BIO CIRCULAR CITIES

Exploring the circular bioeconomy potential in cities

Policy recommendations for implementing circular bioeconomy in the pilot areas

Deliverable D3.3 of WP3

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EXECUTIVE SUMMARY

This report (D3.3) is the third deliverable of Work Package 3 "Circular bioeconomy regulatory framework analysis and set of policy recommendations for the selected urban areas" of the Biocircularcities (BCC) project. WP3 is divided into three phases: The first phase aims to provide an overview of the current regulatory framework and best practices on Circular Bioeconomy (CBE) and biowaste management at European level as well as at national, regional, and local level in the three pilot areas. The second phase analyses the selected regulatory framework in depth and identifies drivers and barriers for the transition to a more biocircular system for organic waste management. The last part formulates policy recommendations (PR) that could help to overcome the identified regulatory gaps or shortcomings in the pilot areas.

The objective of D3.3 is to provide PR aimed at addressing the challenges and opportunities identified for the BCC pilot areas and facilitating the transition towards more sustainable biowaste management and bio-based products. The target audience is defined as decision-makers at EU level and/or national, regional, and local level in the pilot areas. The BBC PR stem from a synthesis of the regulatory framework analysis of drivers and barriers (D3.2) combined with feedback from local stakeholders and international experts gathered during the BCC local Living Labs, Advisory Board Meetings and Peer Review Sessions, as well as relevant good practices and existing legislation in EU countries other than the pilot countries Bulgaria, Italy, and Spain.

In total, this report contains 94 PR, thereof 30 are "**general policy recommendations for all three pilot areas**" which encompass broader principles and strategies that can be adapted and applied in other regions and value chains. They also include bioplastics, as they are a potential bio-based product in all three value chains. The main general policy recommendations per category are summarised below:

Data management

- At EU level, introduce standardised guidelines for data collection and analysis for all types of organic waste (forestry residues, agro-industrial organic waste, separately collected biowaste, etc.).
- At national and regional level, introduce into law annually updated, comprehensive, transparent, and freely accessible databases on municipal biowaste streams (quantity, quality, destination) using European standardised guidelines. Introduce the waste data flows into national electronic waste management systems to allow performance monitoring at national and regional level.

Organic waste treatment and sustainable biorefineries

- At EU and national level, ensure planning security with regard to legal framework conditions and subsidies, while at the same time phase out subsidies that are not consistent with the EU waste hierarchy and EU bioeconomy targets.
- At regional level, introduce financial incentives (especially for SMEs) for technical improvements of existing treatment plants, the use of Best Available Technology (BAT) and investments for the construction of new (decentralised) biorefineries, giving preference to bio-based products according to the "cascading use of biomass principle", i.e., biochemicals are preferred over bioenergy.

- At national level, build capacity in the municipalities responsible for issuing permits and streamline good practices to speed up the permitting process for new biorefineries.

Market incentives for bio-based products

- At national, regional, and local level, support Green Public Procurement according to the EU guidance for bio-based products in procurement.
- At EU level, introduce financial incentives for the local production and marketing of bio-based materials (e.g., biochemicals, bioplastics, compost) and bioenergy based on carbon footprint assessment.
- At EU or national level, introduce VAT reductions for bio-based products (e.g., biochemicals) and other environmentally friendly products and services produced in the EU compared to fossil-based alternatives (integrated approach) and products from outside the EU.

Public awareness and support

- At regional and local level, finance well-developed, continuous environmental education programmes on food waste prevention, separate collection, and anti-littering.
- At regional and local level, monitor the success of awareness raising campaigns using common indicators for municipal solid waste management.

Stakeholder involvement

- At regional or local level, promote the participative approach by enshrining stakeholder involvement in legislation for the assessment of the environmental, social, and economic impacts of decisions such as the construction of a new (bio)waste treatment plant, or the modification of the collection system.
- At EU and regional level, promote technology and innovation clusters and transregional exchange of experiences and good practices through the creation of specific networking platforms and the organisation of round tables between policy makers, researchers, and market players with a focus on supporting innovative start-ups to address all relevant aspects of new value chains.

Of the **policy recommendations specifically targeting the pilot areas**, the number of PRs for the Metropolitan Area of Barcelona (MAB) value chain is significantly higher (39) than for the Province of Pazardzhik (PP; 13) and the Metropolitan City of Naples (MCN; 12). This is mainly due to the fact that the legal framework for the feedstock "municipal biowaste" is very extensive and includes biowaste prevention, waste taxation, separate collection and biowaste treatment. Furthermore, the regulatory framework for biogas/biomethane is also more comprehensive than for processing organic waste from agro-industry into novel food products (MCN chain) or the extraction of bioenergy/biochemicals from forestry residues (PP chain). Some concrete examples of PR for the pilot areas:

Pazardzhik Province

- At national level, funding should be made available for local environmental impact assessments to determine the range between forestry residues that must remain on the ground to preserve soil quality and biodiversity and residues that can be used to produce new bio-based products.

- At national level, introduce a fee and incentive scheme to promote the pre-treatment and sustainable collection of forestry waste for biorefineries – especially in difficult terrain – also with a view to reducing the costs of firefighting and reforestation after fires.
- At regional level, provide financial support for the evaluation of the environmental and economic benefits of forestry residues collection, storage, and processing into different biowaste products (e.g., biochemicals, bioenergy) while giving financial support for implementing the most suitable local option, considering local infrastructure, local industry, available subsidies etc.

Metropolitan City of Naples

- At national level, introduce financial incentives and administrative and technical support for companies to use their by-products (e.g., coffee silverskin) internally for the production of new products (e.g., functional food) to avoid classification as waste. At local level, incentivise industrial symbiosis.
- At national level, provide financial support for laboratory analyses in support of risks assessments for EFSA (European Food Safety Authority), which provides independent scientific advice and informs on existing and emerging risks in the food chain, and ECHA (European Chemicals Agency), responsible for the registration, evaluation, authorisation, and restriction of (bio)chemicals, with a view to granting market authorisation.

Metropolitan Area of Barcelona

- At national level, introduce the mandatory application of the pay-as-you-throw (PAYT) principle in local waste charges. Charging based on the actual amount of waste generated creates incentives for separating biowaste (and other recyclables) at source and reducing the amount of mixed residual waste.
- At national level, introduce mandatory door-to-door (DtD) or smart bin collection systems for areas with no previous biowaste collection. The introduction of new "open bins" should be prohibited.
- At local level, introduce clearly communicated sorting obligations for citizens and – in case of DtD collection – enforce the obligation by introducing controls on the separate collection of biowaste and the proportion of organic content in mixed residual waste. Enforcement of the corresponding fines for non-compliance.
- At national and regional level, introduce stricter limits for biowaste impurities in national (10% by 2027) and regional (5% by 2027) legislation.
- At national level, integrate a higher minimum biogas target (at least 5 bcm by 2030) and biomethane target (at least 5% of the total gas consumed) linked to the target for new plants to be built into the Spanish Biogas Roadmap.

Although each country and region has its own priorities and framework conditions, the policy recommendations tailored to the local context of the selected bio-based value chains in the BCC pilot areas can serve as a valuable reference. This will ensure the wider adoption of sustainable biowaste management strategies and support the development of a circular bioeconomy in Europe.

List of acronyms

ACRONYM	Description
AD	Anaerobic digestion
(Bio)PET	(Bio)polyethylene terephthalate
BAT	Best Available Technique
BBI	Bio-based Industries
BCC	Biocircularcities project
CBE	Circular Bioeconomy
CHP	Combined Heat and Power
DtD	Door-to-Door
DBPF	Database on Policy Framework
EC	European Commission
ECHA	European Chemicals Agency
EFSA	European Food Safety Authority
ETS	Emissions Trading System
EPR	Extended Producer Responsibility
EU	European Union
GHG	Green House Gas
LCA	Life Cycle Analysis
LCC	Life Cycle Costing
LL	Living Lab
MAB	Metropolitan Area of Barcelona
MITERD	Spanish Ministry for Ecological Transition and the Demographic Challenge
MBT	Mechanical Biological Treatment
MCN	Metropolitan City of Naples
MS, MSs	Member State, Member States
MSW	Municipal Solid Waste
PAYT	Pay As You Throw
PEMAR	Spanish National Waste Management Framework Plan (PEMAR) 2016-2022
PLA	Polylactic acid or polylactide
PP	Pazardzhik Province
PR	Policy recommendation
PRECAT	Programme for the Prevention and Management of Waste and Resources in Catalonia 2020

PREMET	In the MAB: Metropolitan Program on Prevention and Use of Resources and Municipal Waste 2019-2025, including the Metropolitan Zero Waste Agreement
PRS	Peer Review Session
SDGs	United Nations Sustainable Development Goals
SMEs	Small and medium-sized enterprises (2003/361/EC, Annex, Art.2)
WP	Work Package

1. INTRODUCTION

The Biocircularcities (BCC) project aims at unlocking the potential of unexploited bio-based waste streams in the general framework of the circular bioeconomy (CBE) by investigating the development of economically and environmentally sustainable organic waste valorisation models through three pilot regional bio-based value chains on (i) forestry residues in the Province of Pazardzhik (PP), (ii) agro-industrial biowaste (coffee chain) in the Metropolitan City of Naples (MCN) and (iii) municipal biowaste in the Metropolitan Area of Barcelona (MAB).

This report (D3.3) is the third deliverable of Work Package 3 (WP3) "Circular bioeconomy regulatory framework analysis and set of policy recommendations for the selected urban areas" of the BCC project. The recommendations are focussed on the identification and implementation of the most sustainable bio-based value chains (alternative scenarios) compared to state-of-the art organic waste treatment in each pilot area. The aim of D3.3 is to summarise the results of Task 3.3. "Legislative gaps and opportunities analysis for implementing circular bioeconomy in the pilot areas".

On the one hand, the policy recommendations of this report are based on the results of the analysis of opportunities and gaps for the implementation of the CBE in the pilot areas and across Europe identified within the legal framework documents on biowaste and circular bioeconomy in D3.2 (summary). The identification of gaps and opportunities at pilot level were used to define which supporting measures could help to address the identified shortcomings and contribute to a more efficient and sustainable implementation of the CBE. On the other hand, this report includes policy recommendations based on good practice examples and national and regional legislation of other countries than the pilot areas.

All results are obtained with support of local stakeholders and international experts. The involvement of local stakeholders operating along the three selected biowaste chains during the local Living Labs was crucial to get a real picture of the situation based on the experiences on the ground. They were highlighting the local opportunities for valorisation of municipal biowaste, agro-industrial organic waste and forestry residues, identifying opportunities or the gaps and giving recommendations along the different stages of the identified value chains. After each round of LL, the outcomes were validated and optimised with the support and advice of external international experts (Advisory Board members and peer reviewers). *All minutes and conclusions of the Living Labs and Peer Review Sessions are summarised in report D5.4, the results of the Advisory Board Meetings in D1.8.*

In order to give a holistic view of the recommendations provided within the BCC project, the results of D2.3 "LCT Recommendations through the LCA and LCC analyses of the selected systems producing and managing biowaste in the pilot areas" (WP2) are also partly included in this deliverable.

