert bio-based feedstocks into recyclable-by-design polymers that can displace >90% of today's plastics and other commercial polymers at scale.

Goal 3.3: Engineer Circular Food Protein Production Systems – In 5 years, demonstrate viable pathways to produce protein for food consumption including from biomass, waste, and CO_2 that achieve >50% lifecycle GHG emissions reduction and cost parity relative to current production methods.

The report highlights the wide availability of 368 million metric tons per year of biomass and **biogenic waste as raw materials for conversion to bioproduct** and emphasises their importance for providing sustainable feedstocks to **defossilise chemical and material production**. To this, a rapid transition towards a more circular economy is needed and current fossil carbon-based polymers have to be replaced by recyclable plastics from biobased and waste sources.

[2] The White House Office of Science and Technology Policy (2023) Bold Goals for U.S. Biotechnology and Biomanufacturing

BIOWASTE WILL PLAY AN ESSENTIAL ROLE FOR MATERIAL PRODUCTION AS DEMAND AND COMPETITION FOR BIOMASS GROW

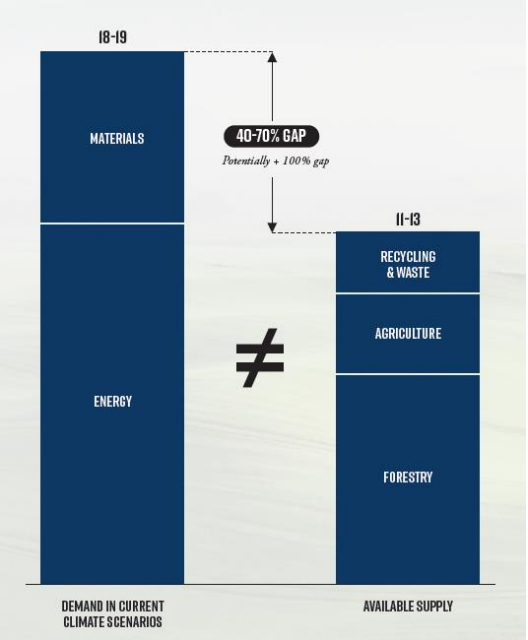


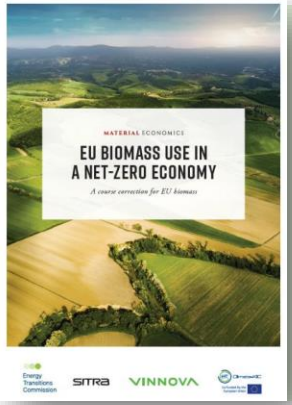
"The importance of a functioning, future-focused **waste management sector**—that both collects and segregates waste at scale and **produces high-quality secondary materials**— is also generally overlooked."

"For the past 200 years at least, the hallmark of global consumption and resource use can be aptly described as 'take-make-waste': a linear economy."

Derived from [3]

Biomass supply and demand for materials and energy in the EU
Primary energy equivalents in EJ per year [4]





- Current climate scenarios risk an over-reliance on biomass resulting in a predicted **biomass gap** by 2050 of **40-100%.**
- Traditional bioenergy applications are set to be **outcompeted** by new options such as electrification and hydrogen.
- The future use of biomass will focus on materials and particularly **high-value** areas such as **fibres, chemicals and textiles.**
- Nearly **all petrochemical products** can in principle be produced from basic chemicals **derived from biomass** including plastics, solvents, fertilisers, fibres etc.
- The sustainable generation and **efficient cascade utilisation of biogenic resources** are in the centre of, both European and National policies, in which material use is generally prioritised over energetic use (e.g., see [5]).

Derived from [4]

[3] Circle Economy (2021) The Circularity Gap Report 2021. Available from www.circularity-gap.world
[4] Material Economics (2021). EU Biomass Use In A Net-Zero Economy - A Course Correction for EU Biomass
[5] BMUV (2022). Eckpunkte für eine Nationale Biomassestrategie (NABIS) [Online]

BIOMASS UTILISATION IS A KEY INTERFACE BETWEEN THE BIOBASED ECONOMY AND CIRCULAR ECONOMY

Derived from [6]

"Utilisation of biomass as a resource is a key interface between the bio-based economy and circular economy."

"An overarching goal of both the bio-based economy and circular economy concepts is that they strive to create a **more sustainable and resource efficient world** with a lower carbon footprint."

European Research Project RoadToBio [6]

Using **biomass residues, by-products and wastes** not only avoids conflict with food production, but brings along several benefits:

- Keeping materials in the economy for longer
- Closing material loops
- Increasing resource productivity

Improved resource efficiency and a lower demand for fresh feedstocks can additionally be supported by so-called **cascading use of biomass**, which refers to sequential recycling of a material into another type of product at its end of life. Often this comes along with added-value of the recycled product as well as new businesses and job creation.

Challenges for the circular bioeconomy

- Conflict/competition between biomass as a feedstock for bio-based chemicals and materials and its use in bioenergy applications caused by a conflict between industrial and environmental policy
- Waste markets can be disrupted as some waste materials that currently go to recycling, landfill or incineration could in the future be bound for biorefineries
- Cascading usually increases the efficient use of resources, but a direct connection to reduced GHG emissions is not guaranteed. Also, along the cascade products can accumulate toxic or critical substances, which can serve as barriers for their further processing or recycling

[6] Horizon 2020 Project (2017-2019) RoadToBio – Del. No. 2.5 (2019) – Roadmap for the Chemical Industry in Europe towards a Bioeconomy

BIOWASTE RECYCLING IS A FUNDAMENTAL ELEMENT OF THE CIRCULAR ECONOMY AND CRUCIAL TO CLOSE MATERIAL CYCLES

The EU Bioeconomy strategy updated in 2018 defines bioeconomy comprehensively:
"The bioeconomy covers all sectors and systems that rely on biological resources (animals, plants, microorganisms and ***derived biomass, including organic waste****), their functions and principles.* [...]"

The importance of urban bioeconomy concepts is emphasised through the **Pilot circular biobased cities** call which funds European cities to develop "urban circular bioeconomy strategies fostering the **sustainable production of biobased products from urban biowaste** and wastewater." Derived from [7]

"The **use of biogenic waste and residues is crucial for a sustainable bioeconomy**. For the most part, they do not compete with food or feed production. Cascade use, which will be a central element of the bioeconomy, relies on the **complete use of biomass, including biogenic wastes and residues**. The unused technical potential of biogenic waste and residues is high, and much more could be used for materials and/or energy: Proven and innovative processes are available to **convert them into valuable products**. [...] In addition to technical, economic and ecological issues, questions of acceptance are therefore also important for a future waste- and residue-based bioeconomy."
Schüch & Hennig, Waste and Residue-Based Bioeconomy [8]

[7] International Advisory Council on Global Bioeconomy (2020). Global Bioeconomy Policy Report (IV): A decade of bioeconomy policy development around the world
[8] Schüch & Hennig (2023) Waste and Residue-Based Bioeconomy, Eds. Thrän & Moesenfechtel, The bioeconomy system [Online]

BIOWASTE SEPARATION AND COLLECTION IS PREREQUISITE TO SUCCESSFUL VALORISATION

"The food and other bio-resources that supply cities are produced primarily in rural areas. Having entered the city, they are processed and consumed, becoming **'waste' in the form of discarded by-products, food waste, and sewage.** The volume of discarded material is significant. A 2017 study estimated that each year cities produce 650 million tonnes of organic waste. By 2030, this volume is projected to double."

Ellen MacArthur Foundation - Circular Example [9]

VALUEWASTE
Unlocking new value from urban biowaste

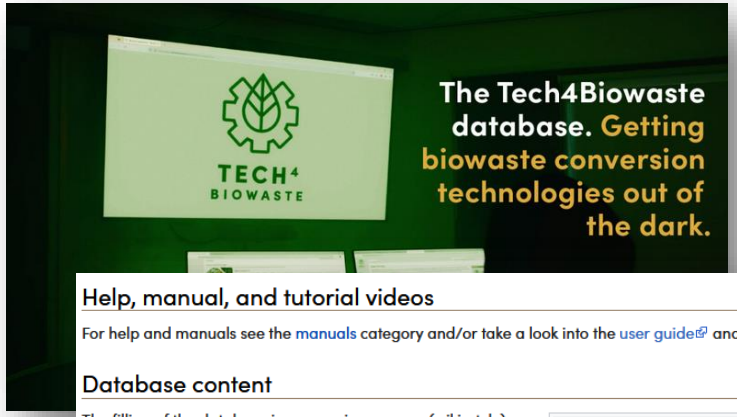
CWA 17866 "Key factors for the successful implementation of urban biowaste selective collection schemes"

- Standardisation activities by VALUEVASTE project & published by the European Committee for Standardization (CEN) in 2022
- "High quality biowaste is crucial for successful valorisation schemes to produce high value products with attractive and sustainable business cases and relies on **efficient selective collection systems and pre-treatments**."
- "Standardization of the influencing key factors for the improvement of the selective collection and management of urban biowaste will help city managers and waste management service providers to **increase the quality of the selectively collected biowaste** [...]."

Derived from [10]

[9] Ellen MacArthur Foundation (2023) Circular Example – Effective Organic Collection Systems [Online] – accessed 29.03.2023
[10] Horizon 2020 Project (2018-2022) VALUEWASTE – CEN Workshop Agreement (2022)

BIOWASTE UTILISATION TECHNOLOGIES CREATE NOVEL VALUE CHAINS BY LINKING FEEDSTOCK SUPPLIERS AND MANUFACTURERS

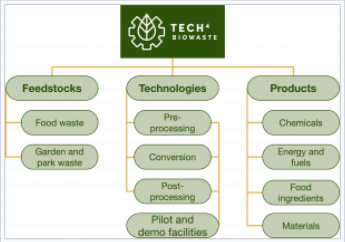


Help, manual, and tutorial videos

For help and manuals see the manuals category and/or take a look into the user guide and tutorial videos.

Database content

The filling of the database is an ongoing process (wiki-style). The first focus is on the description and factsheets for the technologies of bio-waste conversion as listed below. All pages are work in progress ...



Visualisation of the overall database structure

Technologies

- Pre-processing
- Conversion
- Post-processing

Feedstocks (biowaste)

- Food waste
- Garden and park waste

Products

- Chemicals
- Energy and fuels
- Food ingredients

Tech4Biowaste – an open-source database for biowaste conversion technologies

"The Tech4Biowaste project aims to provide the bio-based industry with a complete **overview of existing and emerging technologies** with a Technology Readiness Level (TRL) 4 and higher for biowaste utilisation and valorisation."

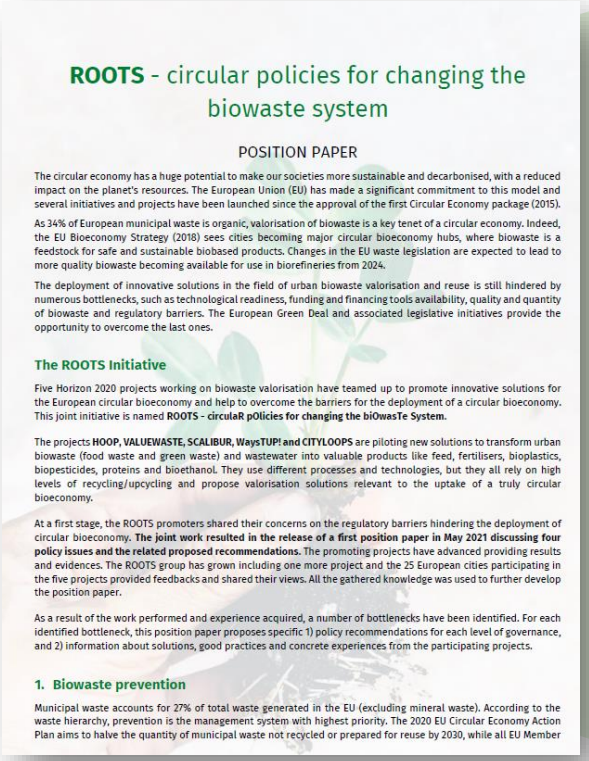
European Research Project Tech4Biowaste[16]

- **Knowledge gap** about increasing biowaste utilisation potential and innovative approaches needs to be bridged
- **Matchmaking and connecting** biowaste collectors, technology providers and biomanufacturers is crucial to transition towards a more circular economy.
- Tech4Biowaste builds a dynamic database of emerging and established technologies along the **value chain of biowaste utilisation** [14]

[11] Horizon 2020 Project (2021-2023) Tech4Biowaste: A dynamic database of relevant technologies of bio-waste utilization

POLICY RECOMMENDATIONS COULD DRIVE ADVANCING THE EU BIOWASTE SYSTEM

Derived from [12]



ROOTS - circular policies for changing the biowaste system

POSITION PAPER

The circular economy has a huge potential to make our societies more sustainable and decarbonised, with a reduced impact on the planet's resources. The European Union (EU) has made a significant commitment to this model and several initiatives and projects have been launched since the approval of the first Circular Economy package (2015).

As 34% of European municipal waste is organic, valorisation of biowaste is a key tenet of a circular economy. Indeed, the EU Bioeconomy Strategy (2018) sees cities becoming major circular bioeconomy hubs, where biowaste is a feedstock for safe and sustainable biobased products. Changes in the EU waste legislation are expected to lead to more quality biowaste becoming available for use in biorefineries from 2024.