2. METHODOLOGY

Definitions of waste streams, by-products, certain bio-based products (biomethane, bioplastics, novel food) and relevant waste concepts can be found in D3.2.

2.1. Definitions

Before detailing the CBE policy recommendations at pilot level, it is relevant to introduce the following definitions:

Implementation of the circular bioeconomy (CBE) means utilising secondary biomass (organic waste, residues, and by-products) to produce food, materials, and energy. This can be done either by changing or improving current treatment systems in a circular perspective: 1) by introducing preventive measures (reduction of biowaste generated), 2) by improving the separate collection of biowaste (quantity and quality); 3) by producing new bio-based products.

Drivers/opportunities/recommendations are factors that favour the implementation of the CBE.

Barriers/gaps/shortcomings are factors that hinder the implementation of the CBE in the bio-based value chain.

Policy recommendation (PR) is a simply written policy advice/suggestion prepared for some group that has the authority to make decisions.[1] In this report the geographical scope varies from EU level to national, regional, and local level for the pilot areas.

Policy instrument (according to the European Environment Agency): when European environmental policies were first developed, many policy instruments focused on specific environmental problems. Since no single policy instrument can provide solutions to all problems, the spectrum of policies has broadened gradually to address increasingly complex environmental and health related problems. Today, many environmental policy interventions combine: (a) Traditional regulatory approaches, sometimes labelled 'command-and-control measures' (for example emission standards, bans of toxic substances, and land planning instruments); (b) Market based instruments (such as environmental taxes and greenhouse gas emission trading); (c) Awareness raising (including for example energy efficiency labels and communication campaigns).[2]

Green Public Procurement (GPP) is defined as process whereby public authorities seek to procure goods, services and works with a reduced environmental impact throughout their life cycle when compared to goods, services and works with the same primary function that would otherwise be procured. The basic concept of GPP relies on having clear, verifiable, justifiable, and ambitious environmental criteria for products and services, based on a life-cycle approach and scientific evidence base (COM/2008/400 final).

Know As You Throw (KAYT): schemes based on diverse information, communication, and nudging actions to make the users aware of their waste prevention and sorting performances (REthinkWASTE 2021).

[1] https://www.igi-global.com/dictionary/policy-recommendation/79483

[2] https://www.eea.europa.eu/themes/policy/intro

Pay As You Throw (PAYT): schemes that charge waste producers on the basis of the actual amount of waste generated and provide incentives for separation at source of recyclable waste and for reduction of mixed residual waste (Directive (EU) 2018/851).

2.2. Development of the BCC policy recommendations

For the policy recommendations, the synthesis of the analysis of drivers and barriers in the regulatory framework (D3.2) is combined with feedback from local stakeholders collected during the BCC's local Living Labs, feedback from international experts during the Advisory Board and Peer Review meetings, and relevant good practices as well as existing legislation in EU countries other than the pilot countries Bulgaria, Italy and Spain (see Figure 1).

The **geographical scope** involves the following levels: **national** (Bulgaria, Italy, Spain), **regional** (Bulgarian South-Central Region, Campania Region, Catalonia Region) and **local** (Pazardzhik Province, PP; Metropolitan City of Naples, MCN; Metropolitan Area of Barcelona, MAB). However, the legislative framework relevant to the three pilot areas at EU level is also taken into consideration.

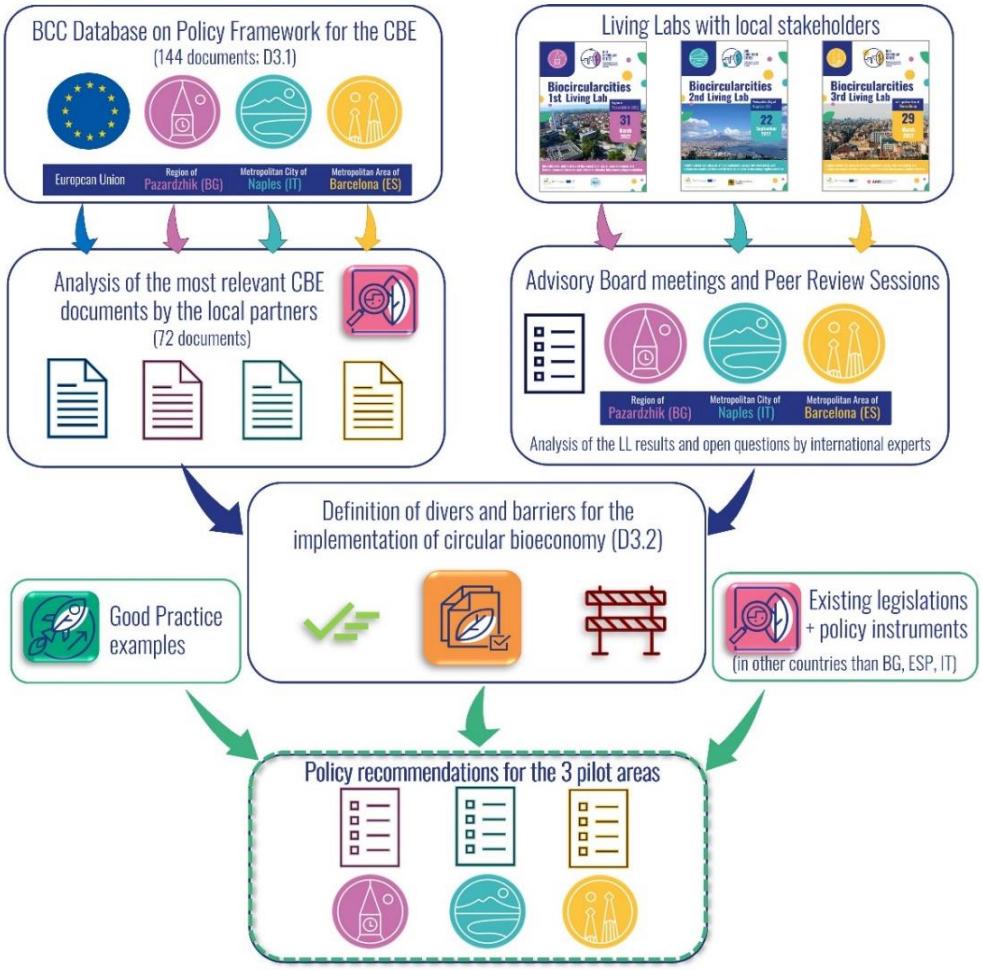


Figure 1 : Methodology for policy recommendations for the selected value chains in the three pilot areas.

2.2.1. Analyses of drivers and barriers in the current policy framework

For the analysis of legal, environmental, economic, technical, and social drivers and barriers, the most relevant documents were selected from the updated Database on Policy Framework (DBPF, from D3.1). The BCC local partners REAP, CMNA and AMB were identifying the main legal drivers and barriers to the implementation of circular bioeconomy identified in the selected documents, first at EU level and then at national, regional, and local level for the PP pilot, the MCN pilot and the MAB pilot. All identified drivers and barriers are analysed in detail in D3.2 (summary) and represent the basis for many policy recommendations, specifically the ones focussing on concrete national, regional and local legislation in the pilot areas.

2.2.2. Multi-actor-involvement

At pilot city level, bi-annual on-site or online Living Labs in local language ensured the participation of relevant local stakeholders of the selected value-chains, allowing to collect input on the current challenges for the implementation of the alternative scenarios in the respective pilot areas. These stakeholders come from different sectors, all of which play a role in the analysed value chains: local waste management authorities, local authorities, academic and research institutions, private companies, NGOs, professional associations, municipalities as well as companies collecting and managing biowaste. They contributed to: (i) validate the information related to the state of the art of the current biowaste management systems at pilot level, (ii) the selection of the most realistic and sustainable alternative scenario, (iii) the identification of the related existing challenges and the potential solutions in the current biowaste management system, (iv) give feedback on policy recommendations for the pilot areas, and (v) the validation of the alternative scenarios.

In addition to the local stakeholders, international external experts have been carefully selected to provide input during the Advisory Board Meetings (see D1.8) and Peer Review Sessions after each round of Living Labs. For these tasks, experts from local and regional authorities, private companies and research organisations were selected. Their contribution was fundamental to validate and support project choices and preliminary results and answer to questions prepared by the consortium for each pilot.

The collective knowledge of policy recommendations that has emerged thanks to the support of local stakeholders and international experts ensures that the models proposed by the BCC project are in line with local priorities and existing international practices.

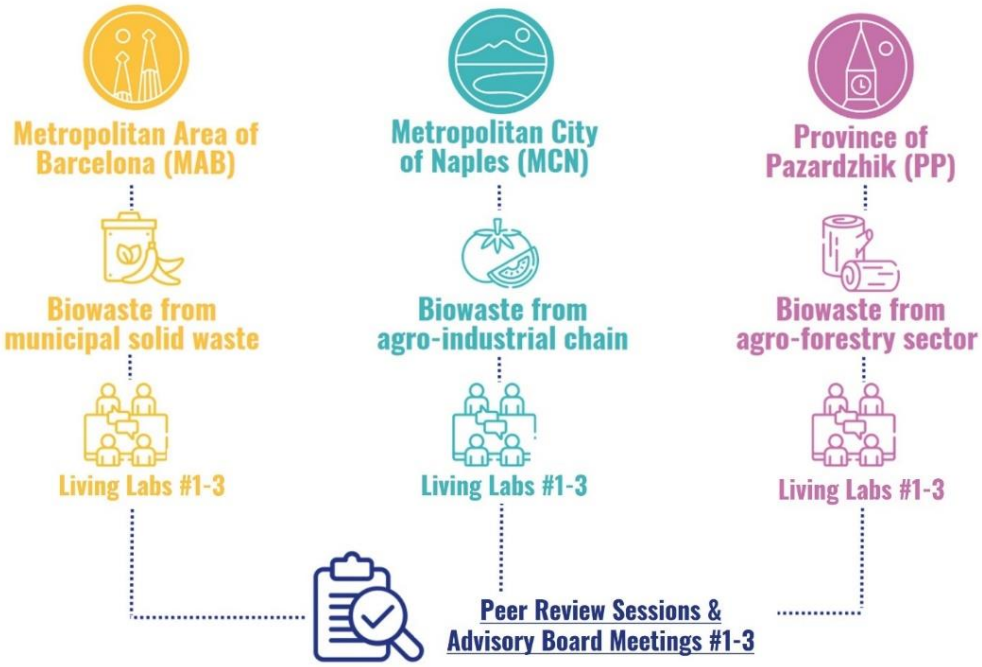


Figure 2 : Muti-actor contribution in the BCC project in the three pilot areas.

2.2.3. Good practice examples

The good practices listed in this report are partially based on the pre-selection of D3.1. The very first criterion for selecting good practices was to focus on actions related to the specific value chains in the three BCC pilot areas (municipal biowaste, agro-industrial organic waste and forestry residues). After selecting the good practices relevant to the selected chains in the BCC pilot countries, examples from available databases from other European countries were also included. The geographical scope of the good practices was the EU. Together with the local partners, the most relevant good practices for the three pilot areas were selected. In the case of forestry waste in remote areas, there is still a lack of good practices that could serve as an example for Pazardzhik Province.

For D3.3, some good practice examples also come from other EU projects such as for example BIOBRIDGES[3], HOOP[4], SCALIBUR[5], SEMPRE-BIO[6], SWEETWOODS[7] and the ROOTS joint initiative (2022), LIFE INFUSION[8], LIFE-Food.Waste.StandUp[9] and LIFE REthinkWASTE (2021).

[3] https://www.biobridges-project.eu/
[4] https://hoopproject.eu/
[5] https://scalibur.eu/
[6] https://sempre-bio.com/
[7] https://sweetwoods.eu/
[8] https://lifeinfusion.eu/
[9] http://www.lifefoodwastestandup.eu/en

3. POLICY RECOMMENDATIONS FOR THE BCC PILOT AREAS

This section presents the policy recommendations (PR) identified for the selected bio-based value chains at pilot level. The discussion takes place by structuring the identified PR for the implementation of the CBE according to the different stages of the respective value chain including the bio-based products relevant for the three pilot projects. A summary of the main legal framework at EU level (extended version: D3.2) is briefly explained. PR relevant to all three pilot areas are included in chapter 3.1.

3.1. General policy recommendations for all three pilot areas

3.1.1. Data management

What the national, regional, and local plans have in common is that measuring target achievement is sometimes difficult due to a lack of data and that there are no consequences for non-compliance. High-quality data is the basis for decision-making processes, from the choice of collection system to the choice of treatment method.

For the reliability of the results of Life Cycle Costing (LCC) and Life Cycle Assessment (LCA), the transparency of the data, i.e., the primary data sources, the background information, and the secondary data sources as well as the calculation methods, is important. For the validation of LCA and LCC analyses, a third-party review should be conducted to verify the consistency of the study and to use the results obtained as a credible communication tool for decision makers.

PR#1: At EU level, introduce standardised guidelines for data collection and analysis for all types of organic waste (forestry residues, agro-industrial organic waste, separately collected biowaste, etc.). Promoting standardisation and harmonisation of data collection methods is crucial to ensure replicability across different EU countries and regions. This would enable easier data exchange, comparison of results and meaningful benchmarking.

PR#2: At national and regional level, introduce into law annually updated, comprehensive, transparent, and freely accessible databases on municipal biowaste streams (quantity, quality, destination) **and food waste** (quantity) using European standardised guidelines. **Introduce the waste data flows into a national centralised system** (see PR#3) **to allow performance monitoring at national and regional level.** Collaborations with data providers, biowaste management agencies, and research institutions can play a vital role in ensuring the availability of reliable and up-to-date data necessary for conducting LCA and LCC analyses in European contexts.

PR#3: At national level, consolidate and accelerate the development of national electronic platforms for waste management regarding the documentation, registration, and reporting obligations in the waste management sector and data exchange between all regions in one country. **A best practice example for a national platform** is the **Austrian "Electronic Data Management" (EDM)**, managed by the BMK (Austrian Ministry of Climate Action, Environment, Energy, Mobility, Innovation and Technology) since 2005. In the EDM all waste producers, collectors, treaters are registered, and every waste stream reported annually (waste balances). In addition to various other

reports, also all waste shipments between different Austrian regions and neighbour countries are registered.[10] In Spain, such a system is currently being further development at national level: "eSIR"[11], managed by MITERD (Spanish Ministry for Ecological Transition and the Demographic Challenge), was launched in 2022.

PR#4: At EU and national level, allocate more funds for public administration/university cooperation to support the analysis of the environmental and economic impacts of different biowaste collection and treatment technologies. Provide support to public administrations in the assessment, monitoring and analysis of data, including the use and interpretation of LCA and LCC results.

PR#5: At EU and national level, allocate more funds for BBI/research cooperation to support the choice of the most sustainable biowaste management strategies (e.g., with LCA and LCC), especially where there is uncertainty about the environmental benefits of certain bio-based products such as bioplastics, which so far have a mostly linear life cycle (no reuse or recycling at their end-of-life stage).

3.1.2. Organic waste treatment and sustainable biorefineries

The sustainable management and use of biological resources is a pillar of the EU bioeconomy strategy and a difficult challenge that must be addressed in order to efficiently introduce bioeconomy. Bioeconomy systems can only be beneficial to society if consumption and production models are aligned, considering and respecting the regenerative capacity of the planet and the increasing demand for secondary rather than primary biomass from additional sectors and markets. Also, the end-of-life stage is an important factor – circularity needs to be ensured (e.g., for bioplastics; chapter 3.1.6). This can be achieved through the local introduction of biorefineries and short domestic supply chains to limit the impact of transport and promote local development, especially in rural areas.

The **EU Forestry Strategy for 2030 (COM/2021/572 final)** urges member states to integrate the "**cascading use of biomass principle**" into national support schemes as part of the July 2022 revision of the **Renewable Energy Directive (REDIII)**. This principle promotes the use of biomass for the production of materials, including bioplastics, over bioenergy (see Figure 3). It also gives clear preference to organic waste and by-products over primary biomass (e.g., stem wood), especially for short-lived products.

[10] https://secure.umweltbundesamt.at/edm_portal/cms.do?get=/portal/informationen/anwendungenthemen.main

[11] https://servicio.mapa.gob.es/esir-web-adv/

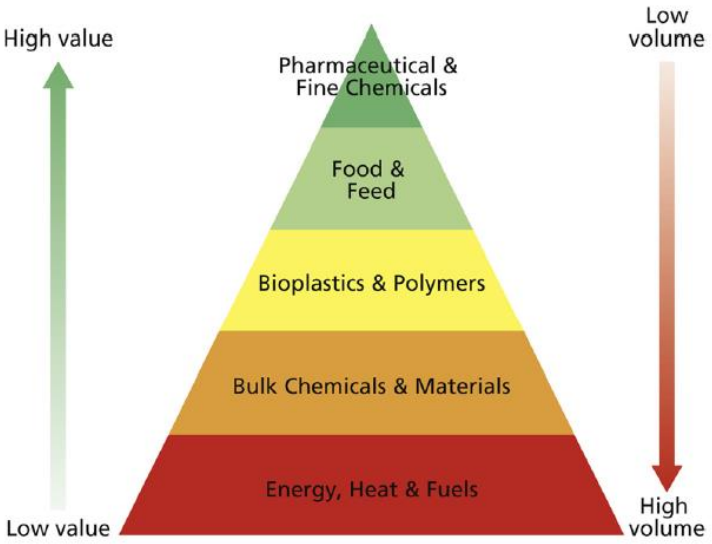


Figure 3: Bio-based value pyramid according to the "cascading use of biomass principle" (Stegman et al. 2019).

PR#6: **At EU and national level, ensure planning security with regard to legal framework conditions and subsidies** (see example from PR#77, chapter 3.4.2). **In addition, the supply of bio-based feedstock must be ensured for at least 15 years, e.g., by extending tender intervals** (e.g., biowaste for biomethanisation).

PR#7: **At national level, phase out subsidies that are not consistent with the EU waste hierarchy and EU bioeconomy targets.** For example, "Directive (EU) 2018/2001 on the promotion of the use of energy from renewable sources" prohibits subsidies for energy from waste incineration in cases where the separate collection obligation has not been met.

PR#8: **At regional level, introduce financial incentives (especially for SMEs) for the technical improvement of existing treatment plants, the use of best available technology (BAT) and for investments in new (decentralised) biorefineries** for the sustainable utilisation of municipal biowaste, agro-industrial organic waste or forestry residues, giving preference to bio-based products according to the principle of "cascading biomass use", i.e. biochemicals are preferred over bioenergy (see Figure 3). The aim should be to create jobs in rural areas.

PR#9: **At national level, incentivise the reduction of the current delay in permitting procedures for new biorefineries by increasing the capacity in municipalities responsible for issuing permits and streamlining good practices** such as the establishment of one-stop shops for biomethane-related permits and setting a maximum processing time according to the EU Biomethane targets (SWD/2022/230 final). Facilitate the upscaling of research pilot plants to industrial scale.

PR#10: **At national level, introduce economic incentives** (e.g., tax exemptions or reductions, renewable energy support schemes) **for the use of renewable energy in biowaste treatment and valorisation processes** (according to Directive (EU) 2018/2001).

PR#11: Coordinate national and EU research and innovation strategies and funding (co-financing from national funds). Increase funding for research and development for the development of sustainable biorefinery processes, demo and scale-up facilities, especially technologies that can be used in remote areas.

3.1.3. Market incentives for bio-based products

The bioeconomy offers the opportunity to develop innovative value chains that require research and development as well as infrastructure development. Financial investment by governments is an important lever, but the potential for innovation should also attract private investment along the value chain.