The deployment of innovative solutions in the field of urban biowaste valorisation and reuse is still hindered by numerous bottlenecks, such as technological readiness, funding and financing tools availability, quality and quantity of biowaste and regulatory barriers. The European Green Deal and associated legislative initiatives provide the opportunity to overcome the last ones.

The ROOTS Initiative

Five Horizon 2020 projects working on biowaste valorisation have teamed up to promote innovative solutions for the European circular bioeconomy and help to overcome the barriers for the deployment of a circular bioeconomy. This joint initiative is named **ROOTS - circulaR pOlicies for changing the biOwasTe System.**

The projects **HOOP, VALUEWASTE, SCALIBUR, WaysTUP! and CITYLOOPS** are piloting new solutions to transform urban biowaste (food waste and green waste) and wastewater into valuable products like feed, fertilisers, bioplastics, biopesticides, proteins and bioethanol. They use different processes and technologies, but they all rely on high levels of recycling/upcycling and propose valorisation solutions relevant to the uptake of a truly circular bioeconomy.

At a first stage, the ROOTS promoters shared their concerns on the regulatory barriers hindering the deployment of circular bioeconomy. **The joint work resulted in the release of a first position paper in May 2021 discussing four policy issues and the related proposed recommendations.** The promoting projects have advanced providing results and evidences. The ROOTS group has grown including one more project and the 25 European cities participating in the five projects provided feedbacks and shared their views. All the gathered knowledge was used to further develop the position paper.

As a result of the work performed and experience acquired, a number of bottlenecks have been identified. For each identified bottleneck, this position paper proposes specific 1) policy recommendations for each level of governance, and 2) information about solutions, good practices and concrete experiences from the participating projects.

1. Biowaste prevention

Municipal waste accounts for 27% of total waste generated in the EU (excluding mineral waste). According to the waste hierarchy, prevention is the management system with highest priority. The 2020 EU Circular Economy Action Plan aims to halve the quantity of municipal waste not recycled or prepared for reuse by 2030, while all EU Member

ROOTS is a group of the five Horizon 2020 projects: HOOP, VALUEWASTE, SCALIBUR, WaysTUP! and CITYLOOPS. Their recent position paper addresses EU policy makers to inspire changes to the EU biowaste framework with recommendations:

1. **Biowaste prevention**
2. **Recycling targets & treatment plants**
3. **Waste and by-products**
4. Biopesticides
5. Insects for animal feed
6. Single cell protein
7. Citizen awareness

"The ROOTS group wants to play an important role in achieving a more sustainable society through **circular biowaste valorisation schemes that comply with safety and health standards.** [...] For this reason, we must combine the development of new innovative solutions with the necessary dialogue with policy makers on regulatory barriers."

ROOTS Position paper [12]

Recommendations

1. Including targets for specific biowaste streams prevention and a reporting system
2. Setting recycling targets for biowaste and establish the implementation of door-to-door collection for commercial activities, including a minimum percentage to be recovered in mechanical-biological treatment plants
3. Establishing the criteria required for End-of-Waste status for several kinds of urban biowaste (i.e. food waste, green waste, used cooking oils) to help set an EU reference

WaysTUP! SCALIBUR VALUEWASTE hoop CITYLOOPS

[12] ROOTS (2022). Circular policies for changing the biowaste system. Position paper

SPOTLIGHT ON BIOWASTE...

- **Defossilising** urban production and consumption will contribute to mitigating climate change.
- **Utilisation of biowaste** plays a key role to promote emission reductions on an urban level.
- **Biomanufacturing** technologies based on sustainable biomass will progressively replace conventional fossil-based industries.
- **Demand and competition** for biobased raw materials to feed bioproduction industries will increase.
- **Biowaste** will become increasingly relevant as abundant and sustainable bioresource.
- **Recycling** of biowaste is fundamental to close material cycles and advance the circular bioeconomy.
- **Collection** systems and pretreatments lay the foundation for high-quality biowaste and successful valorisation schemes
- **Valorisation** and cascade use of organic residues is essential to create novel bioeconomic value chains.
- **Policies** on European, national and regional levels need to push optimisation of biowaste collection systems and facilitate optimal valorisation

Bioeconomy expansion and rising demand for biobased raw materials

Biomass availability

Assessment of underutilised organic waste streams suitable for CAFIPLA e.g. OMSW, green waste, by-products and residues

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SECTION 2
The CAFIPLA Concept and Technology Requirements

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Bio-based Industries Consortium

Horizon 2020 European Union Funding for Research & Innovation

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CAFIPLA: COMBINING CARBOXYLIC ACID PRODUCTION AND FIBRE RECOVERY AS AN INNOVATIVE, COST-EFFECTIVE AND SUSTAINABLE PRE-TREATMENT PROCESS FOR HETEROGENEOUS BIO-WASTE

- The CAFIPLA project aims to **radically alter biomass pretreatment** for bioeconomy applications. Current biomass use comes at a high cost, either in terms of land, energy or chemical use. **Biowaste** is massively produced in urban and rural areas but hardly valorised, in part due to its heterogeneous nature.
- The CAFIPLA project will tackle both issues by developing an integrated biomass valorisation strategy that combines the **Carboxylic acid platform (CAP)** and the **Fibre recovery platform (FRP)** to convert heterogenous organic materials into building blocks for the bio-based economy.
- CAFIPLA will first optimise the separation of the easily biodegradable fraction and recalcitrant biomass, as input for the CAP and FRP. This allows the **implementation of tailored valorisation strategies for both routes**, which in turn allows the use of heterogeneous biowaste as input, while still ensuring high overall yields.
- The **CAP converts easily degradable fraction into short chain carboxylic acids** (SCCA). Research focuses on process control strategies to obtain specific spectra of carboxylic acids to feed into bioproduction of microbial protein, PHA or caproic acid bio-oil.
- The **FRP recovers insoluble fibres** from the remaining fraction. Fractionation into different fibre ranges will result in intermediates that can be valorised as packaging or insulation material.
- A **TRL5 pilot** demonstrates the upscaling potential of the CAFIPLA technology.

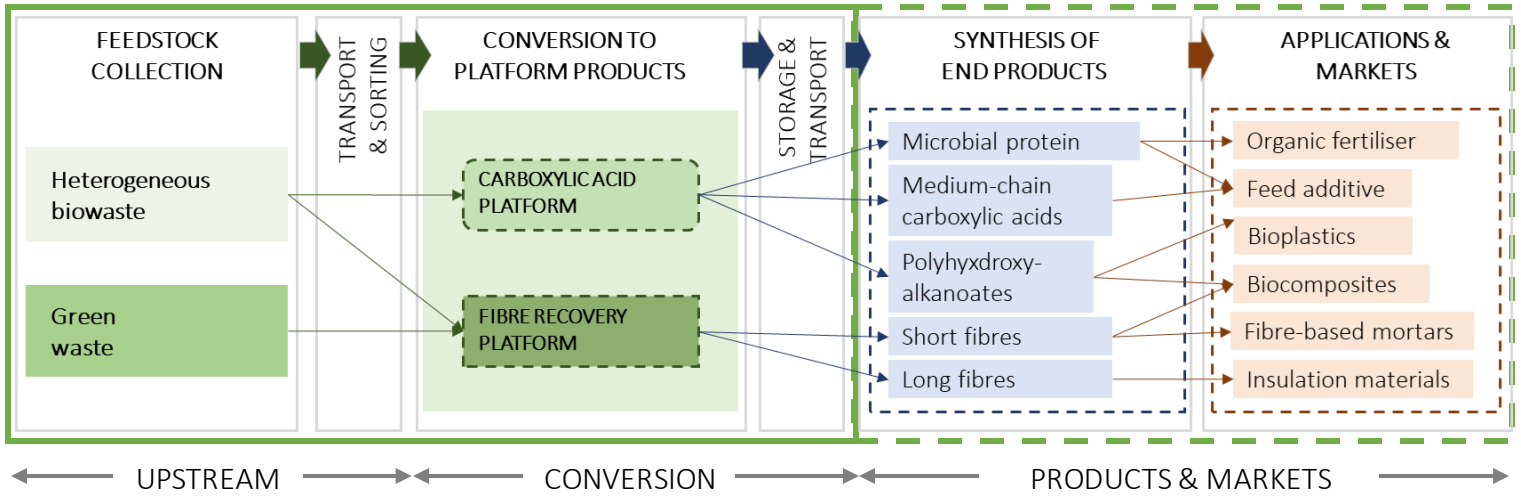
CAFIPLA's PLATFORM PRODUCT-BASED APPROACH FACILITATES TAILORED BIOWASTE VALORISATION

CAFIPLA valorisation via two levels:

1. The CAFIPLA technology integrates the collection and preparation of suitable organic residual feedstocks with the conversion processes via CAP and FRP to achieve the **primary valorisation into platform products.**

2. The subsequent manufacturing and synthesis of **CAFIPLA end products can be added as secondary valorisation modules**. Depending on the available type of biomass, local supply chain actors, ecological, economic and social considerations, most promising value chains can be selected.

CAFIPLA Technology



The CAFIPLA supply chain concept can be defined as a network of shareholders and stakeholders, such as feedstock suppliers, competitors, collection, transportation and service providers, and pilot plant operators as well as authorities from politics and society. The CAFIPLA supply chain is divided into an upstream, midstream/conversion and downstream/products & markets part, which were each analysed within the project regarding key actors, requirements as well as chances and challenges.

Derived from [x]

[13] Horizon 2020 Project (2020-2023) CAFIPLA – Deliverable D4.7 (2022) – Enablers and hindrances for implementation of supply chain concept at IDE pilot plant

CAFIPLA DEMO PLANT AT THE TEST SITE OF IDELUX ENVIRONNEMENT

Derived from [14]

Profile of the test plant for CAFIPLA in Tenneville

- **IDELUX Environnement** is an intermunicipal, public non-profit company in Belgium
- **Household waste management** in the province of Luxembourg with an area of 4,000 km² and 350,000 inhabitants
- Plant: **Anaerobic digestion** (AD) plant with DRANCO reactor
- Treatment of organic municipal solid waste (OMSW; 35,000 t/a) and green waste (25,000 t/a)
- Products:
  - Biogas: 5-6 Mio. Nm³
  - Electricity: 8-10,000,000 kWh/a
  - Heat: 7,500,000 kWh/a
  - Digestate: 25,000 t/a
- Installation and operation of the **CAFIPLA Pilot plant**

Waste treatment site in Tenneville

OMSW treatment in Tenneville

CAFIPLA Pilot plant: LOOP reactor and DSP [15]

[14] Horizon 2020 Project (2020-2023) CAFIPLA – Deliverable D4.6 (2022) – Pilot plant integrated at IDE [Online]
[15] Horizon 2020 Project (2020-2023) CAFIPLA – Deliverable D1.5 (2023) – Final report on the market assessment [Online]

Image source: IDELUX

REQUIREMENTS REGARDING IOMASS SUPPLY AND TECHNICAL FEASIBILITY

Assessing feasibility of a given site for a CAFIPLA pilot and implement the CAP/FRP pre-treatment

Analysis of biomass supply and requirements:

- Screening of theoretical **biomass potential around pilot plant location**
- **Feedstock characterisation** and analysis of biogas and carboxylic acid potential to identify promising biogenic residues as CAFIPLA feedstocks
- Integration of **assessment results with biomass databases** to facilitate identification of promising locations for the implementation of the CAFIPLA process
- Identification of **mobilisable biomass potential** through stakeholder engagement

Integration of combined CAP/FRP process:

- Installing two complementary platforms with different product applications, resulting in **maximal valorisation of biowaste** input streams
- Implementation of a **supply chain concept** for the pilot plant
- Integration of the CAFIPLA pretreatment with AD/composting to ensure complete valorisation
- Analysis of **market players and macro-environmental factors** affecting the transferability of the biomass supply chain concept

TEST SITE ENVIRONMENT OF THE CAFIPLA DEMO PLANT

Characterization of the pilot plant location

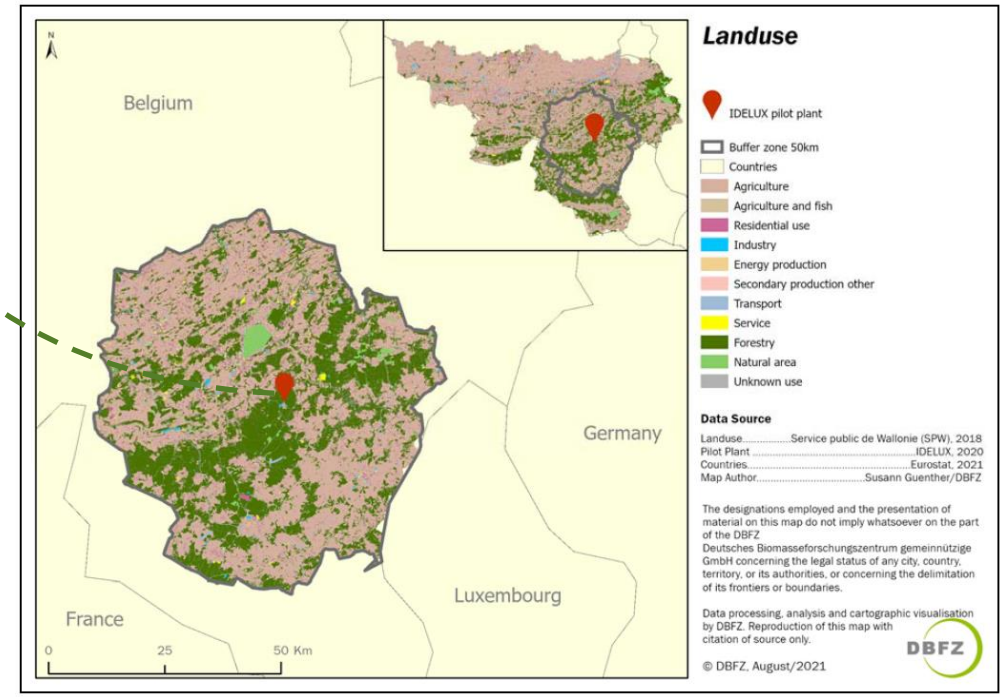
- **Tenneville** in Wallonia, Belgium: population density of 60 persons per square kilometre (rural area)[17]
- **Climate**: humid and temperate; rich vegetation and forest
- **Agriculture**: cereal, meadow and fodder production [18]
- **Land use**: mainly primary biomass, several smaller residential areas with integrated industries
- **Land use change**: low, therefore more continuous output of agricultural by-products
- **Waste collection**: annually about 35,000 t FM of biogenic municipal waste from household collection, schools and kitchens as well as small companies; 20,000t FM of green waste from city amenity sites in the province of Luxembourg and treated at the same plant

FM = Fluid matter

Derived from [16]

Waste treatment site in Tenneville, Belgium

Land use Wallonia [18]



[16] Horizon 2020 Project (2020-2023) CAFIPLA – Deliverable D1.3 (2021) – Assessment report of bio-waste potentials for the IDE pilot plant (Grant agreement ID: 887115)
[17] EUROSTAT (2021)
[18] SPW: Service public de Walloni (2023): Parcellaire agricole anonyme. [Online], accessed online 2021

BIOMASS SCREENING AND PROMISING FEEDSTOCKS FOR THE CAFIPLA PROCESS

Assessment of biomass: Quality and technical/mobilisable quantities

- **Feedstock screening** around the planned location of the pilot plant:
  1. Which feedstocks are applicable?
  2. Is the applicable feedstock available around the pilot plant?
  3. How high is the theoretical biomass potential?
  4. What is the distance to the pilot plant?
- Analysis of **technical biomass potentials** around the pilot side of IDELUX to be used as feedstocks for the CAFIPLA process within a transport distance of 50 km:
  - Industrial residues (1,870t FM/year)
  - Municipal waste residues (50,000t FM/year)
  - Agricultural by-products with (25,000t DM/year)
- Determination of **mobilisable biomass**:
  - Accounting for flows and quantities of industrial residues is time-consuming and elaborate due to the lack of a central monitoring system
  - Many residues are already bound towards a utilisation purpose (oftentimes at a lower value level compared to the CAFIPLA valorisation approach)

FM = Fluid matter

Derived from [16, 17]

Municipal waste residues	Industrial residues from	Agricultural by-products
Biogenic municipal waste	Meat processing	Cereal straw
	Vegetable processing	Maize stover
Green waste	Starch processing	Sugar beet leaves
	Milk processing	Oilseed rape straw
	Brewery	Sunflower straw

Potentially available feedstock for the CAFIPLA process:

- **Residues from food production**, kitchens and canteens are especially interesting as they are free from plastics, toxics and other contamination
- Supply of **biogenic municipal and green waste** secured through collection by IDELUX, currently treated via anaerobic digestion and composting, but several waste strategies ask to bring this waste into higher valorisation

[16] Horizon 2020 Project (2020-2023) CAFIPLA – Deliverable D1.3 (2021) – Assessment report of bio-waste potentials for the IDE pilot plant
[19] Horizon 2020 Project (2016-2020) VOLATILE – CEN Workshop Agreement (2020)

FEEDSTOCK CHARACTERISTION TO QUANTIFY VALORISATION POTENTIAL

OWS Research Foundation

Characterisation of identified CAFIPLA feedstocks: Chemical composition, carboxylic acid potential and biowaste variability

Selectively collected urban biowaste which is treated at the anaerobic digestion and composting plant of IDELUX (IDE biowaste) serves as the main feedstock. Additionally, **industrial and agricultural by-products** (e.g., pastry waste, charcuterie waste, spent grain, brewing waste, wheat bran) within a 50 km radius from the treatment facility were characterised to assess their benefit as co-substrates supplemented in the CAP.

- **Chemical analysis** of feedstocks comprised dry matter content, organic matter content, macronutrient content (N, P, K, Mg, Ca), heavy metals and physical impurities. If applicable, also a screening for organic contaminants (BTEX, AOX, PAH, PCB, dioxins) was performed.
- **Carboxylic acid potential** assessment of IDE biowaste showed production of lactic acid with varying yields depending on temperature and pH and further conversion to VFA (C2-C7) over time. Large effect of temperature on carboxylic acid yield and composition was detected and analysed.
- **Co-fermentation** of IDE biowaste and selected industrial waste streams resulted in improved SCCA yield: Charcuterie and meat waste, pasta waste, waste from wheat processing as well as milk processing waste showed promising results in view of a high carboxylic acid potential, as in the potential to steer the carboxylic acid spectrum when combined with IDELUX biowaste.
- **Seasonal variability** was assessed by analysing samples taken 1-2 times per month at different times throughout the year. Slight differences from month to month were shown to not be linked to seasonal variability but occurred due to **heterogeneity of the biowaste**.

Total amount of available and technically suitable feedstocks and co-substrates was more than sufficient at the IDELUX test site.

VFA = Volatile fatty acid; SCCA = Short-chain carboxylic acid

Derived from [19-21]

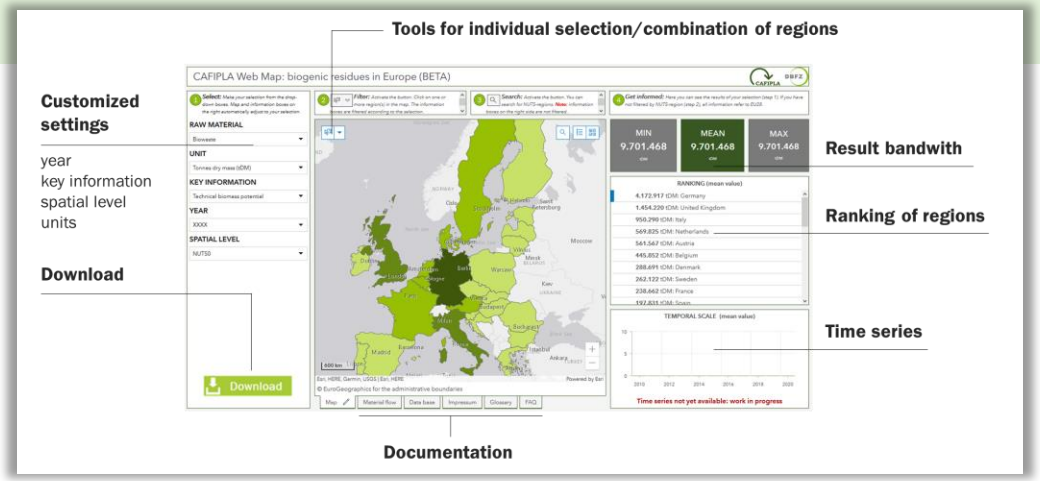
CAFIPLA

[19] Horizon 2020 Project (2016-2020) VOLATILE – CEN Workshop Agreement (2020)
[20] Horizon 2020 Project (2020-2023) CAFIPLA – Deliverable D1.2 (2021) – Initial feedstock characterization report
[21] Horizon 2020 Project (2020-2023) CAFIPLA – Deliverable D1.4 (2022) – Final Feedstock analysis report (incl. seasonal variability)

BIOMASS AVAILABILITY ASSESSMENT VIA NEW DBFZ WEB TOOL

Development of web atlas for biomass potentials within the EU

- **Description**: Dynamic online tool to assess and present information on EU biomass availabilities
- **Content**: Web maps of theoretical biomass potentials of residual and waste materials e.g., urban biowaste, brewery waste, cereal straw…
- **Output**: Biomass potential information can be visualized either for individual biomasses or for freely selected combinations of different biomasses.
- **Application**: Identification and evaluation of hot spot regions for the location of future pre-treatment plants utilising CAFIPLA technology
- **Status**: Currently under development within CAFIPLA; publication at the end of the project with free access (May 2023)
- **Outlook**: Post-project maintenance and continuous updates by DBFZ



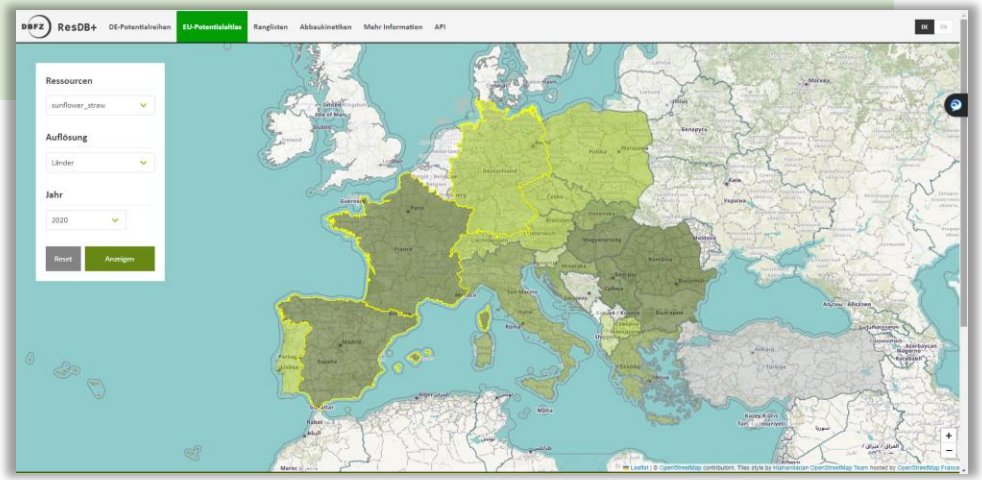


Image source: DBFZ

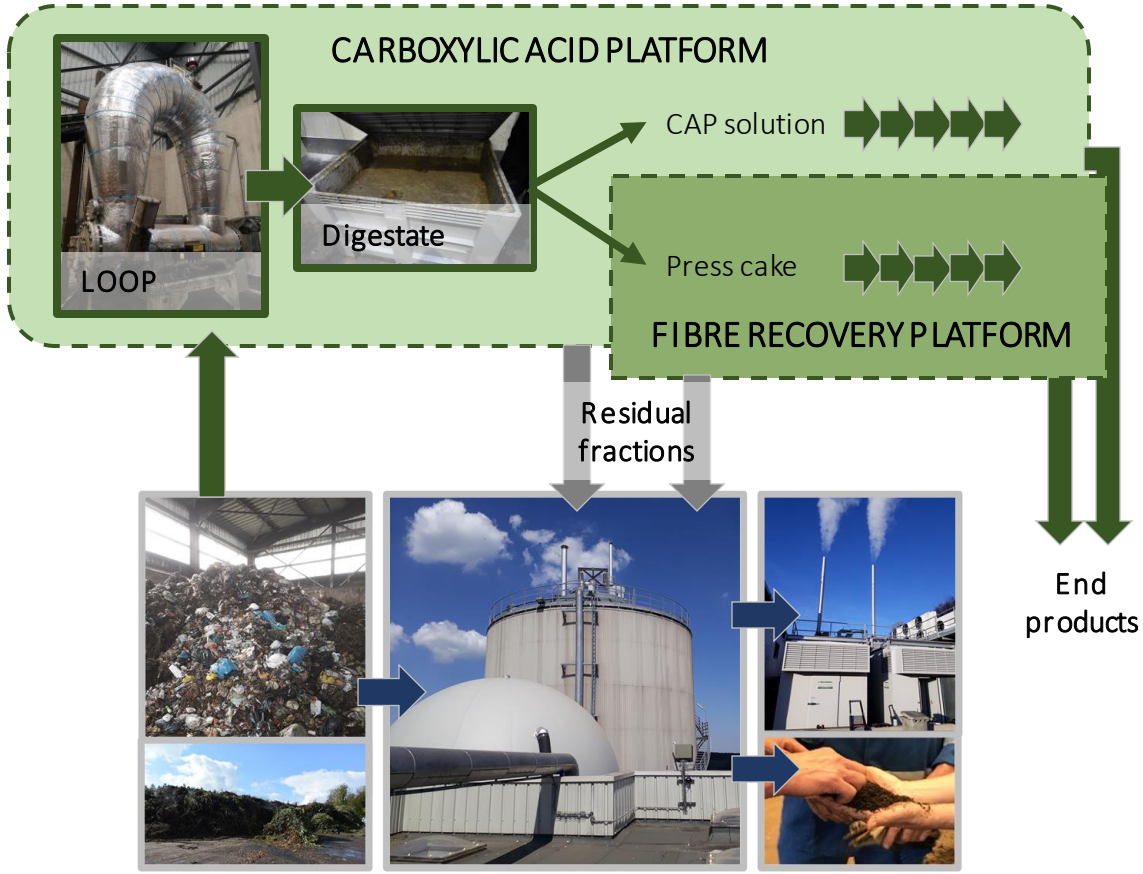
PRETREATMENT VIA CAP AND FRP FOR OPTIMAL VALORISATION

Derived from [14, 22]

[14] Horizon 2020 Project (2020-2023) CAFIPLA – Deliverable D4.6 (2022) – Pilot plant integrated at IDE [Online]
[22] Horizon 2020 Project (2020-2023) CAFIPLA – Deliverable D4.5 (2022 – Pilot plant: final technical design plan

Image source: IDELUX

INTEGRATION OF CAFIPLA PRETREATMENT WITH AD/COMPOSTING



Utilisation of residual fractions from the CAFIPLA pilot process to ensure complete valorisation of the input substrates by combining CAP/FRP with state-of-the-art AD or composting

- Evaluation of the **biogas potential** of the residual streams from the CAFIPLA process via continuous AD digestion tests and comparison with the original IDE biowaste feedstock.
- Analysis showed **maximal biogas potential** for the press cake. The solid fraction after decanting showed high biogas and maximal methane potential.
- CAFIPLA residual streams can consequently be **re-integrated with the existing AD digestion process** without a notable loss of biogas potential while obtaining valuable SCCAs through the CAP.
- Post-composting and sieving of the AD reactor content resulted in the production of **45% of compost** of the total digestate being processed.