The **EU Strategy for financing the transition to a sustainable economy** (COM/2021/390 final) refers to the practice of making financial investments in a way that aligns financial flows with the Paris Agreement and the United Nations Sustainable Development Goals (SDGs). The **EU Sustainable finance package** includes measures to help improve the flow of money towards sustainable activities across the European Union. By enabling investors to re-orient investments towards more sustainable technologies and businesses, these measures shall be instrumental in making Europe climate neutral by 2050.[12]

Another important driver is **Green Public Procurement (GPP) of sustainable bio-based products** which aims to help public authorities to obtain goods and services with lower environmental impacts, thereby potentially working as a market pull mechanism to stimulate the growth of sustainable bio-based product markets. GPP is within the framework of Strategic Public Procurement[13], together with Socially Responsible Public Procurement[14] (SRPP) and Innovation Procurement[15]. Within the EU, the potential of GPP was first highlighted in the 2003 Commission Communication on Integrated Product Policy (COM/2003/302 final) where Member States were recommended to adopt national action plans for GPP by the end of 2006. In 2008, the EC published a Communication called "Public procurement for a better environment" (COM/2008/400 final), which establishes a framework for the integrated implementation of a mix of instruments aimed at improving the energy and environmental performances of products. Furthermore, following the adoption of the Circular Economy Action Plan 2020, the Commission proposes binding minimum criteria and targets for GPP in sectoral legislation and gradual mandatory reporting to monitor the implementation of GPP. The criteria consider the full lifecycle of the sustainability of the raw materials and the manufacturing process, energy efficiency, biodegradability, and recyclability.[16]

Bio-based products can make the economy more sustainable and lower its dependence on fossil fuels. The EU has declared the bio-based products sector to be a priority area with high potential for future growth, reindustrialisation, and addressing societal challenges. The second pillar of the EC bioeconomy strategy focuses

[12] https://finance.ec.europa.eu/publications/sustainable-finance-package_en

[13] https://single-market-economy.ec.europa.eu/single-market/public-procurement/strategic-procurement_en

[14] https://single-market-economy.ec.europa.eu/single-market/public-procurement/strategic-procurement/socially-responsible-public-procurement_en

[15] https://single-market-economy.ec.europa.eu/single-market/public-procurement/strategic-procurement/innovation-procurement_en

[16] https://green-business.ec.europa.eu/green-public-procurement_en

on the development of markets and competitiveness in bioeconomy sectors by sustainably increasing primary production, conversion of waste streams into value-added products (biorefineries), and mutual learning mechanisms for improved production and resource efficiency.[17] However, the "sustainability" of bio-based products must first be verified on a case-by-case basis (e.g., through LCA). The following policy recommendations refer to **bio-based products with a clear environmental benefit** – designed in a circular way – based on consolidated LCA studies:

PR#12: At national, regional, and local level, support Green Public Procurement according to the EU guidance for bio-based products in procurement [18] to drive the market towards more sustainable products and processes, considering the full lifecycle. Each year European public authorities spend the equivalent of 16% of the EU Gross Domestic Product on the purchase of goods, such as office equipment, building components and transport vehicles; services, such as buildings maintenance, transport services, cleaning and catering services and works. Public procurement can shape production and consumption trends. Moreover, a significant demand from public authorities for "greener" goods will create or enlarge markets for environmentally friendly products and services.[19] By doing so, it will also provide incentives for companies to develop environmental technologies and sustainable products (COM/2008/400 final). As a **good practice example, the City of Amsterdam** is planning the implementation of 100% "circular procurement" by 2030.[20]

PR#13: At EU level, introduce financial incentives for the local production and marketing of bio-based materials /bioenergy based on carbon footprint assessment. The lower the carbon footprint [CO_2 g/MJ], the higher the price/incentive should be for this product/energy source (instead of having a flat incentive rate). The carbon footprint assessment should be done according to the International Sustainability and Carbon Certification (ISCC).[21]

PR#14: At EU level, link carbon footprint-based incentives for bioenergy (carbon footprint avoided) **to the emission commitments of industry or other sectors**, i.e., those subject to the **EU Emissions Trading System** (EU ETS). The EU ETS covers about 45% of the EU's greenhouse gas (GHG) emissions and is an important part of the EU's policy to combat climate change. The EU ETS is a cap-and-trade system, limiting the right to emit certain pollutants in a given geographical area and allowing companies to trade emission rights within that area. It is the main instrument for reducing GHG emissions, such as carbon dioxide (CO_2), from more than 11,000 installations such as power plants and larger industrial plants (e.g., factories producing cement, lime, and chemicals). The EU ETS renders investments in environmentally friendly technologies economically attractive for industry and airlines.[22] The use of bioenergy (e.g., biomethane) can be effectively used to reduce industry emissions.

[17] https://single-market-economy.ec.europa.eu/sectors/biotechnology/bio-based-products_en

[18] https://single-market-economy.ec.europa.eu/publications/guidance-bio-based-products-procurement_en

[19] https://www.switchtogreen.eu/eu-green-public-procurement/

[20] https://assets.amsterdam.nl/publish/pages/867635/amsterdam-circular-2020-2025_strategy.pdf

[21] https://www.iscc-system.org/

[22] https://www.epa.ie/our-services/licensing/climate-change/eu-emissions-trading-system-/

PR#15: **At EU or national level, introduce VAT reductions for bio-based products** (e.g., biochemicals) and other environmentally friendly products and services produced in the EU **compared to fossil-based alternatives** (integrated approach) and products from outside the EU.

PR#16: **At EU level, introduce a quality certification/label for bio-based products** (e.g., biochemicals from forestry residues) with minimised administrative burden and costs. **Advertise the label to the public to encourage the purchase of bio-based products.** Examples for well-known EU certification systems are the EU Ecolabel[23], the EU Energy Label[24] and the EU Organic Logo[25].

PR#17: **At regional level, give administrative** and **financial support for SMEs for the preparation of health risk assessments** (e.g., potential accumulation of heavy metals) **for new bio-based products in order to obtain market approval**. The cost of these assessments, which are based on comprehensive laboratory analyses, is often prohibitive.

3.1.4. Public awareness and support

Citizens have a key role in valorising organic waste streams into high added-value bioproducts. Knowledge-gaps and carelessness regarding the prevention of (food) waste, the correct separate collection of municipal biowaste and the benefits of sustainable bio-based products are still widespread among citizens.

Well-designed and developed awareness-raising campaigns can help address the lack of knowledge and motivation by informing citizens about proper biowaste separation and changing attitudes and perceptions. Effective communication between waste management organisations and citizens is crucial for the successful operation of waste management services. Citizens should be aware of what services are available to them and the timetable and requirements of these services so that they can use them efficiently. Citizens are also more willing to separately collect waste if they understand what happens to the sorted biowaste that is sent for recycling and what the environmental benefits are (EU Green Best Practice Community)[26].

PR#18: **At regional and local level, finance well-developed, continuous environmental education programmes** on food waste prevention, separate collection, and anti-littering[19] **(minimum of 12-15 EUR/person/year).**[27] In addition, a special focus should be given to non-native speakers (residents and tourists) through multilingual or pictorial communication and to school-based activities. Awareness-raising campaigns need to provide continuity, coherence, complementarity, and clarity of all communication with clearly defined objectives, create clear messages that are appropriate for and directed to a well-defined target audience and guarantee efficient implementation through the integration of activities and clear responsibilities. Citizen awareness campaigns can

[23] https://environment.ec.europa.eu/topics/circular-economy/eu-ecolabel-home_en

[24] https://commission.europa.eu/energy-climate-change-environment/standards-tools-and-labels/products-labelling-rules-and-requirements/energy-label-and-ecodesign/about_en

[25] https://agriculture.ec.europa.eu/farming/organic-farming/organic-logo_en

[26] https://greenbestpractice.jrc.ec.europa.eu/node/84

[27] Based on empirical values from AMB.

be carried out directly by the waste management organisation, by professional agencies on its behalf, or by partner organisations (including stakeholders in other sectors). A variety of communication channels may be employed, including advertising, public relations, direct marketing, community engagement, online engagement, social media, and product labelling.[28] As a good practice example, the **SIRCLES project in Italy improved source separated collection of biowaste.** Schools, citizens and the HO.RE.CA (hotels-restaurants, cafes) sector were the target audiences. In schools, meetings were held informing about the organic supply chain and the use of biodegradable and compostable bags. Territorial info points were created for citizens. For the HO.RE.CA sector, a green label campaign was carried out, awarding this label to those who adopted good practices in biowaste management.[29]

PR#19: **At regional and local level, monitor the success of awareness raising campaigns/ environmental education programmes** using common indicators for municipal solid waste management: Assessing the budget spent on awareness-raising per resident per year (EUR/resident/year), the share of total MSW management budget spent on awareness-raising, the share of population informed[28] and the results per money spent (euros/inhabitant/increase of separate collection).

PR#20: **At regional level, employees should be involved in food waste prevention, as enshrined, for example, in Law 3/2020 of 11 March on the Prevention of Food Losses and Waste in Catalonia**: food businesses, social initiatives and other non-profit organisations involved in food distribution must ensure that their employees are trained to actively participate in reducing food waste and involve them in these actions.

PR#21: **At EU level, invest in education to develop a skilled and competent workforce** in order to strengthen the competitiveness of the European bioeconomy, including businesses and public authorities, while creating jobs.

3.1.5. Stakeholder involvement

The **Quadruple Helix Model** is an efficient way of fostering cooperation in research and development between four major actors in the innovation system: science, policy, industry, and society (Schütz et al. 2019 In recent decades, Quadruple Helix Collaborations have received increasing attention due to their dual promise of increasing problem-solving capacity, achieving more success where individual sectors would fail alone, while creating a more responsible innovation environment (Riconfigure project, D6.4 2021).

Sharing knowledge, experiences, and good practices is crucial for developing and successfully replicating new sustainable value chains based on the CBE concept. The importance of establishing partnerships – from national, regional to local level – needs to be highlighted as a key strategy for the development of innovative value chains but also for replicating project results. There is a great need to collaborate with regional bioeconomy initiatives, waste management associations, and policy-making bodies in other regions. Through these partnerships, tailor-

[28] https://greenbestpractice.jrc.ec.europa.eu/node/84

[29] https://www.enicbcmed.eu/sircles-italy-launches-massive-awareness-campaign-improve-source-separated-collection-biowaste

made methodologies can also be adapted to the specific characteristics and challenges of bio-based value chains in each region.

PR#22: At regional or local level, promote the participative approach by enshrining stakeholder involvement in environmental legislation. An example at local level is the City of Vienna: Since March 2006, the Vienna Waste Management Act[30] has stipulated that the **Waste Management Plan** of the city must be subjected to a "**Strategic Environmental Assessment**" (SEA, "Strategische Umweltprüfung, SUP"), which involves environmental authorities, citizens, NGOs and other stakeholders in the assessment of the environmental, social and economic impacts of decisions such as the construction of a new (bio)waste treatment plant, or the modification of the collection system, etc.[31] Another **example at regional level is the Strategic Environmental Assessment in Catalonia** (Avaluació ambiental de plans i programes)[32] according to Law 6/2009 of 28 April on the environmental assessment of plans and programmes. The PREMET25 (MAB Metropolitan Program on Prevention and Use of Resources and Municipal Waste 2019-2025) and the PRECAT20 (Programme for the Prevention and Management of Waste and Resources in Catalonia) also involved relevant stakeholders, authorities, and general public in their elaboration, which is in line with Directive 2008/98/EC on waste.

PR#23: At EU and regional level, promote technology and innovation clusters and transregional exchange of experiences and good practices as well as future cooperation through the creation of specific networking platforms and the organisation of round tables between policy makers, researchers, and market players with a focus on supporting innovative start-ups to address all relevant aspects of new value chains. "**Task 42: Biorefining in a Circular Economy**" by the International Energy Agency (IEA) is a good practice example for an international platform for collaboration and information exchange between industry, SMEs, municipalities, NGOs, research and technology organisations and universities concerning biorefinery research, development, demonstration, and policy analysis. For the period 2022-2024, Task 42 developed activities including (i) the provision of quantitative, and scientifically sound data on the technical, economic and environmental added-value of biorefining to co-produce bioenergy and bio-products in a sustainable way, (ii) the description of the "global implementation status", major deployment barriers and market data (Biorefinery database and web GIS, Biorefinery Country Reports, Report on Green Biorefinery Status etc.); and (iii) the utilization of the T42 international platform to actively stimulate cooperation and information exchange (Task42 website, lectures, webinars, broad stakeholder workshop etc.).[33]

PR#24: At national level, strengthen Public Private Partnerships (PPP) **for bio-based industries, e.g., the Circular Bio-based Europe Joint Undertaking (CBE JU),** a 2 billion EUR partnership between the European Union and the Bio-based Industries Consortium (BIC) that funds projects advancing competitive circular bio-based industries in

[30] https://www.ris.bka.gv.at/GeltendeFassung.wxe?Abfrage=LrW&Gesetzesnummer=20000141

[31] https://www.wien.gv.at/umwelt/ma48/beratung/umweltschutz/sup.html

[32] https://mediambient.gencat.cat/es/05_ambits_dactuacio/avaluacio_ambiental/avaluacio_ambiental_de_plans_i_programes/index.html

[33] https://task42.ieabioenergy.com/about/work-programme-activities-task-42/

Europe.[34] One example of a PPP in the bioenergy sector is the **Biomethane Industrial Partnership (BIP)**, which is open to all EU countries, private companies, industry associations, academia and civil society organisations in order to achieve the REPowerEU target of increasing the annual production and use of biomethane to 35 billion cubic metres by 2030.[35]

PR#25: At national level, support universities, research institutions and bioeconomy networks to implement capacity building programmes and workshops on the bioeconomy targeting policy makers and industry representatives. Facilitate knowledge exchange and networking. **Support the dissemination of research results** on bio-based value chains – success stories and lessons learned – (e.g., with LCA) by using different channels such as **open-access publications, conferences, webinars, and stakeholder engagement events** to encourage other cities and regions to adopt similar approaches in their own CBE initiatives.

3.1.6. Bioplastics

The analysis of bioplastics as bio-based chemicals is also relevant to this report, even though they are not studied in the BCC pilot areas. Indeed, different types of organic residues, such as agro-industrial organic waste (MCN pilot area) or forestry residues (PP pilot area) can be used as potential feedstock for the production of bioplastics. In addition, some bioplastics, even if classified as "biodegradable" (not EN 13432 compliant), can prevent the proper degradation of biowaste during biological treatment and reduce the quality of the compost obtained (see chapter 3.4.5; MAB value chain).

The **"EU policy framework on bio-based, biodegradable and compostable plastics"** (COM/2022/682 final) raises awareness of the sustainability challenges associated with the sourcing, labelling and use of bio-based plastics. Manufacturers should prioritise organic waste and by-products as feedstock to minimise the use of primary biomass. Furthermore, a competition with crops intended for human consumption should be avoided. The EU bioplastics framework also promotes longer life and the use of recycled material for bio-based plastics by setting a strict definition for useful carbon storage.

Currently, the life cycles of bioplastics are mostly linear. Many different materials and applications of bioplastics further complicate mechanical sorting and recycling. There still seems to be a lack of clear collection and recycling routes for bio-based plastics. The most important current routes for bioplastics recycling are described in D3.2.

PR#26: At EU level, introduce a coherent policy framework for bio-based, biodegradable, and compostable plastics, as highlighted by a stakeholder consultation in the EU. On the one hand, innovation in bio-based plastics and the reduction of dependence on fossil fuels for plastics should be supported. However, bioplastics placed on the market must meet strict guidelines to be more sustainable than fossil-based plastics, including clear labelling

[34] https://european-union.europa.eu/institutions-law-budget/institutions-and-bodies/search-all-eu-institutions-and-bodies/circular-bio-based-europe-joint-undertaking-cbe-ju_en

[35] https://www.europeanbiogas.eu/about-us/partnerships/biomethane-industrial-partnership/

based on certification standards to promote correct use and disposal and reduce negative environmental impacts (EC 2022).

PR#27: At EU level, accompany the growing bioplastics production by **sound bioplastics waste management strategies for each of the most common types of bioplastics**, e.g., introduce bioplastics separate collection and recycling targets for EPR schemes. **For the different types of bioplastics, the collection routes ("biowaste bin" or "yellow bin for all types of plastics") must be clearly defined in coordination with recyclers and composters.** Some packaging EPR schemes (e.g., CONAI[36], Altstoff Recycling Austria[40]) have some fee modulation based on biodegradability, incentivising the recyclability through composting.

PR#28: At EU level, label biodegradable plastics with a uniform logo in order to be better recognisable for consumers instead of the current variety of logos (Figure 4). **At national and regional level,** this measure needs to be **combined with public awareness raising campaigns** to avoid cross-contamination within different recycling streams as well as to educate the consumers about the meaning of this new logo and about the fact that also bioplastics shall not be littered. The labelling must be clear, must not confuse (bio-based can be confused with biodegradable) and must contain sorting instructions (biowaste bin vs. "yellow bin") in agreement with the recycling industry (composters, plastics recyclers; EC 2019).

Figure 4 : Certified logos for compostable packaging: 'Seedling' logo via TÜV AUSTRIA Belgium or DIN CERTCO, 'OK compost' label via TÜV AUSTRIA Belgium.[37]

PR#29: At EU level, develop and advertise a European standard specifying the conditions for home composting of biodegradable plastics instead of several national standards (e.g., French standard NF T 51-800).[38]

PR#30: At national level, integrate the mandatory use of compostable bioplastic bags - facilitating organic waste collection - into national legislation as for example in the Spanish national Law 7/2022, where biowaste must be collected in compostable bags that comply with the European standard EN 13432:2000 or other European and national standards on the compostability of plastics, resulting in less contamination with non-degradable plastic bags. The **good practice example of Milan** shows that the use of ventilated kitchen-bins, together with compostable (EN 13342 certified) biowaste bags (see Figure 5) leads to a high acceptance among citizens and the share of non-

[36] https://www.conai.org/en/news/conai-determines-ad-hoc-fee-modulation-for-bioplastic-packaging/
[37] https://www.european-bioplastics.org/bioplastics/materials/biodegradable/
[38] https://norminfo.afnor.org/norme/nf-t51-800/plastiques-specifications-pour-les-plastiques-aptes-au-compostage-domestique/108638

compostable plastic bags is significantly reduced (total impurities rate <5% in 2019).[39] However, it must be stressed that **local anaerobic digestion and composting plant operators need to be involved** in this process to ensure the feasibility of the composting process in their treatment plant: In many composting facilities, bioplastic bags are sorted out and consequently disposed of together with non-biodegradable bags, as they are indistinguishable before entering the composting process.In other cases, composting takes place without sorting before composting, so that the biodegradable plastics are degraded and only the remaining non-biodegradable contaminants are screened out during sorting after composting. In the case of methanitzation process it cannot be guaranteed that bags enter the digestor or, if they do so, end up digested.

Figure 5: Distributed household kits including informative leaflets and cards, compostable bags and 10l ventilated kitchen bins as initial equipment (free of charge) to optimize the collection service in Milan.[40]

3.2. Policy recommendations for the PP forestry residues value chain

Introduction to the PP pilot area

In the case study of Pazardzhik Province (PP), the value chain of forestry wood biomass residues is analysed. Currently, forestry residues are mainly used for wood pellet production. The exact amount of residues left on the forest ground is unknown. However, the local partner REAP estimated that about 35% of the forestry residues remain unused in the forest. This value chain was selected as a sustainable collection of unused forestry residues in PP may lead to new business opportunities with positive environmental (less forest fires) and economic impacts. Two alternative scenarios were considered: (i) cogeneration of electricity and heat (bioenergy) and (ii) valorisation of the lignocellulosic fraction for the production of biochemicals (Figure 6).

Chapter 3.2.1 gives general PR on forestry residue collection - from analysis of the current status, recommendation of collection or non-collection of forestry residues and financial incentives. Chapter 3.2.2 deals with PR on biochemicals and bioenergy from forestry residues.

[39] https://www.municipalwasteeurope.eu/sites/default/files/6.Danilo%20Vismara.pdf
[40] https://www.municipalwasteeurope.eu/sites/default/files/6.Danilo%20Vismara.pdf

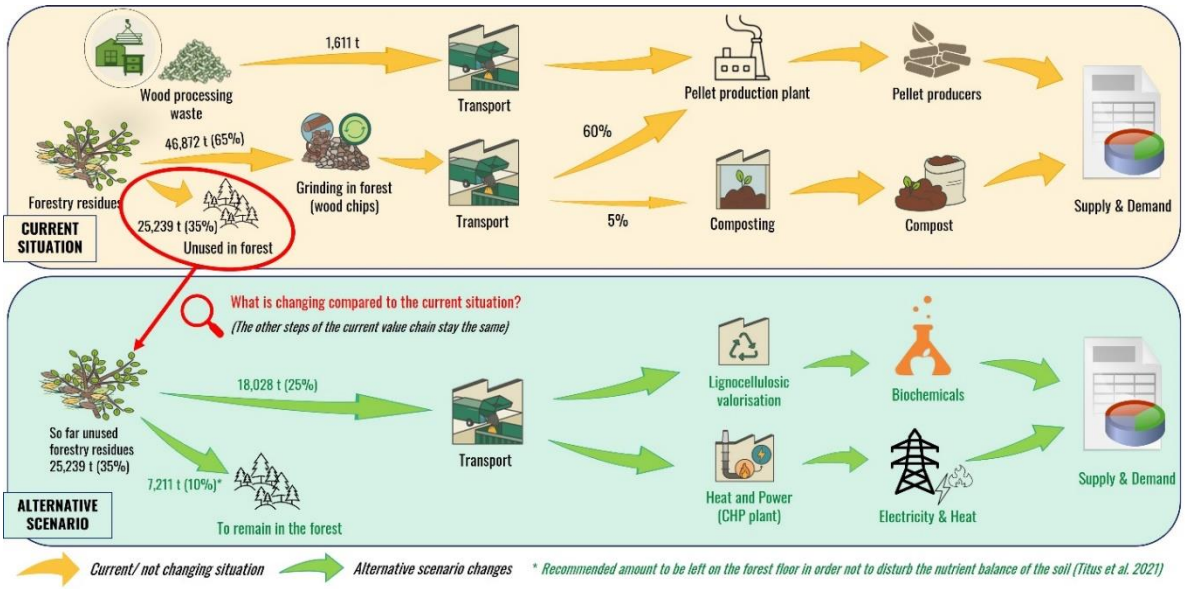


Figure 6 : Forestry residues chain in PP - Current situation and alternative scenario.