Derived from [23]

[23] Horizon 2020 Project (2020-2023) CAFIPLA – Deliverable D6.3 (2023) – Report on the integration of CAFIPLA pretreatment with AD/composting

Image source: IDELUX

CAP: CARBOXYLIC ACID PLATFORM TO VALORISE EASILY DEGRADABLE BIOMASS

SELECTED BIOWASTE

Prior to the CAFIPLA pretreatment, the organic municipal solid waste (OMSW) is shredded, sieved at a size of 60 mm and transported through metal separation. Per week, on average 1.2t OMSW are processed via the LOOP.

LOADING

The LOOP reactor is filled with the pretreated OMSW via the attached conveyer belt leading up to the chimney. Every two days, 350 kg of fresh input material is fed to the LOOP.

LOOP REACTION

The LOOP reactor is a semi-continuous reactor (capacity appr. 2t) and works by displacing biowaste mixture using two screws and silos. Biowaste is added until an overflow is created. Then, precise temperature and pH are established to create the desired SCCA-spectra.

[14] Horizon 2020 Project (2020-2023) CAFIPLA – Deliverable D4.6 (2022) – Pilot plant integrated at IDE [Online]
[22] Horizon 2020 Project (2020-2023) CAFIPLA – Deliverable D4.5 (2022 – Pilot plant: final technical design plan

Image source: IDELUX

CAP: CARBOXYLIC ACID PLATFORM TO VALORISE EASILY DEGRADABLE BIOMASS

DIGESTATE

Every two days, around 350 kg (25% of the total reactor volume) of digestate are extracted from the LOOP. The dry matter content is 25-30% on average. Samples are taken for further tests, such as the analysis of nitrogen contents.

PRESS & DECANTER

The digestate is further processed to separate solid and liquid fractions. After screw pressing, the liquid fraction is decanted to further reduce the amount of biomass and solids and obtain the CAP solution. The dry fractions are further treated via the FRP to recover the fibres.

FILTRATION

To purify the CAP solution, two filtration units are used: First, an ultrafiltration step is performed to remove leftover biomass, solids and macromolecules. Then, the permeate is subjected to a reverse osmosis unit, after which the concentrated SCCA-solution is stored.

PLATFORM PRODUCTS

FIBRE RECOVERY PLATFORM

[14] Horizon 2020 Project (2020-2023) CAFIPLA – Deliverable D4.6 (2022) – Pilot plant integrated at IDE [Online]
[22] Horizon 2020 Project (2020-2023) CAFIPLA – Deliverable D4.5 (2022 – Pilot plant: final technical design plan

Image source: IDELUX

FRP: FIBRE RECOVERY PLATFORM TO VALORISE RECALCITRANT BIOMASS

CARBOXYLIC ACID PLATFORM

GREEN WASTE

The green waste is pretreated for the subsequent fibre recovery process. Due to logistic and practical reasons, it is easier to first shred the green waste prior to shipment. This can be easily performed in any organic waste treatment plant. After this, fibre extraction occurs through (1) drying and milling or (2) the NADES* protocol.

LENZ DRYER: Dry route

The container with shredded green waste is unloaded from the truck and fixed to the LENZ dryer system fed with the heat of the CHP gas motors of the AD plant. The containers are generally left for three to four full days of drying. The dried material is then milled into different sizes to obtain the recovered fibres as platform product.

NADES* protocol: Wet route

The fibre-rich solid fraction obtained from the CAP after screw press will be forwarded to fibre extraction via the NADES protocol. As the process requires the use of bigger amounts of NADES at low pH, a chemical laboratory is needed for safety issues. Therefore, the NADES fibre recovery is implemented at the external part of the pilot at TECNALIA facility. The extraction uses stirred glass reactors for NADES preparation and the recovered fibres are dried and milled in the end of the process.

PLATFORM PRODUCTS

*NADES = Natural deep eutectic solvents

[14] Horizon 2020 Project (2020-2023) CAFIPLA – Deliverable D4.6 (2022) – Pilot plant integrated at IDE [Online]
[22] Horizon 2020 Project (2020-2023) CAFIPLA – Deliverable D4.5 (2022 – Pilot plant: final technical design plan

Image source: Tecnalia, IDELUX

CAFIPLA PLATFORM PRODUCTS

CARBOXYLIC ACID PLATFORM

SCCA CONCENTRATE

After filtration, the **CAP solution with an average concentration of 30 g/L of SCCA** (e.g., acetic acid, propionic acid, butyric acid) is used for the subsequent valorisation steps towards the CAFIPLA end products. To prepare the concentrated SCCA solution to serve as fermentation substrates, a **purification strategy** was developed to remove particles from the CAP solution while maintaining SCCA concentration.
Understanding the **influence of co-substrates** on the anaerobic fermentation processes to produce SCCA enables the prediction of product yields and specific SCCA spectra, which are needed for different subsequent valorisation steps. Optimal **process parameters** (e.g., temperature, pH, residence time and moisture content) for IDELUX biowaste and three co-substrates (milk powder, pasta waste and charcuterie waste) were determined.

Purification of concentrated CAP solution

Microbial protein | Medium-chain carboxylic acids | PHA | Biocomposites

FIBRE RECOVERY PLATFORM

RECOVERED FIBRES

The dry fraction is prepared for further manufacturing into **fibre-based materials or biocomposites**. Fibres are characterized regarding physico-chemical properties:

- Cellulose, hemicellulose, lignin content
- Ash & Moisture content
- Granulometry & Morphology
- Bulk & tapped density
- Thermal properties
- Mechanical properties

Upcycling of green waste to recovered fibres

Based on analysis results about fibre specifications, **potential applications** and markets are derived. Application related specifications such as general aspect (including the aesthetic aspect), the granulometry (fibre length), the moisture content and the morphology of the fibres, as well as the properties specific to the various markets studied served as a basis for **further development and refinement** of dry process fiber extraction routes.

Short fibres | Long fibres

[24] Horizon 2020 Project (2020-2023) CAFIPLA – Deliverable D2.3 (2021) – Influence of process parameters on SCCA spectrum using mixed culture fermentation
[25] Horizon 2020 Project (2020-2023) CAFIPLA – Deliverable D2.4 (2022) – Influence of feedstock composition on SCCA spectrum using mixed culture fermentation
[26] Horizon 2020 Project (2020-2023) CAFIPLA – Deliverable D2.6 (2022) – Report on SCCA downstream processing

Image source: FRD, IDELUX

GUIDELINE FOR A SUCCESSFUL INTEGRATION OF THE CAFIPLA TECHNOLOGY

- Perform a **biomass potential analysis** to quantify suitable feedstocks around the plant location e.g., by employing the biomass potential web atlas.
- Get familiar with the current practices for **biowaste collection** in your region.
- Investigate whether **additional biomass** such as industrial biomass or residues from food production can be **mobilised** given the higher value of CAFIPLA end products.
- **Analyse feedstocks** e.g., regarding their biogas and carboxylic acid production potential.
- Draft your **supply chain concept** based on findings from the biomass potential and feedstock analysis.
- Analyse how the CAFIPLA technology can be **integrated into existing processes** considering current material flows and available equipment to maximise process integration and efficiency.
- Engage with **feedstock suppliers** and **relevant stakeholders** from an early stage on.
- Identify **key market players** and **macro-environmental factors** to ensure transferability of your supply chain concept.
- Identify **potential customers** of your CAFIPLA platform or end products (see SECTION 3, [27, 15]).
- **Prioritise** which end products are most relevant given the identified customers.
- Analyse how **residual process streams** can be valorised by AD or composting to ensure complete valorisation of your feedstocks and **close all material loops**.

CAFIPLA technology

TRL5 pilot process integrating CAP and FRP to produce carboxylic acids and recovered fibres from organic waste

Economic potential

New biowaste-based value added product portfolio with high market potentials in diverse application fields

[27] Horizon 2020 Project (2020-2023) CAFIPLA – Deliverable D1.1 (2021) – Report on the initial market assessment [Online]
[15] Horizon 2020 Project (2020-2023) CAFIPLA – Deliverable D1.5 (2023) – Final report on the market assessment [Online]

CAFIPLA

SECTION 3
Economic Potential of the CAFIPLA-Based Value Chains in the Bioeconomy

This project has received funding from the Bio-based Industries Joint Undertaking (JU) under the European Union's Horizon 2020 research and innovation programme under grant agreement No 887115. The JU receives support from the European Union's Horizon 2020 research and innovation programme and the Bio-based Industries Consortium.

Bio·based Industries Consortium

Horizon 2020 European Union Funding for Research & Innovation

BBI JU

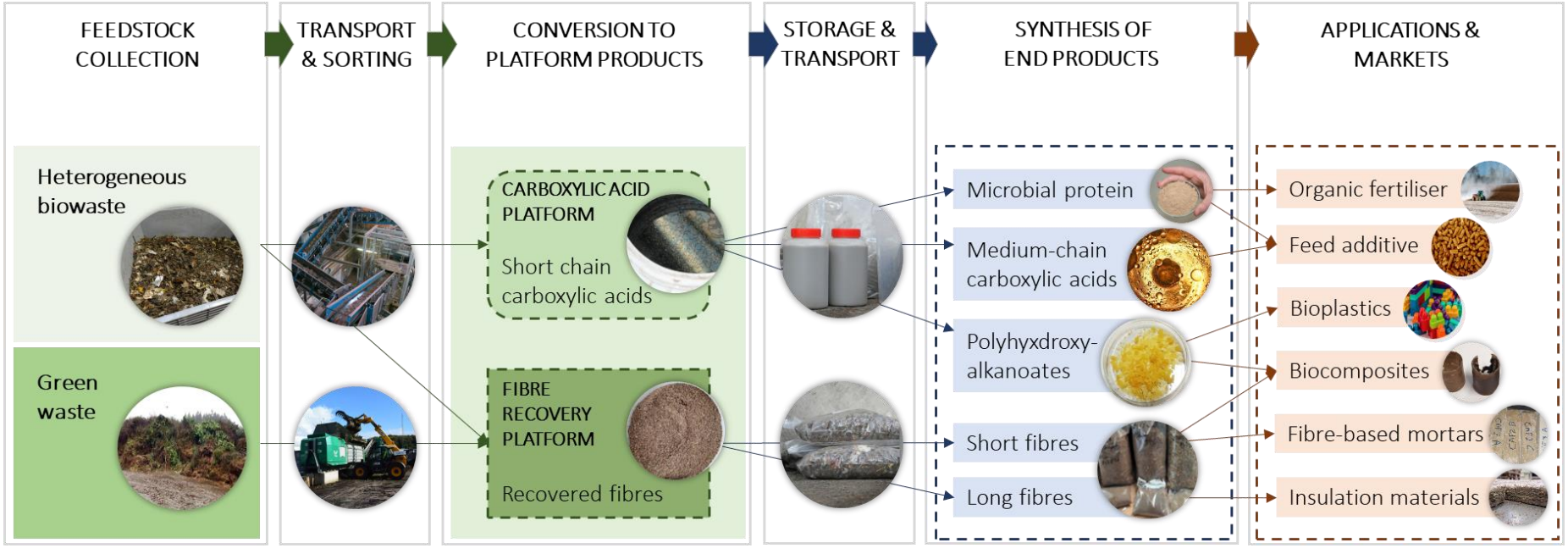
CAFIPLA TURNS BIOWASTE INTO VALUABLE PLATFORM PRODUCTS AND DIVERSE END PRODUCTS

The CAFIPLA value chains start from abundantly available but currently undervalorised **heterogenous biowaste and green waste**.

Via an innovative, cost effective and sustainable pretreatment process, biowaste and green waste are converted **into two platform products**:

- Short-chain carboxylic acids (SCCA) via the Carboxylic acid platform (CAP)
- Recovery of fibres via the Fibre recovery platform (FRP)

In a second valorisation step, the platform products are converted into a broad range of **valuable bio-based end products**.



⇨ CAFIPLA-derived biowaste-based end products target diverse **high-value applications and growing markets**.

Image source: Pixabay, AdobeStock, Avecom, Biotrend, FRD, IDELUX

CAFIPLA END PRODUCTS AND APPLICATIONS HAVE HIGH MARKET POTENTIAL

CAFIPLA

PRESS Release No.2

27TH OF AUGUST 2021

MARKET ANALYSIS DEMONSTRATES: BIO-BASED PRODUCTS FROM MIXED BIOWASTE ARE PROFITABLE

The market analysis conducted as part of the BBI-funded CAFIPLA project, which is developing a new technology for obtaining biobased chemicals and products from biowaste, shows high potential for four customized biobased products in the initial economic assessment.

Source: IDELUX

The market assessment included consideration of CAFIPLA processes and four potential future products. CAFIPLA target products include polyhydroxyalkanoates (PHA), which can be used as biobased and biodegradable plastics or bio composites. Medium chain carboxylic acids (MCCA) in the form of MCCA bio-oil can be used as antimicrobial feed additives. Further, microbial proteins considered in CAFIPLA offer good possibilities as slow-release fertilizers or food and feed additives. Reinforced natural fibres have high environmental benefits and are relevant for the insulation and construction market segments.

Main findings of the initial market assessment for CAFIPLA end products

- The CAFIPLA technology represents an attractive utilisation option for biowaste, especially for biogas plant operators.
- Current and future technical as well as societal developments will push the use of such technologies.
- The market attractiveness of the products will benefit from changing framework conditions (e.g., increased awareness of environmental and health issues, legal framework, etc.)
- All identified target markets will grow in the near future.
- The technologies developed and the use of widely available, very cost-effective feedstocks will lead to competitive product prices, which also promotes the future market permeation.

⇨ See CAFIPLA Deliverable D1.1 – Report on the initial market assessment of CAFIPLA as biowaste valorisation strategy and pre-treatment to feed the bio-economy with CAP/FRP-based bioproducts.[27]

CAFIPLA end products	Suggested applications
Polyhydroxyalkanoates (PHA)	Biodegradable and bio-based plastics, bio-composite
Bio oil of medium chain carboxylic acids (MCCA), caproic acid (C6)	Antimicrobial feed additive, bulk chemical
Microbial protein (MP)	Slow-release fertiliser, food additive
Fibres	Wood-plastic composite, insulation material

[27] Horizon 2020 Project (2020-2023) CAFIPLA – Deliverable D1.1 (2021) – Report on the initial market assessment [Online]

CAFIPLA OFFERS HIGHER VALUE COMPARED TO EXISTING VALORISATION APPROACHES

DECHEMA
Gesellschaft für Chemische Technik und Biotechnologie e.V.

CAFIPLA

PRESS Release No.7

8 FEBRUARY 2023

FINAL MARKET REPORT HIGHLIGHTS THE ROLE OF BIOWASTE AS ESSENTIAL RESOURCE FOR A GROWING CIRULAR BIO-BASED ECONOMY

The market assessment details the high relevance and impact of biowaste-derived materials in an expanding bioeconomy and demonstrates how novel value chains and markets are created from biowaste by the CAFIPLA project. The CAFIPLA technology presents a radically new approach to biowaste pretreatment via two integrated platforms to achieve maximum valorisation into bioproducts and consequent creation of new bioeconomic value chains.

Current climate scenarios risk an over reliance on biomass which results in a predicted biomass gap of 40-70% by 2050. In an expanding bioeconomy, demand, and competition for biomass as a feedstock will increase, making the efficient utilisation of biowaste, an abundant but currently underused resource, become increasingly important. The European Commission assesses in their recent Bioeconomy Strategy Progress Report how their currently ongoing pilot actions are focused on developing urban circular bioeconomy concepts *"[...] for the production of safe, sustainable and valuable bio-based products from urban biowaste and wastewater."*

⇨ See CAFIPLA Deliverable D1.5 – Final report on the market assessment of CAP/FRP based bioproducts and CAFIPLA as technology in the bio-economy expansion and CAFIPLA as technology in the bioeconomy expansion.[15]

Main findings of the final market report for the CAFIPLA technology

- CAFIPLA end-products exhibit considerable advantages compared to competing products:
  - **PHA** derived from the CAFIPLA technology exhibits enhanced mechanical properties and improved processability.
  - **PHA and fibres** obtained from the CAFIPLA process can be combined to yield biocomposites with tailor-made properties.
  - **Caproic acid** (CA) obtained via a lactic acid chain elongation route results in below-average market prices and offers an environmentally-friendly replacement of CA made from palm kernel oil (e.g., advantages regarding land use, GHG emissions)
  - **Microbial protein** can be produced at reduced production costs and with tailored MP-composition (e.g., protein content and amino acid profile) complies with specific regulations needed for usage as feed-additive or fertiliser.
  - **Fibres** recovered from biowaste offer an environmentally friendly and sustainable alternative for a wide range of fibre applications with growing markets and have significant penetration rates in the fields of plastics (10% market share), insulation (9%) or concrete (0.5%).
- The CAFIPLA technology offers a more economic alternative to existing valorisation approaches of heterogenous biowaste e.g., by generating end products with 3 - 15 times higher value per ton of input material compared to regular anaerobic digestion plants.

CAFIPLA

[15] Horizon 2020 Project (2020-2023) CAFIPLA – Deliverable D1.5 (2023) – Final report on the market assessment [Online]

PORTFOLIO OF CAFIPLA END PRODUCT ALLOWS TARGETED VALORISATION

MICROBIAL PROTEIN

- Short-chain carboxylic acids (SCCAs) from the Carboxylic acid platform (CAP) are converted into Microbial protein (MP)
- The three-step process from SCCA to MP powder includes (1) Fermentation of SCCAs into microbial protein, (2) Dewatering of liquid microbial protein by centrifugation, (3) Drying of microbial protein paste
- Microbial protein is obtained as powder with a high protein content of more than 60% protein/TSS*

MARKET APPLICATIONS

- Food additive
- Feed additive
- Slow-release fertiliser

Microbial protein powder

Detailed information and analyses of the MP markets, including e.g. volumes, projected growth and product prices for potential applications can be found in the CAFIPLA Initial Market Report [27].

*TSS = total suspended solids

CAPROIC ACID & BIO OILS

- Lactic acid derived from the Carboxylic acid platform (CAP) is further converted to Caproic acid and medium-chain carboxylic acids (MCCAs) via a dedicated microbial chain elongation process
- Efficient and continuous production in an optimised bioreactor configuration with selective *in situ* product recovery
- High product selectivities of > 90% are achieved for chain elongation intermediates

MARKET APPLICATION

- Bulk chemical
- Energy sector e. g. biofuel
- Antimicrobial feed additive
- Bio-plasticizer

Granular biomass

MCCA bio-oil

Detailed information and analyses of the Caproic acid market, including e.g. global market volume, projected growth, product prices and productions volumes can be found in the CAFIPLA Initial Market Report [27].

[27] Horizon 2020 Project (2020-2023) CAFIPLA – Deliverable D1.1 (2021) – Report on the initial market assessment [Online]

Image source: Pixabay, Avecom, Ghent University

PORTFOLIO OF CAFIPLA END PRODUCT ALLOWS TARGETED VALORISATION

POLYHYDROXYALKANOTES (PHAs)

- Based on CAFIPLA SCCAs, PHA biopolymers with 50-55% PHA content were produced as solid powder, crystal or can be casted to obtain especially thin and transparent films e.g., for packaging applications
- Material properties of PHA biopolymers were characterized e.g., melting temperature, tensile strength, elongation at break, young modules
- Using mixed carboxylic acids in the single-strain fermentation processes enables enhanced mechanical properties and improved processability of the resulting PHAs

Extracted PHBV

Transparent biofilms

MARKET APPLICATIONS

- Biodegradedable biobased plastics
- Biocomposites

Detailed information and analyses of the PHA and biopolymer markets, including e.g., market and production volumes, projected growth and product prices can be found in the CAFIPLA Initial Market Report [27].

BIOCOMPOSITES

- Biocomposites produced from short fibres (with a µm-mm scale) obtained from green waste via the Fibre recovery platform (FRP) and PHB
- Tailored properties by adaptation of fibre/PHB content
- Glycerol used as plasticiser

MARKET APPLICATIONS

- Domestic Sector
- Building materials
- Automotive industry

Composites of CAFIPLA short fibres & industrial PHB

Detailed information and analyses of the Biocomposites market, including e.g., global market volume and projected growth and potential applications can be found in the CAFIPLA Initial Market Report [27].

[27] Horizon 2020 Project (2020-2023) CAFIPLA – Deliverable D1.1 (2021) – Report on the initial market assessment [Online]

Image source: Biotrend, FRD, Tecnalia

PORTFOLIO OF CAFIPLA END PRODUCT ALLOWS TARGETED VALORISATION

SHORT FIBRES FOR MORTAR

- Mortar was made with short fibres (with a µm-cm scale) and other selected raw materials
- Material properties of mortar was characterised e.g., bending resistance, compression resistance and density
- The mechanical properties are equivalent to comparable commercial products
- CAFIPLA can provide not only an alternative low-price and resource-saving source for fibres but will rather enhance the quality of incoming raw materials by improvement of bio-waste characterization methods.

MARKET APPLICATIONS

- Mortars
- Tile adhesives
- Cement

Ground fibres for mortar production

Fibre-based mortar

Detailed information and analyses of Natural fibres and fibre-based materials markets, including e.g., market and production volumes, projected growth and product prices can be found in the CAFIPLA Initial Market Report [27].

LONG FIBRES FOR INSULATION MATERIALS

- Insulation materials made with long fibres (with a mm-cm scale) as well as other selected raw materials
- Material properties of insulation panels were characterised e.g., density and thermal conductivity
- Thermal conductivity was found to be close to commercial products

MARKET APPLICATIONS

- Housing
- Indoor construction
- Outdoor construction

Insulation panels made with green waste (left) and paper waste (right)

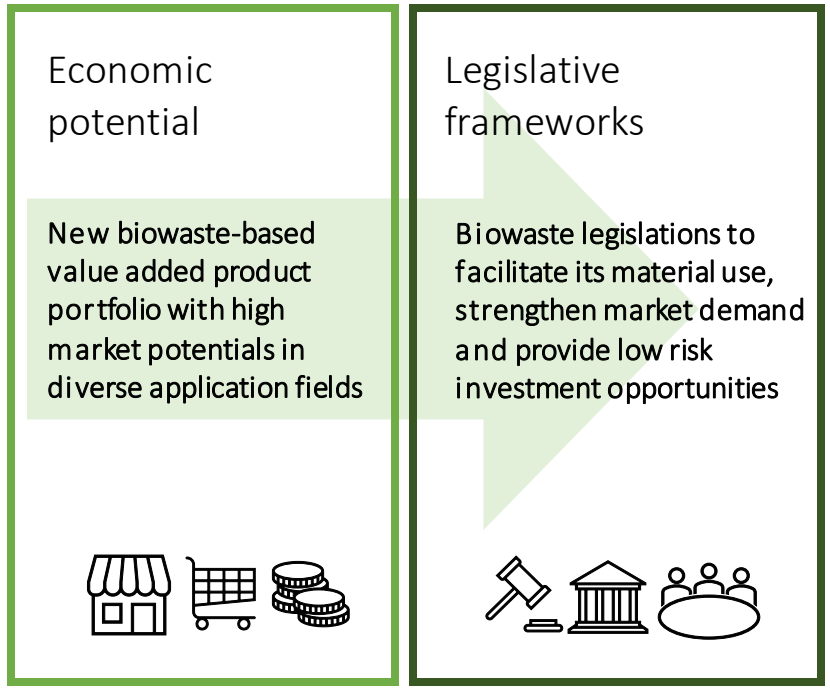
Detailed information and analyses of fibres and the thermal insulation markets, including e.g., market and production volumes as well as projected growth can be found in the CAFIPLA Initial Market Report [27].

[27] Horizon 2020 Project (2020-2023) CAFIPLA – Deliverable D1.1 (2021) – Report on the initial market assessment [Online]

Image source: FRD

ADDED VALUE OF THE CAFIPLA END PRODUCT PORTFOLIO

- The two CAFIPLA platform products **short chain carboxylic acids** and **recovered fibers** give a flexibility towards the selection of end products that **meet current needs of markets and customers**.
- CAFIPLA end products can be applied in a **broad range** of markets and applications and **fine-tuned** given specific market needs e.g., by adapting polymer contents or fibre sizes.
- All identified end product markets are predicted to **expand in the near future** [27].
- Besides economic aspects, **social, environmental and legal aspects** will accelerate the market demand of biowaste-based products [15, 27].
- CAFIPLA end products exhibit **considerable advantages** compared to competing products with regards to material property, environmental sustainability, costs and adaptability [15].
- The CAFIPLA product portfolio is **growing continuously** and demonstrates **real-life use cases**, e.g., for housing, construction and sustainable materials.