3.2.1. Forestry residues collection

Directive (EU) 2018/2001 on the promotion of the use of energy from renewable sources aims at ensuring that despite the growing demand for forest biomass, harvesting is carried out in a sustainable manner in forests where regeneration is ensured, and that special attention is given to areas that shall be explicitly designated for the protection of biodiversity.

PR#31: At regional level, introduce legislation such as the "Bioeconomy Strategy of Catalonia 2021-2030" (GOV/141/2021), which, among others, aims at (i) improving the use of Catalonia's biomass through characterisation, quantification, optimisation of management and distribution and (ii) promoting the use and consumption of bioenergy, together with biomaterials.

PR#32: At national and regional level, provide financial support for the development of a good, transparent database on forestry residues (type, quantity, quality) for the evaluation of potential collection and treatment systems. The existence of general data facilitates the decision on whether the collection of forestry residues is generally useful or not. For the planning of new biorefinery processes, a preliminary assessment of forestry data (type, quantity, quality, location) is necessary. This includes an assessment of soil characteristics, forest species composition, topography, type of forest management, i.e., the area from which timber is taken and whether it is clear-cut or continuously managed, etc. Informal collection of firewood by citizens must also be taken into account to determine the actual amount of wood remaining on site.

PR#33: At national level, funding should be made available for local environmental impact assessments to determine the range between forestry residues that must remain on the ground for environmental reasons and residues that can be used to produce new bio-based products. In PP, the removal of forestry residues should help reduce the risk of forest fires. The European Commission (EC 2021) identified the following risks of forestry residues removal: (i) removal of nutrients may lead to productivity losses in the long term, while reducing nitrate

leaching; (ii) removal of carbon sources could lead to a decrease in soil organic carbon in the long term (with all the associated impacts on the forest ecosystem), while removing a CO_2 source through respiration and decomposition; (iii) substrates on which all saproxylic species depend are removed. In addition, logging residues collection and removal practices carry risks such as the removal or damage of other deadwood with high ecological value (e.g., older stumps/logs or other coarse woody debris) and the creation of ecological traps when logging piles are left in the forest and then removed. According to a review of current residue harvesting guidelines for a sustainable forest management, between 10% to 30% of the forestry residues should be left on the soil in order to maintain nutrient circles and biodiversity (Titus et al. 2021).

PR#34: **At national level, finance fire risk assessments:** It is also necessary to assess whether forest fires – which severely affect flora, fauna and human health and increase GHG emissions – are of natural or anthropogenic origin, and in the latter case whether they are deliberately set to remove residues, and whether they are local ("controlled") or spreading.

PR#35: **At national level, introduce a fee and incentive scheme to promote the pre-treatment and sustainable collection of forestry waste for biorefineries** – especially in difficult terrain – also with a view to reducing the costs of firefighting and reforestation after fires.

PR#36: **At regional level, provide financial support for the efficiency improvement of existing collection, storage, and transport facilities for forestry residues.** Introduce new regional biomass logistics centres.

3.2.2. Biochemicals and bioenergy from forestry residues

It is important to underline that bioenergy based on the "cascading use of biomass principle" is not the priority option (see chapter 3.1.2). When forestry residues, food and feed crops are used for energy purpose, the sustainability aspect has been identified as the most important issue to be clarified before a decision on collection and use for alternative value chains is made. The **EU Biodiversity Strategy for 2030**[41] (COM/2020/380 final) provides relevant guidance to be considered in this context.

PR#37: **At national or regional level, adopt a Bulgarian bioeconomy strategy**. An example at regional level is the Bioeconomy Strategy of Catalonia 2021-2030 (GOV/141/2021) which includes objectives such as (i) improving the use of Catalonia's biomass through characterisation, quantification, optimisation of management and distribution, (ii) promoting the use and consumption of bioenergy, together with bioproducts and biomaterials, (iii) strengthening the role of the administration and adapting the regulatory framework to promote the CBE.

PR#38: **At regional level, introduce long-term forest management to create more planning security for biorefineries and promote sustainable forest management at regional level, but also for privately owned forests.** Currently, most forests in Bulgaria are owned and managed by the state. However, municipal administrations (such as PP) that are dissatisfied with the state administration often file lawsuits against the state forestry agency to regain management and ownership of the forests, which leads to changes in ownership between the state and the

[41] https://environment.ec.europa.eu/strategy/biodiversity-strategy-2030_en

municipality. At the same time, a reprivatisation process has taken place in Bulgaria over the last 2-3 decades. During the communist era, much private property (including forests and agricultural land) was confiscated by the state. Nowadays, the state offers the return of land to former private owners. However, this process is long and complex and sustainable forest management must also be guaranteed for privately owned forests.

PR#39: **At national level, promote the compliance with certification schemes for responsible forest management such as the Forest Stewardship Council (FSC)**.[42]

PR#40: **At regional level, provide financial support for the evaluation of the environmental and economic benefits of forestry residues collection, storage, and processing into different biowaste products** (e.g., biochemicals, bioenergy) while **giving financial support for implementing the most suitable local option**, considering local infrastructure, local industry, available subsidies etc.

PR#41: **At national level, introduce financial incentives to produce bioenergy (feed-in tariffs) or biochemicals (e.g., tax reduction) from forestry residues.**

PR#42: **At EU level, give financial support to the long-term implementation of forestry residues research projects such as the BBI-JU H2020 project SWEETWOODS,**[43] which uses a novel pre-treatment technology in combination with innovative enzymatic solutions to provide sugar recovery levels of over 90% and exceptionally high-quality lignin. The focus should be set on countries with a currently low share of biorefineries.

PR#43: **At national and regional level, give support to international good practices and experience exchange (round tables, platforms)** on forestry residues collection, storage, and processing into bio-based products – especially concerning rural areas with similar landscapes and SMEs.

[42] https://fsc.org/en

[43] https://sweetwoods.eu/

3.3. Policy recommendations for the MCN agro-industrial organic waste value chain

Introduction to the MCN pilot area

The selected biowaste stream for the Metropolitan City of Naples (MCN) is coffee silverskin, a thin tegument, which is located directly around the two beans of the coffee cherry and accounts for about 90% (by weight) of the total residues from coffee roasting (besides broken and unsuitable coffee beans). Currently, in the MCN this type of waste is treated in a composting plant together with other agro-industrial and green waste (Figure 7). This chain was chosen as an example of biowaste from the agro-industrial sector because the alternative value chain is new and primary data are available. The case study under investigation is already running at pilot scale in the MCN: It is based on 20 tonnes of coffee silverskin recovered from an industry that roasted around 2,600 tonnes of coffee in 2021 – around 3% of the 95,700 tonnes of total coffee roasted in the MCN.

In the alternative scenario, pelletised coffee silverskin is processed into functional ingredients that can be used in a local bakery to produce baked goods. According to Nolasco et al. (2022a, 2022b), coffee silverskin has a great potential for use in the food sector due to its nutritional profile, as it contains about 19% protein and about 35% fibre and has a low fat content (3.0%). Coffee silverskin is suggested to be used as dietary fibre source, for example in bakery products (breads, biscuits) or beverages (e.g., tea; Klingel et al. 2020). In addition to that it could be incorporated into different polymer matrices (Hejna et al. 2021) or for the production of biodegradable packaging (Garcia & Young-Teck 2021).

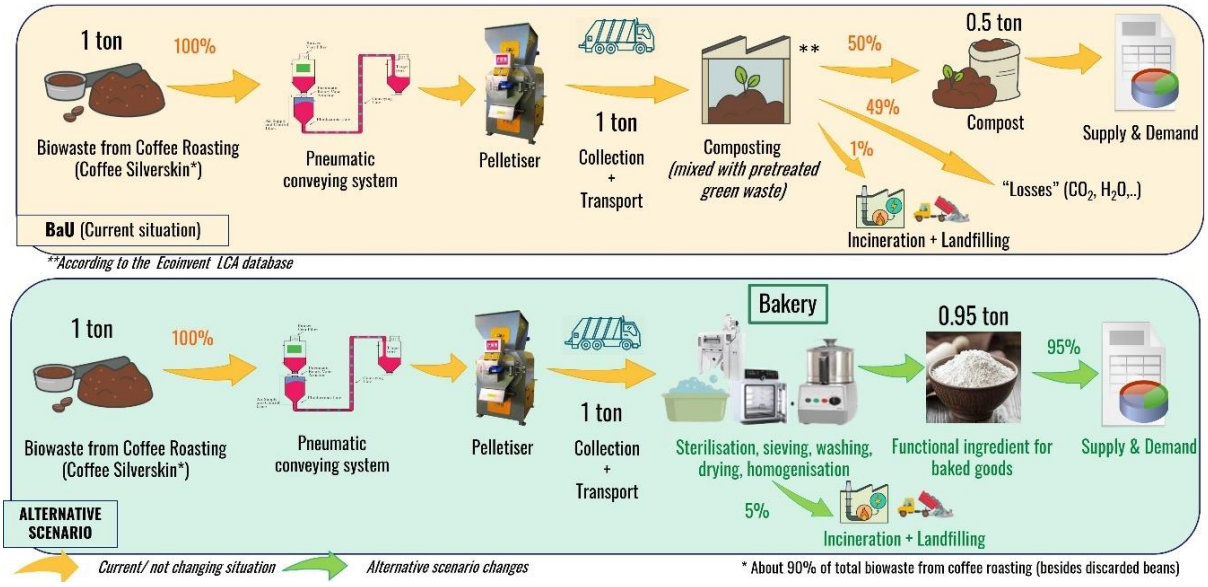


Figure 7 : Agro-industrial biowaste (coffee residues) in the MCN - Current situation and alternative scenario.

There is a great variety of valorisation and bio-based product options for agro-industrial organic waste and by-products, including also the production of biogas/biomethane and compost (additional details are provided in chapters 3.4.4 and 3.4.5). According to the cascading use of biomass principle, novel food has a higher priority, which is why it was selected for the MCN value chain and discussed below in chapter 3.3.2.

3.3.1. Using agro-industrial by-products

According to the **European Green Deal** (COM/2019/640 final), EU businesses should benefit from a robust and integrated **single market for secondary raw materials and by-products**. The **Farm to Fork strategy**[44] also aims at reducing the environmental impacts of food processing and retailing through measures on transport, storage, packaging, and food waste. This will also strengthen the enforcement and investigation capacities at EU level and launching a process to identify new innovative food and feed products.

A by-product is defined as a substance or object resulting from a production process whose primary aim is not the production of that substance or object that can only be regarded as a by-product rather than as waste if (a) further use of the substance or object is certain; (b) the substance or object can be used directly without any further processing other than normal industrial practice, c) the substance or object is produced as an integral part of a production process; and d) further use is lawful, i.e., the substance or object fulfils all relevant product, environmental and health protection requirements for the specific use and will not lead to overall adverse environmental or human health impacts (Directive 2008/98/EC).

As the use of waste is much more restricted than the use of by-products, it is crucial to enable, wherever possible, a classification as "agro-industrial by-product", meaning discarded organic materials produced from the raising of plants and animals as part of agronomic, floricultural, horticultural, silvicultural, vinicultural, or viticultural operations including, but not limited to, animal manure, bedding materials, plant stalk, leaves, other vegetative matter and discarded by-product from the on farm processing of fruits and vegetables.[45]

PR#44: At national level, introduce financial incentives and administrative and technical support for companies to use their by-products (e.g., coffee silverskin) **internally for the production of new products** (e.g., functional food) **to avoid classification as waste. In addition, incentivise local industrial symbiosis,** i.e., the physical exchange of resources, energy and/or by-products among different industries to contribute to the greening of industry and the development of circular economies and organic waste-based products on regional and local level as it is suggested in the "Communication on a sustainable bioeconomy for Europe (COM/2018/673 final). **A good practice example** of using by-products in an industrial environment is the cooperation between an energy company and a beverage producer in **Lahti, Finland**. This partnership sets an example of successful local industrial symbiosis and bio-based circular economy, where by-products of the food industry are utilized to produce fuel. At the Lahiti Etanolix production plant, bio-based process residues from beverage production and waste materials from the local grain industry are used to produce bioethanol. This bioethanol is then blended with petrol to produce bio-based fuel for vehicles with a bioethanol concentration of 80%. Waste, consisting of residual yeast and beverages, accounts for 30-40%of the total material for bioethanol production. The location of the energy plant next to the beverage plant allows for easy transfer of the yeast between the two plants.[46]

[44] https://food.ec.europa.eu/horizontal-topics/farm-fork-strategy_en

[45] https://www.lawinsider.com/dictionary/agricultural-byproduct

[46] https://www.interregeurope.eu/good-practices/bioethanol-from-by-products-of-food-industry

PR#45: At EU level, establish standardized end-of-waste criteria for agro-industrial organic waste categories, similarly to what was done for e.g., scrap metals (Council Regulation (EU) 333/2011), glass (Commission Regulation (EU) No 1179/2012) or fertilising products (Regulation (EU) 2019/1009).

PR#46: At national level, reduce bureaucracy and create a fast-track procedure for obtaining waste management licences for actors who recover or recycle agro-industrial organic waste. Currently, such assessments are sometimes even organised at regional level, are not standardised and the process can be very lengthy.

PR#47: At national level, create financial incentives for decentralised biorefineries for agro-industrial waste streams and thus also jobs in rural areas. So far, for logistic and economic reasons, agro-industrial waste streams are often treated together with municipal biowaste in composting and anaerobic treatment plants.

PR#48: At national level, set up collection systems (separated streams) for agro-industrial organic waste: Give financial incentives to companies or businesses to collect and store a certain waste stream (e.g., collection of spent coffee grounds in cafeterias) and for the use of "soft" transport (e.g., bicycles) for new biowaste collection chains (e.g., coffee grounds) in urban areas to limit the impact of transport related GHG emissions.

PR#49: At national level, provide financial support for laboratory analyses in support of risks assessments for EFSA (European Food Safety Authority), which provides independent scientific advice and informs on existing and emerging risks in the food chain[47] **and ECHA** (European Chemicals Agency), responsible for the registration, evaluation, authorisation and restriction of (bio)chemicals,[48] **with a view to granting market authorisation.**

PR#50: At national level, fund the creation of an updated, comprehensive, and transparent online database (or web application) to create a good understanding of the unutilized biomass potential in agro-industrial waste streams. Providing information on quantity, quality, and location to the BBI, public authorities and research institutions.

PR#51: At regional and local level, introduce start-up events for potential feedstocks and innovative products, such as functional food from coffee residues. Create collaboration between agro-industry, BBI, researchers etc. for the use of biowaste and by-products.

PR#52: At regional level, introduce awareness raising campaigns targeted at large companies on the topic of "biocircular life cycle thinking", e.g., in the coffee sector – from agricultural cultivation, to processing, the potential use of by-products, packaging types and recycling options (e.g., capsules vs. pads vs. conventional coffee packaging) and waste management.

[47] https://www.efsa.europa.eu/en

[48] https://echa.europa.eu/

3.3.2. Novel Food

In order to be included in the list of novel foods, any food which corresponds to one of the categories defined in Article 3(2)(a) of **Regulation (EU) No 2015/2283 on novel foods** and which was not used for human consumption to a significant degree within the EU before 15 May 1997 must undergo an authorisation procedure[49]. In this context, novel technologies in food production processes that may have an impact on food and thus on food safety, i.e., production processes that were not used for food production in the EU before 15 May 1997 and that lead to significant changes in the composition or structure of a food affecting its nutritional value, metabolism, or level of undesirable substances, shall also be assessed. In addition, requirements for the use and labelling of novel foods to avoid harm to (human) health and the environment have to be met. Furthermore, foods may not be replaced by novel foods if the latter are nutritionally less beneficial, in order to protect consumer health.

Since the new EU Novel Food Regulation came into force in January 2018, the procedure for the scientific risk assessment of a novel food application has been centralised. The **European Food Safety Authority (EFSA)** carries out risk assessments on the safety of a novel food at the request of the European Commission.[50]

Coffee silverskin (relevant to the Italian BCC pilot area) was listed as a novel food (category: "Foodstuffs from plants or parts of plants")[51] according to the **Regulation (EU) 2015/2283 on novel foods.**[50] As novel foods require pre-market authorisation, the **European Food Safety Authority (EFSA)** is currently carrying out a risk assessment.[52]

PR#53: At national level, provide financial support to SMEs for laboratory analyses in support of EFSA's mandatory health risk assessment of novel foods with a view to granting market authorisation (minimum 2-year process). The data requirements for novel food applications are outlined in "EFSA Guidance on the preparation and presentation of an application for authorisation of a novel food in the context of Regulation (EU) 2015/2283", i.e., the description of the novel food, production process, compositional data, specification, proposed uses and use levels, and anticipated intake of the novel food. In addition, data on the history of use of the novel food and/or its source, absorption, distribution, metabolism, excretion, nutritional information, toxicological information and allergenicity should be included by the applicant (EFSA NDA Panel 2021). EFSA has a legal deadline to adopt its scientific opinion within 9 months from the date of receipt of a valid application from the EC.

PR#54: At national level, establish a counselling centre for consulting applicants with the scientific requirements set by EFSA for novel food applications: The requirements for risk assessment of novel foods are interlinked and only a rigorous and cross-cutting approach taken by applicants in preparing their respective application dossiers can result in scientifically sound dossiers (Ververis et al. 2020). **Advise start-ups on market approval procedures for novel foods** (e.g., via webinars).

PR#55: At regional and local level, support education campaigns for people (of all ages) about the benefits of using sustainable, locally produced bio-based products compared to conventional alternatives **to increase the demand**

[49] https://food.ec.europa.eu/safety/novel-food/consultation-process-novel-food-status_en

[50] https://www.efsa.europa.eu/en/topics/topic/novel-food

[51] https://food.ec.europa.eu/system/files/2022-06/novel-food_consult-status_2022-4778355.pdf

[52] https://multimedia.efsa.europa.eu/riskassessment/index.htm

for bio-based products. For (novel) food and feed, the focus should be on ensuring health safety and reducing consumer aversion to products made from organic waste. An example of **good practice is the BIOBRIDGES project**, which focused on improving the marketability of bio-based products by fostering close cooperation and partnerships between BBI, brand owners and consumer representatives.

3.4. Policy recommendations based on the MAB municipal biowaste value chain

Introduction to the MAB pilot area

The case study of the Metropolitan Area of Barcelona (MAB) analysed the current treatment of separately collected biowaste in one of the MAB's biowaste treatment facilities (Ecoparc 2).[53] The alternative scenario proposed foresees: (i) the introduction of prevention measures to reduce the generation of organic waste (assumption: 5% reduction), (ii) a change in the separate collection of biowaste from open street containers to door-to-door (DtD) collection and/or smart bins to increase the quality and quantity of biowaste collected (assumption: 30% increase, thus generating a net 25% increase taking into account the reduction of 5% for the application of prevention measures), and (iii) the upgrading of the biogas produced from anaerobic digestion into biomethane to be injected into the local gas grid or to be used as biofuel (Figure 8). At present, 40% of the energy produced from the biogas delivered to the CHP unit is used for the plant's own consumption. An increase in the amount of high quality biowaste collected would also lead to an increase in the organic fraction to be fermented into biogas. With the planned improvement of the biowaste collection system, the quantity and quality of compost from post-composting of digestate would also increase.

On the one hand, the policy recommendations for the MAB chain focus on biowaste prevention (chapter 3.4.1). Food waste prevention measures need to be considered when planning long-term biowaste feedstock supply for valorisation technologies. On the other hand, they focus on biowaste source separation. In accordance with the European Biogas Association, improving the quality and quantity of source-separated biowaste (chapter 3.4.2) is the most important requirement for the development of new biowaste value chains such as the production of biomethane (see Figure 9). Chapter 4.3 also contains some PR measures on food waste prevention and separate collection (highlighted in purple) that are already applied in Spain (e.g., the introduction of landfill taxes) but are still missing in other European countries. In addition to increasing the feedstock (separately collected biowaste), the number and size of anaerobic digestion plants must also be increased (chapter 3.4.3) in order to enhance the production of biogas and thus biomethane. Separate recommendations on biomethane are summarised in chapter 3.4.4. Policy recommendations for compost from composting of digestate from anaerobic digestion or direct composting of source-separated biowaste, are presented in chapter 3.4.5.