[27] Horizon 2020 Project (2020-2023) CAFIPLA – Deliverable D1.1 (2021) – Report on the initial market assessment [Online]
[15] Horizon 2020 Project (2020-2023) CAFIPLA – Deliverable D1.5 (2023) – Final report on the market assessment [Online]

CAFIPLA

SECTION 4
Chances and Challenges Along the CAFIPLA Value Chain

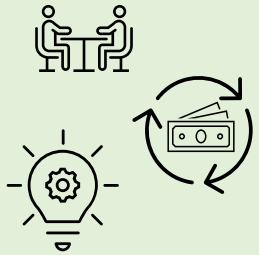
This project has received funding from the Bio-based Industries Joint Undertaking (JU) under the European Union's Horizon 2020 research and innovation programme under grant agreement No 887115. The JU receives support from the European Union's Horizon 2020 research and innovation programme and the Bio-based Industries Consortium.

Bio-based Industries Consortium

Horizon 2020 European Union Funding for Research & Innovation

BBI JU

BENEFITS OF THE CAFIPLA CONCEPT AND SUPPLY CHAIN ON REGIONAL AND EU BIOECONOMY



- Regional **economic and social development** e.g., job creation and capacity building, through new businesses and applications for biowaste-based products
- Complete value chains **strengthen the EU bioeconomy** and increase economic autonomy
- Improving **economic flexibility and robustness** through cross-sector linking of energy production and biobased product synthesis

THE CAFIPLA VALUE CHAIN

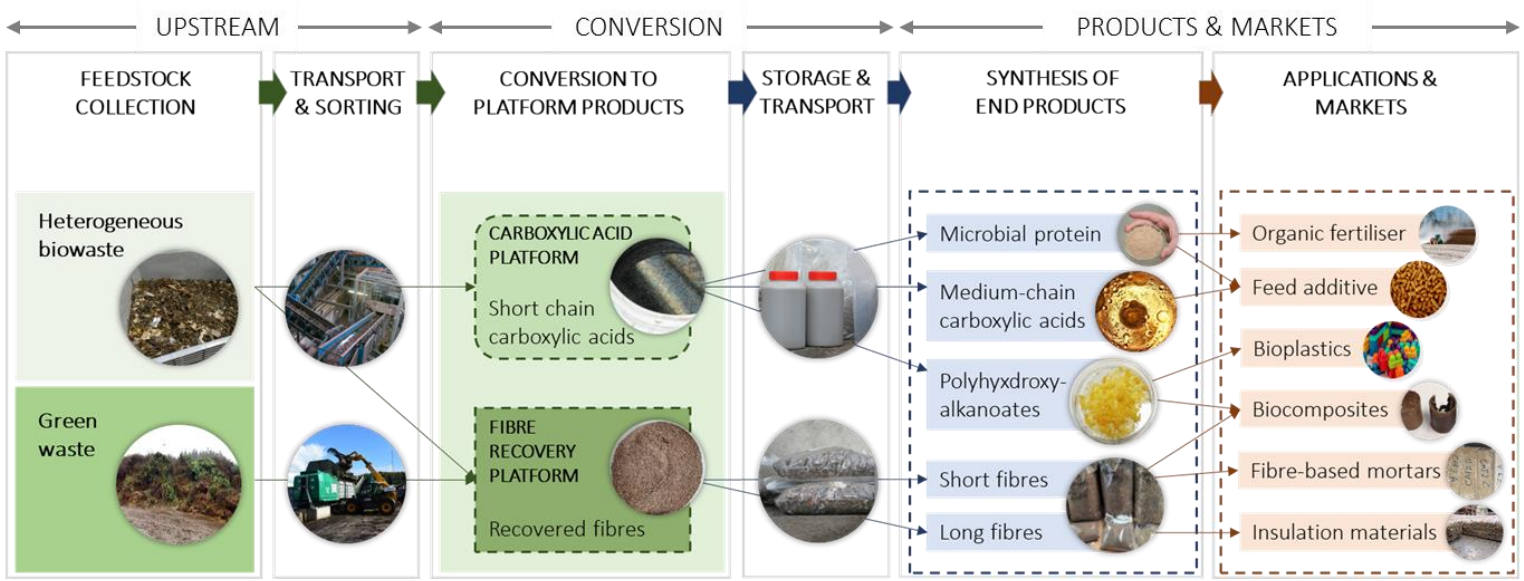
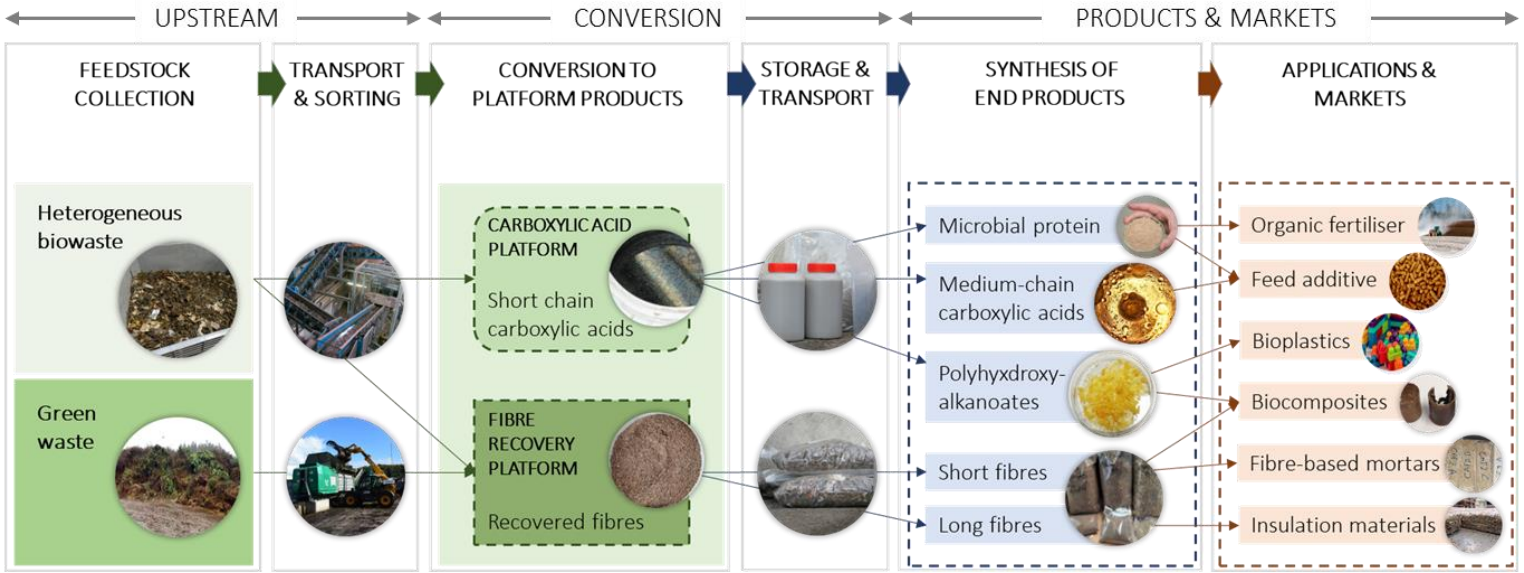


Image source: Pixabay, AdobeStock, Avecom, Biotrend, FRD, IDELUX

ANALYSIS OF CHANCES AND CHALLENGES ALONG THE CAFIPLA VALUE CHAIN



ANALYSIS OF ENABLERS AND HINDRANCES ALONG THE CAFIPLA VALUE CHAIN

Image source: Pixabay, AdobeStock, Avecom, Biotrend, FRD, IDELUX

INFLUENCE FACTORS ON CAFIPLA FEEDSTOCK SUPPLY AND COLLECTION

Derived from [28]

ENABLERS

- ✓ High availability and low costs of feedstocks (in the near future) in certain suitable regions ("CAFIPLA hot spots")
- ✓ EU and regional legislations on material and cascade utilisation of bioresources, limitations of landfill strengthen the relevance of the CAFIPLA technology
- ✓ Upcoming harmonisation of waste collection and sorting policies will improve structures e.g., in Belgium in 2025
- ✓ Innovations will improve pretreatment, collection and sorting systems and thus quality of waste streams
- ✓ Transportation costs of waste may be reduced/reimbursed through higher valorisation e.g., producers of organic residues (i.e. food industry) deliver straight to the plant to maintain purity and value of residues
- ✓ Establishing new local bioeconomic supply chains
- ✓ Contracts and approvals for industrial urban and agricultural biowaste are negotiated locally for the pilot project with low administrative thresholds

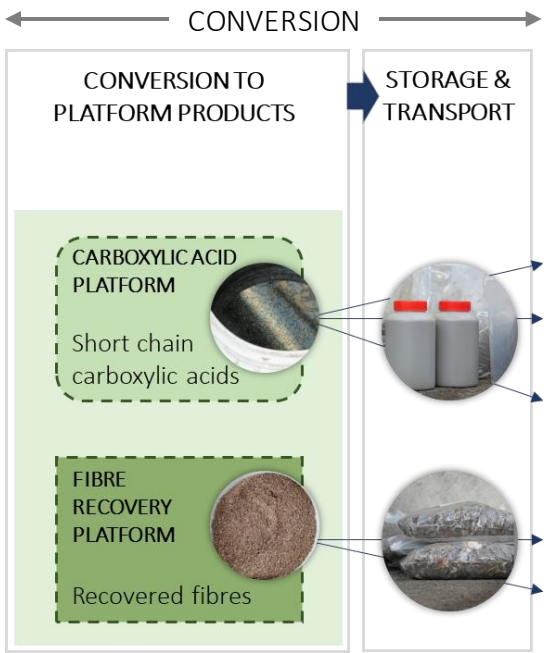
HINDRANCES

- x Quantity of mobilisable regional biowaste varies, green waste underlies seasonal fluctuations, long-term feedstock availability is uncertain, and costs may increase
- x Quality of organic residues highly varies and can be insufficient e.g., due to contaminants in household waste
- x Impurities or even toxic residues could have serious consequences for the direct use of derived products and must be excluded prior
- x Organic materials have a short shelf life/undergo degradation, which poses a challenge to feedstock stability
- x Missing EU legislation for green waste reuse
- x Logistic systems (transportation & storage infrastructure) must be implemented locally and cause investment costs
- x Regional differences in implementation of EU guidelines for waste disposal complicates "one-fits-all" solutions
- x Potential competition for feedstocks with the biomethane industry, especially in times of increased energy demand
- x Uncertainty about market prices for organic waste e.g., by-products and other residues

[28] Horizon 2020 Project (2020-2023) CAFIPLA – Deliverable D4.3 (2022) – Report on the transferability of the supply chain concept

INFLUENCE FACTORS ON IMPLEMENTATION OF THE CAFIPLA PROCESS

Derived from [28]



ENABLERS

- ✓ Production costs for biobased products can be reduced by using low-cost waste streams as input material, if the process is simple and the cost-benefit ratio is positive.
- ✓ Actual CAFIPLA TRL already "higher" than 5
- ✓ EU financial incentives e.g., the emission trading system (ETS) or the CO_2 price, push larger industries to re-orient towards climate-friendly technologies.
- ✓ CAFIPLA fits into the upcoming vision of industrial ecology: The technology helps to lower CO_2 emissions of biogas plants and energy requirements can be self-sustained
- ✓ New valorisation perspectives for established biogas plants to stay competitive
- ✓ Currently increasing energy and gas price might drive the energetic use of biomass, but this might be also offering new integration points for CAFIPLA
- ✓ Upcoming policy framework planned on biobased, biodegradable and compostable plastics will prioritise material use and push demand for biobased precursors

HINDRANCES

- x EU legislation for biowaste is outdated as it currently refers to one general definition of biowaste which hinders the market uptake of biowaste-derived products
- x Common (ISO) standards for fossil-based production oftentimes do not make sense for heterogeneous, versatile biowaste & bioproducts
- x Currently, still low TRL of CAFIPLA (pilot scale/TRL 5) and need for upscaling to TRL 8-9
- x High costs of CAPEX and OPEX and unknown installation costs
- x Technology readiness for fatty acids is still low, achieving sufficient amounts and concentration could be challenging
- x Market price stability is needed to make CAFIPLA a safer and low risk investment opportunity

[28] Horizon 2020 Project (2020-2023) CAFIPLA – Deliverable D4.3 (2022) – Report on the transferability of the supply chain concept

INFLUENCE FACTORS ON THE ECONOMIC SUCCESS OF THE CAFIPLA PRODUCTS

Derived from [28]

ENABLERS

- ✓ Flexible CAFIPLA technology can adapt to local industry landscape and market needs
- ✓ Conventional biogas plants might not be subsidised which opens opportunities for new biogas concepts and technologies
- ✓ CAFIPLA as integrated concept includes biogas as a side product
- ✓ Valuable "green" certified products
- ✓ Increasing demand for organic fertilisers
- ✓ Other biobased technologies for C6 use palm oil, but currently small market for C6, C8, C10 and higher prices
- ✓ Biobased fatty acids market is growing (certification needed)
- ✓ Current debate on EU level regarding quota for waste-based materials advanced CAFIPLA products

HINDRANCES

- x Low acid concentration of SCCA solution must be improved to provide a more attractive platform product
- x Product quality could be an issue; contamination e.g., with pesticides or bacteria, must be excluded to guarantee product safety
- x Market entry might be challenging as some markets are not yet existing
- x Social acceptance of waste-based products must be improved
- x Legislation on applying biowaste-derived products for medical and food purposes e.g., EFSA permits needed

SCCA = Short-chain carboxylic acids
EFSA = European Food Safety Authority

[28] Horizon 2020 Project (2020-2023) CAFIPLA – Deliverable D4.3 (2022) – Report on the transferability of the supply chain concept

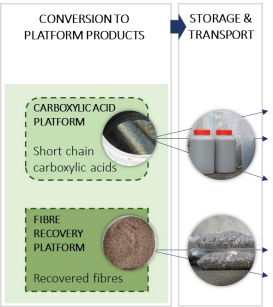
STRATEGIES SUPPORTING THE FASTER IMPLEMENTATION OF THE CAFIPLA TECHNOLOGY

Derived from [28]

UPSTREAM

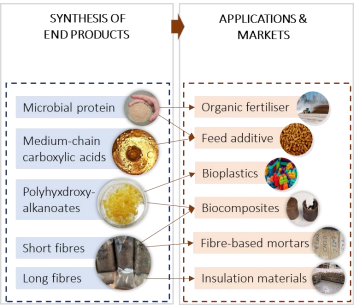
- ⇨ Estimate regional **feedstock availability** in the long-term
- ⇨ Specify **taxonomy** e.g., new categories at SPW in Belgium
- ⇨ Develop optimised **logistic and sorting concepts** for biowaste
- ⇨ Create regional smart biowaste applications/new **business models**
- ⇨ Develop concepts together with the **bioenergy sector**
- ⇨ Establish project platforms to **transfer knowledge** from pilot project experiences

CONVERSION



- ⇨ Improve **pretreatment and purification** processes
- ⇨ Combine with **renewable energy** sources
- ⇨ Increase credibility of technology by **patent and green label**
- ⇨ Perform **cost-benefit analyses** of the technology at different scales and products

PRODUCTS & MARKETS



- ⇨ Promote CAFIPLA with focus on its **diverse product portfolio**
- ⇨ Create additional **financial incentive for biowaste products**
- ⇨ Conduct further **market-oriented feasibility studies** e.g., market opportunities for C6/8/10
- ⇨ Involve **partners from the chemical and food industries** in follow-up projects
- ⇨ Form or join association to **connect partners along the value chain**
- ⇨ Contact **investors sooner** regardless of lower TRL instead of waiting until TRL 8/9

[28] Horizon 2020 Project (2020-2023) CAFIPLA – Deliverable D4.3 (2022) – Report on the transferability of the supply chain concept

ANALYSIS OF CHANCES AND CHALLENGES BEYOND THE CAFIPLA VALUE CHAIN

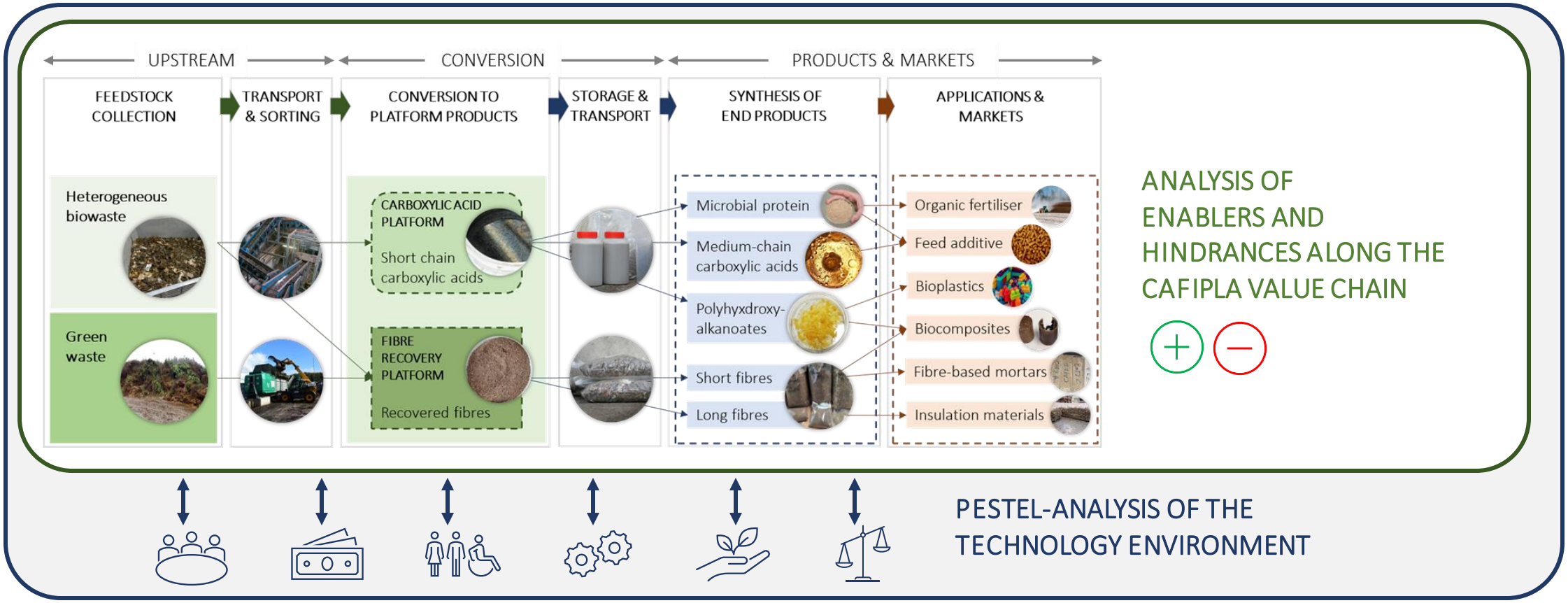


Image source: Pixabay, AdobeStock, Avecom, Biotrend, FRD, IDELUX

PESTEL: POLITICAL FACTORS

Derived from [13, 29]

DBFZ DECHEMA Gesellschaft für Chemische Technik und Biotechnologie e.V.

ENABLERS

- ✓ **Landfill directive** EU 2018/850 and **Waste Framework Directive** (WFD) EU 2018/851 support the increase of reuse and recycling of wastes including quotas for municipal waste recycling (e.g., 55% by 2025) and demand separate biowaste collection for 2023. End-of-waste criteria are described to encourage recycling, including composting and digestion of biowaste and promoting materials produced from biowaste
- ✓ Policy framework planned on **biobased, biodegradable and compostable plastics** [30]
- ✓ Proposal of a regulatory EU framework for the certification of carbon removal [31]
- ✓ Future amendments of **REDII** EU 2018/2001 and initiatives for a **REMD** (Renewable Energy and Material Directive) may facilitate to prioritise material over energetic use [32, 33]

HINDRANCES

- x **EU guidelines for waste disposal and treatment** not implemented uniformly across EU yet: E.g., conflict of WFD with RED as current subsidies make conventional AD plants more cost-efficient compared to additional material recycling of organic waste
- x Waste management often **regulated on local level;** personal interests and lobby groups can interfere with establishing novel biowaste-based value chains
- x Heterogeneous and versatile biowaste and biobased products **not considered in common (ISO) standards**
- x Applications of **biowaste products for medical and food purposes** will have to pass high hurdles and standards
- x **Competing sectors** (e.g., fossil-based industry, bioenergy, waste ignition) prevent large scale market uptake of products and processes from recycled bio-waste

WFD = Waste Framework Directive

[13] Horizon 2020 Project (2020-2023) CAFIPLA – Deliverable D4.7 (2022) – Enablers and hindrances for implementation of supply chain concept at IDE pilot plant
[29] Siegfried et al. (2023) Boosting biowaste valorisation by modifying European law for end of waste
[30] European Commission (2022) [Online]; [31] European Commission (2021) Communication on Sustainable Carbon Cycles [Online]
[32] Directorate-General for Environment (2022) [Online] – accessed 29.03.2023; [33] Proposal for a Directive amending Directive 2003/87/EC

PESTEL: ECONOMIC FACTORS

Derived from [13, 28, 29]

ENABLERS

- ✓ Production costs for biobased products could be largely reduced by using waste streams for feedstock supply
- ✓ EU emission trading system (EU ETS) and high CO_2 price can stimulate waste disposal companies, large chemical industries and (bio)refineries to invest in sustainable climate friendly technologies. EU support of recycling of residues and wastes together with rising demand of the chemical industry for biobased building blocks requires new technologies to extract and provide chemicals from organic wastes
- ✓ Demand for sustainable palm oil replacement could support market uptake of biowaste-derived alternatives
- ✓ Involving key actors of the waste supply chain takes advantage of their expertise and infrastructure (e.g., transportation network, storage facilities, waste handling) and ensures the functionality of the value chain
- ✓ The rising demand for bioenergy can be strategically used to establish supply chains that allow utilisation of biowaste for both, biogas production and bioproduct formation.

HINDRANCES

- x Biobased products or feedstocks have to meet the same characteristics as their fossil-based counterparts in order to work as drop-in-solutions for established processes and technologies. Investing in new or adapting existing processes and manufacturing lines entails high costs and efforts
- x Purchase of available feedstocks of suitable quality and composition could lead to higher prices of some biobased products which reduces the competitiveness against conventional alternatives
- x Missing concepts for an industrial-sized production site. Pilot plant trials should lay the base to calculate process parameters for larger scale operation, cost-benefit for the CAFIPLA technology as well as investment cost and other expenses (OPEX, CAPEX)
- x Upstream value chain must be local with short transportation distances due to high-water contents (weight) of municipal waste.
- x Chemicals originating from waste targeting food and feed markets will face strict regulations

[13] Horizon 2020 Project (2020-2023) CAFIPLA – Deliverable D4.7 (2022) – Enablers and hindrances for implementation of supply chain concept at IDE pilot plant
[28] Horizon 2020 Project (2020-2023) CAFIPLA – Deliverable D4.3 (2022) – Report on the transferability of the supply chain concept
[29] Siegfried et al. (2023) Boosting biowaste valorisation by modifying European law for end of waste

PESTEL: SOCIAL FACTORS

Derived from [13, 28, 29]

ENABLERS

- ✓ Current high demand and trend for 100% biobased products which are e.g., environmental-friendly, climate-neutral and reduce dependence on external resources
- ✓ Labels and marketing indicating the environmental benefits of recycling organic wastes and using local resources support social acceptance by creating better awareness and a community sense
- ✓ Collection efficiency and quality of separation can be controlled by introduction of financial incentives (e.g., fees for mixed waste/no fees for separated wastes)
- ✓ Local circular supply chains strengthen the region through a growing innovative economy, save financial means of citizens and the community, create jobs and higher incomes

HINDRANCES

- x Social acceptance plays a big part in market development and Public perception of waste-based products is still rather negative, waste-based products are still not accepted by a large number of customers.

[13] Horizon 2020 Project (2020-2023) CAFIPLA – Deliverable D4.7 (2022) – Enablers and hindrances for implementation of supply chain concept at IDE pilot plant
[28] Horizon 2020 Project (2020-2023) CAFIPLA – Deliverable D4.3 (2022) – Report on the transferability of the supply chain concept
[29] Siegfried et al. (2023) Boosting biowaste valorisation by modifying European law for end of waste

PESTEL: TECHNOLOGICAL FACTORS

Derived from [13, 28, 29]

ENABLERS

- ✓ Promising results and growing number of technologies developing in the field lead to competition and acceleration of research & development progress
- ✓ Organic fraction of municipal waste represents one of the most challenging waste streams to be used as feedstock, due to its heterogeneous and varying quality and yearly fluctuation. Therefore, successful concepts will be a big step forward in the reuse of biowaste.
- ✓ Collection of specific wastes directly from the waste producers (e.g., food industry) and delivered to the conversion plant helps to avoid mixing of organic wastes with contaminants e.g., metal, glass and plastic wastes
- ✓ Flexibility to develop tailored valorisation routes depending on feedstock availability and composition as well as local economy: E.g., fertiliser is highly needed in areas with intensive agriculture, whereas not necessarily in urban areas

HINDRANCES

- x Heterogeneity of feedstocks could compromise product quality and create challenges in industrial processing to high value bioproducts
- x Waste pretreatment and sorting systems can be adjusted to new innovative technologies and processes, but current legislation is preventing fast change of existing systems because the adaption processes of existing regulations are slow.
- x Pretreatment processes could lead to higher energy and material demand and oppose environmental and financial benefits..
- x Investment and further research in upscaling activities not clearly supported by political framework. Large scale investments hindered by missing long-term regulations and standardisation guidelines
- x Competition of industries for biowaste, e.g. for energy production

[13] Horizon 2020 Project (2020-2023) CAFIPLA – Deliverable D4.7 (2022) – Enablers and hindrances for implementation of supply chain concept at IDE pilot plant
[28] Horizon 2020 Project (2020-2023) CAFIPLA – Deliverable D4.3 (2022) – Report on the transferability of the supply chain concept
[29] Siegfried et al. (2023) Boosting biowaste valorisation by modifying European law for end of waste

PESTEL: ECOLOGICAL FACTORS

Derived from [13, 28, 29]

DBFZ DECHEMA Gesellschaft für Chemische Technik und Biotechnologie e.V.

ENABLERS

- ✓ Creation of local supply chains reduces carbon emissions and dependencies on imports (sustainability, low carbon footprint)
- ✓ Replacement of fossil materials and products with biobased materials is key to mitigate climate change and stop the use of oil and gas
- ✓ Linking the Carboxylic acid Platform (CAP) and the Fibre Recovery Platform (FRP) allows for a more complete material use of feedstocks in terms of life cycle extension. This is reducing adverse environmental impact and is expected to decrease GHG emissions.

HINDRANCES

- x Impurities and toxic remains in biowastes can have a serious effect on the direct use in manufacturing processes as well as on manufactured materials and products
- x Recycling and composting processes for biobased plastics are not sufficiently developed yet and create problems with waste separation and treatment

[13] Horizon 2020 Project (2020-2023) CAFIPLA – Deliverable D4.7 (2022) – Enablers and hindrances for implementation of supply chain concept at IDE pilot plant
[28] Horizon 2020 Project (2020-2023) CAFIPLA – Deliverable D4.3 (2022) – Report on the transferability of the supply chain concept
[29] Siegfried et al. (2023) Boosting biowaste valorisation by modifying European law for end of waste

PESTEL: LEGAL FACTORS

Derived from [13, 28, 29]

ENABLERS

- ✓ Development of standards for biolubricants, biopolymers, biosurfactants and biosolvents by the European Committee for Standardization (CEN) [34]
- ✓ Mandates M/429 (for the elaboration of a standardization program for bio-based products), M/430 (on bio-polymers and bio-lubricants), M/491 (on bio-solvents and bio-surfactants) and M/492 (for the development of horizontal standards for bio-based products) were issued by the EC and accepted by CEN [35]
- ✓ CAFIPLA products already registered at REACH (EC 1907/2006)/ECHA only require co-admission which is less elaborate and less expensive: Carboxylic acids C1-C5 and C5-C9, as well as caproic acid/hexanoic acid
- ✓ Contracts and approvals for organic, municipal biowaste, and green waste already approved in case of CAFIPLA which (1) facilitates follow-up activities at IDELUX and (2) can serve as best practice example for transfer to other plants

ECHA = European Chemicals Agency; REACH = Registration, Evaluation, Authorisation and Restriction of Chemicals

HINDRANCES

- x The legislation for waste (End-of-waste criteria), recycling and consumer protection needs to be updated, as it is blocking the market uptake of innovative circular bioeconomy developments.
- x Regulations on protection of environment and for consumer protection are conflicting with transition to circular economy.

[13] Horizon 2020 Project (2020-2023) CAFIPLA – Deliverable D4.7 (2022) – Enablers and hindrances for implementation of supply chain concept at IDE pilot plant
[28] Horizon 2020 Project (2020-2023) CAFIPLA – Deliverable D4.3 (2022) – Report on the transferability of the supply chain concept
[29] Siegfried et al. (2023) Boosting biowaste valorisation by modifying European law for end of waste; [34] BioBasedEconomy (2022a); [35] BioBasedEconomy (2022b)

PESTEL FACTOR ANALYSES PINPOINT MAIN ENABLERS AND HURDLES TO BE OVERCOME

Derived from [28]

Policy & Legal: Newly consolidated or amended regulatory frameworks such as reforming the Renewable Energy Directive to a Renewable Energy and Materials Directive (REMD) and the EU Waste Framework Directive will support market demand and uptake of technologies for conversion of biowaste to high value bio-based products, such as CAFIPLA. The Renewable Carbon Initiative (RCI) and EC communication paper for Sustainable Carbon Cycles as well as mandates for standardisation of biobased products will further strengthen the biobased products market.

Economic & Technological: The main economic advantage of waste-based bioproducts lies in the reduction of production costs due to the use of low-cost waste feedstock. Innovative sorting and recovering processes of the heterogenous biowaste will help to reach cost-efficient processing of waste streams. New business models and financial incentives (government) for separation and high fees for mixed waste also improve biowaste qualities. Depending on specific characteristics and requirements of targeted products, wherever possible 'fit for purpose' wastes should be collected directly from the waste producers (food industry) and delivered to the conversion plant tailored for production of specific bio-products to avoid mixing with other organic material or risk contamination. Tailored local value chains based on waste resources not only reduces strengthens the region through a growing circular bioeconomy, saves financial means of citizens and the municipality, creates jobs and higher incomes and reduces dependency on external imported resources.

Ecological & Social: The CAFIPLA end products prolong material life cycles and reduce GHG emissions compared to the conventional AD/composting approach. The environmental benefit and climate friendly reuse of organic wastes and local resources should be indicated by a transparent labels to promote social acceptance of the products and create a positive image of all actors in such value chains. This is urgently needed since waste-based products still adheres a negative image in public. Some of the wastes contain impurities and toxic contaminations which could lead to high purification processing costs and adverse effects on the health of product users. Smart and simple detection systems as well as 'safe product' guarantees are needed to ensure safety and build trust of customers.

[28] Horizon 2020 Project (2020-2023) CAFIPLA – Deliverable D4.3 (2022) – Report on the transferability of the supply chain concept

4. CHANCES AND CHALLENGES ALONG THE CAFIPLA VALUE CHAIN

POLITICAL

To foster biowaste-based value chains:

- ⇨ **Streamlined regulations** are needed to steer industries and money towards more circular and more biobased directions
- ⇨ **Compulsory registering** and tracking of organic residues and wastes produced by companies will improve accessibility.
- ⇨ Public procurement should prioritise biobased processes/products even if at higher costs as long as equal technical properties are met.

ECONOMIC

To facilitate Market entry of CAFIPLA products:

- ⇨ Most **promising markets** such as presumably the fertilisers, fibre-based products and plastic precursors markets should be targeted
- ⇨ **Unique selling points** of biowaste-based products must be transparently communicated to target consumers
- ⇨ Product **performance and safety** must be guaranteed through regulations
- ⇨ **Economic viability** must be given, but sustainability benefits additionally motivate to change existing value chains

SOCIAL

To ensure consumer acceptance of CAFIPLA products:

- ⇨ Biobased product development should aim at same **quality and performance** compared to the fossil-based product (consumer experience)
- ⇨ **Transparent marketing and labelling** is needed (“bioresource” instead of “waste”)
- ⇨ Consumers should be able to trust that **product safety** is guaranteed by legislations
- ⇨ Education, communication and networking are key to increase **understanding and acceptance**

TECHNOLOGICAL

To implement CAFIPLA:

- ⇨ Implementation of TRL 8/9 case studies needed to showcase **reliability and scalability** of the CAFIPLA technology
- ⇨ **Economic analyses** (LCC) results needed to verify viability of the CAFIPLA concept for AD plants

ECOLOGICAL

To promote the ecological impact of CAFIPLA:

- ⇨ **Environmental analyses** (LCA) results needed to quantify environmental benefit of the CAFIPLA concept
- ⇨ Eco-friendly **biowaste recycling technologies must be supported** to compete with established processes by e.g., reduction of taxes or subsidy schemes for material use of biowaste, higher taxes for energetic applications

LEGAL

To advance the EU bioeconomy:

- ⇨ Implementation of biowaste recycling must be simplified. E.g., **End-of-waste** is processed and decided on a regional level case by case making it elaborate, costly and increases risk of negative decisions
- ⇨ Existing **regulations or legislations should be updated** and/or implemented more thoroughly: EC 767/2009 Feed directive; EU 2019/1009 Fertilisier directive; EC 1907/2006 REACH directive; 2008/98/EC Waste framework directive

[13] Horizon 2020 Project (2020-2023) CAFIPLA – Deliverable D4.7 (2022) – Enablers and hindrances for implementation of supply chain concept at IDE pilot plant
[28] Horizon 2020 Project (2020-2023) CAFIPLA – Deliverable D4.3 (2022) – Report on the transferability of the supply chain concept

STANDARDISATION: UPDATE OF EXISTING CWA ON VOLATILE FATTY ACID PLATFORM INTEGRATION

CEN WORKSHOP AGREEMENT

CWA 17484

September 2020

ICS 13.020.55; 03.100.99; 27.190

English version

Anaerobic digestion plants - Feasibility assessment methodology for integrating a Volatile Fatty Acid Platform Technology

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CWA 17484:2020 reflects the agreement only of the registered participants responsible for its content and was developed in accordance with the CEN-CENELEC rules and practices for the development and approval of CEN/CENELEC Workshop Agreements.

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CWA 17484 "Anaerobic digestion plants - Feasibility assessment methodology for integrating a Volatile Fatty Acid Platform Technology"

Evaluation methodology for biogas plant operators, investors, and municipalities on how to assess whether the **upgrade of a given biogas plant to a coupled energetic and material use** by integration of a Volatile Fatty Acid Platform (VFAP) is ecologically and economically reasonable considering certain conditions, including e.g.:

- **Non-technical and technical criteria and dimensions** to evaluate the feasibility
- **Discussion of economic and non-technical aspects**, as well as contextual factors such as subsidies, policy vision, and legal frameworks
- A **multi-criteria decision guide** for evaluating the technical criteria, such as biobased raw material availability, the impact of the integration of a VFAP on current anaerobic digestion plants and an overview of available VFA conversion technologies
- **Assessment guideline** based on well-established methods tailored to VFAP technology integration e.g., SWOT analysis, LCA, cost analyses and economic feasibility studies

Derived from [19]

Current CWA valid until 2025:

⇨ Future re-evaluation should include an **update on feedstock feasibility and requirements** as e.g., assessed within CAFIPLA, as well as the additional valorisation to **fibre-derived products including biocomposites** achieved via integration with a Fibre Recovery Platform

EUROPEAN COMMITTEE FOR STANDARDIZATION
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[19] Horizon 2020 Project (2016-2020) VOLATILE – CEN Workshop Agreement (2020) – Anaerobic digestion plants

RECOMMENDATIONS TO OVERCOME IMPLEMENTATION CHALLENGES

- To accelerate technology uptake, establish circular value chains and identify bioresource providers, **comprehensive monitoring and mapping** of feedstock and industrial waste flow availabilities considering location, quality, quantity and current utilisation is needed.
- **Cross-sectoral communication** among all stakeholders of the value chain must be fostered to increase knowledge transfer and boost technology uptake.
- **Decentralised valorisation** facilities can enhance value creating on a local and regional level.
- Tailored, harmonised and transparent **European regulations** for biomass utilisation and quotas for biowaste recycling are needed which are implemented on national and regional levels.
- A **standardised collection and clean sorting of biowaste** will minimise processing issues, thereby reducing maintenance costs and will help to further streamline processes and increase cost-efficiency and robustness.
- **Subsidies for waste companies** and biorefinery sites are needed to accelerate the uptake of new technologies such as CAFIPLA.
- Further **incentives for circular systems** are needed to disrupt the current linear production system e.g., subsidies, taxes, CO_2 pricing, quotas for biobased material.
- Further **technology standardisation** will enhance technology uptake (e.g., CWA)

Legislative frameworks

Biowaste legislations to facilitate its material use, strengthen market demand and provide low risk investment opportunities

Unlocking biowaste as resource for bioeconomic value chains

CAFIPLA

SECTION 5
Conclusion and Outlook

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Bio-based Industries Consortium

Horizon 2020 European Union Funding for Research & Innovation

BBI JU

CONCLUSION

The present deliverable "CAFIPLA Guideline for successful integration of the technology platform":

- Highlights the **relevance of biowaste recycling** to advance the circular bioeconomy (⇨ page 17)
- Analysed the CAFIPLA technology requirements considering supply chain and technical feasibility (⇨ page 22)
- Provides a guideline to stir the **successful implementation** of the CAFIPLA concept (⇨ page 33)
- Pinpoints the **economic added value** of the diverse biowaste-based end product portfolio (⇨ 41)
- Identified **chances and challenges** that must be considered when taking the next steps towards implementation (⇨ 48)
- Gives clear recommendations what needs to done to **accelerate biowaste utilisation** and the circular transition (⇨ 58)

The **CAFIPLA technology** presents an innovative, future-oriented and economic alternative to existing biowaste utilisation concepts by facilitating improved carbon recycling, achieving higher valorisation and advancing the competitiveness of the **circular European bioeconomy**.

OUTLOOK

CAFIPLA offers a highly flexible biowaste valorisation concept that can be tailored precisely to specific local requirements by adapting the value chains to given environments. Therefore, different implementation routes for the CAFIPLA technology can be drafted, such as e.g., the **integration into existing biorefinery or waste treatment sites** to complement existing valorisation approaches but also **stand-alone options for CAFIPLA biorefineries** are conceivable.

According to the European Biogas Association, in Europe around **20,000 plants are producing biogas**[36], while the European Compost Network assessed in a survey [37] that approximately 12.4 million tonnes of biowaste are currently treated via anaerobic digestion at over 700 plants. Additionally, 133 plants treat organic waste in combined anaerobic digestion and composting facilities. The European Environment Agency (EEA) assessed an even higher potential, estimating a volume of approximately **17 million tonnes of biowaste** being available for anaerobic digestion[38].

Given the derived extensive implementation potential for the CAFIPLA technology, the larger-scale exploitation and further upscaling of the technology will be the next step to **unlock biowaste as raw material for bioeconomic value chains**.

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