[53] https://www.amb.cat/es/web/ecologia/residus/instalacions-i-equipaments/detall/-/equipament/ecoparc-2-montcada-i-reixac/352170/11818

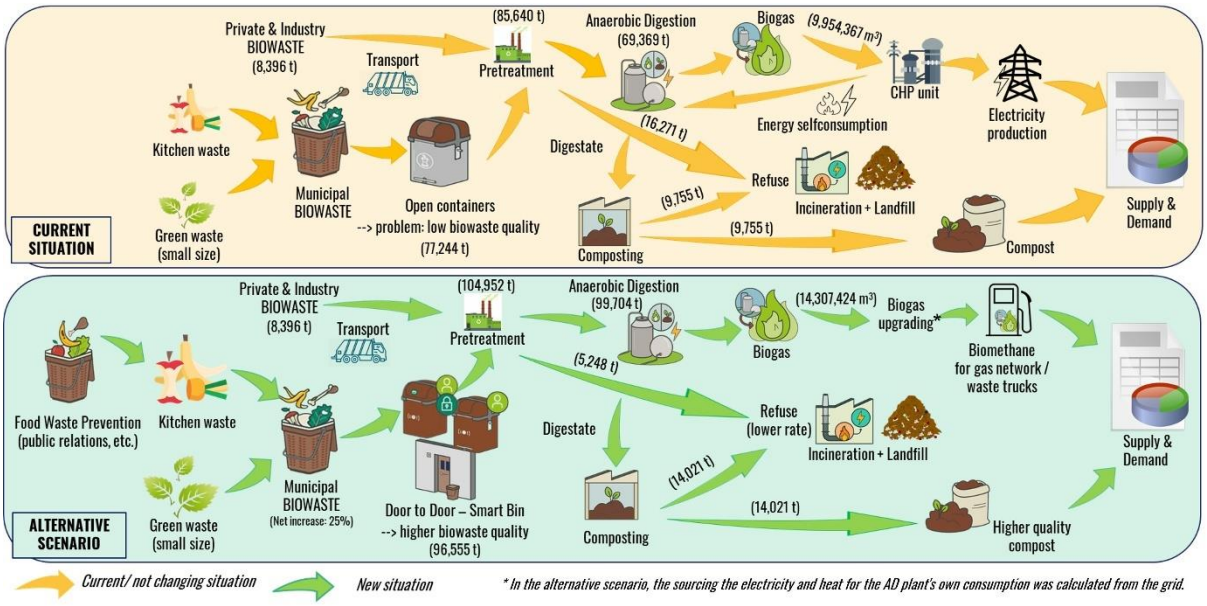


Figure 8 : Municipal biowaste value chain in the MAB - Current situation and alternative scenario.

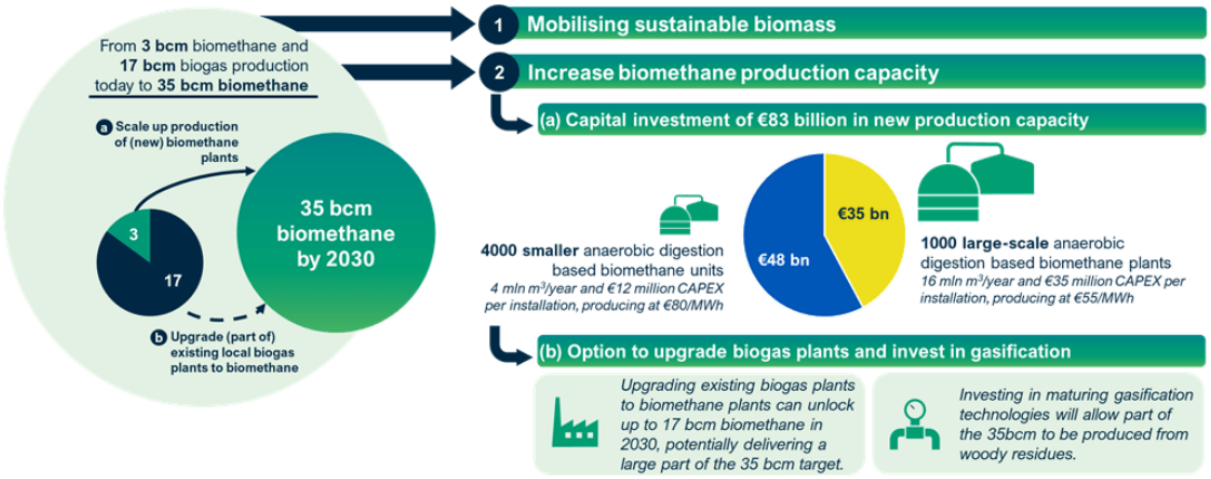


Figure 9: What it takes to produce 35 bcm biomethane by 2030 according to the European Biogas Association.[54]

[54] https://www.europeanbiogas.eu/commission-announces-groundbreaking-biomethane-target-repowereu-to-cut-dependence-on-russian-gas/

3.4.1. Biowaste prevention

At EU level, in line with the first priority of the waste hierarchy (prevention) from Directive 2008/98/EC on waste (amended by Directive (EU) 2018/851), special emphasis is placed on the **prevention of food waste** as it constitutes an important part of biowaste. As part of the 2015 Circular Economy Action Plan, the EU has implemented a dedicated Action Plan to reduce food loss and waste, comprising both regulatory and non-regulatory actions. As established in the **EU Farm-to-Fork Strategy**[55] – one major part of the **European Green Deal** (COM/2019/640 final)[56] – and as part of Directive (EU) 2018/851 on waste, Member States are requested to adopt specific food waste prevention programmes within their waste prevention programmes, to monitor and assess the implementation of their food waste prevention measures by evaluating the levels of food waste on the basis of a defined standard methodology (Commission Delegated Decision (EU) 2019/1597).

Following that, the **EU COM/2020/98 final** (Communication on a new Circular Economy Action Plan for a cleaner and more competitive Europe) includes the **United Nations Sustainable Development Goal (SDG) 12.3**[57]**, targeting responsible consumption and production** to halve the per capita global food waste at the retail and consumer levels, and to reduce food losses along production processes and supply chains by 2030. To boost the EU's progress towards this target, the Commission is proposing that MSs **cut food waste in processing and manufacturing by 10% and in retail and consumption** (restaurants, food services and households) **by 30% (per capita) by 2030** (COM/2023/420 final). The results of the first EU-wide annual monitoring of food waste volumes (131 kg per inhabitant in 2020)[58] provides the basis for assessing progress. By the end of 2027, a formal review of progress made by MS will take place, with the possibility to correct course if there is evidence that the EU can contribute even more to the global target. Moreover, each MS shall take appropriate measures to ensure the reliability and accuracy of the measurements of food waste, report the data and submit the quality check report.

PR#56: At national and regional level, introduce effective strategic Food Waste Prevention Programmes integrating the EU targets for reducing food waste in processing and manufacturing. The different stages of the food supply chain need to be measured separately in primary production, in processing and manufacturing, in retail and other distribution of food, in restaurants and food services as well as in households. **Define and finance appropriate measures and actions to achieve the targets and set a special focus on large producers** such as restaurants, (school) canteens, hotels, supermarkets, and hospitals. Monitoring of the target achievement according to the "Guidance on reporting of data on food waste and food waste prevention" (EC Eurostat 2022)[59]. **At local level, support municipalities in developing food waste prevention programmes and plans in line with**

[55] https://food.ec.europa.eu/horizontal-topics/farm-fork-strategy_en

[56] https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_en

[57] https://sdg12hub.org/sdg-12-hub/see-progress-on-sdg-12-by-target/123-food-loss-waste

[58] https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Food_waste_and_food_waste_prevention_-_estimates

[59] https://ec.europa.eu/eurostat/documents/342366/351811/Guidance+on+food+waste+reporting/5581b0a2-b09e-adc0-4e0a-b20062dfe564

national targets (according to the AMB Metropolitan Waste Prevention Plan 2025[60]). **At regional and local level, executing fines for not meeting the accurate food waste reporting and food waste prevention targets.**

PR#57: **At national level, implement the Commission Delegated Decision (EU) 2019/1597** as regards a common **methodology and minimum quality requirements** for the uniform measurement of levels of food waste, which defines that the **amounts of food waste shall be measured annually separately for the different stages of the food supply chain**, i.e., primary production, processing and manufacturing, retail and other distribution of food, restaurants and food services and household, and defines specifications for the measurement. A standard methodology for food waste datasets is essential to make targets measurable and realistic and to make food waste prevention measures at national, regional, and local level more comparable among Member States, thus providing the basis for the exchange of appropriate good practices.

PR#58: **At national level, establish a platform that brings together all stakeholders to work together on measures and actions to reduce food waste.** An example is the Italian National Food Waste Prevention Plan (PINPAS) in 2016 which includes the "Italy - Country Report on National Food Waste Policy"[61] published by the "**Task Force no.5 - Analysis and elaboration of food waste reduction models**", summarising an extensive consultation with the main stakeholders of the Italian food industry, which identified the main measures to be taken at national level to combat food waste.

PR#59: **At national level, introduce 'Pay-as-you-throw' (PAYT) schemes** that charge waste producers on the basis of the actual amount of waste generated (see PR#69, chapter 3.4.2) **At local level, municipalities may consider to grant a reduction in municipal waste fees to commercial users who implement waste prevention measures**.

PR#60: **At regional level, provide more economic incentives to donate food or process products that have not been sold but are still fit for consumption**, prioritising human consumption over the use as animal feed and processing into non-food products (according to national Law 7/2022). **Simplifying administration and logistics for the donation of surplus food**, such as the possibility of donating food with expired best-before dates, the possibility of donating bakery products that do not need to be thermally conditioned 24 hours after production, the possibility of donating food with labelling errors and the easing of liability issues in the case of gleaning, such as integrated in **Italian national Law No. 166 of 19 August 2016** on the donation and distribution of food and pharmaceutical products. Financial support for investment in new ways to collect and recycle food before it becomes waste in food manufacturing and processing, where new investments in technologies are needed to secure cooling chains or redistribute food that is still edible.

PR#61: **At regional level, ensure the implementation of Law 3/2020 of 11 March on the Prevention of Food Losses and Waste in Catalonia including sanctions for non-compliance**. As part of Law 3/2020, **food businesses, social initiatives and other non-profit organisations involved in food distribution need to ensure that their employees are trained** to actively participate in food waste reduction and involve them in these actions. In addition, measures

[60] https://bop.diba.cat/anunci/3432670/aprovacio-inicial-del-pla-metropolita-de-prevencio-de-residus-2025-area-metropolitana-de-barcelona

[61] https://www.eu-fusions.org/phocadownload/country-report/FUSIONS_IT%20Country%20Report%2030.06.16.pdf

shall be implemented to promote the sale of products with a best before date or a near expiry date, promoting the sale lines of products with defects or damage, facilitating the creation of spaces and systems for the distribution of surplus food and providing funding for food waste reduction and job creation projects for disadvantaged groups.

PR#62: **At regional level, promote the good practice exchange initiatives such as the Milan Urban Food Policy Pact**, an international pact launched in 2015 by the Milan Municipality and signed by >200 cities worldwide committed to support cities wishing to develop more sustainable urban food systems by fostering city to city cooperation and good practices exchange. Each participating city needs to evaluate the following indicators: 1) Total annual volume of food losses and waste; 2) Annual number of events and campaigns aimed at decreasing food loss and waste; 3) Presence of policies or regulations that address food waste prevention, recovery and redistribution; 4) Total annual volume of surplus food recovered and redistributed for direct human consumption.[62] **Disseminate the results of the "EUROCITIES Working Group Food"**, which is, among others, mapping actors, actions and goals connected to food waste prevention in different cities (Figure 10).

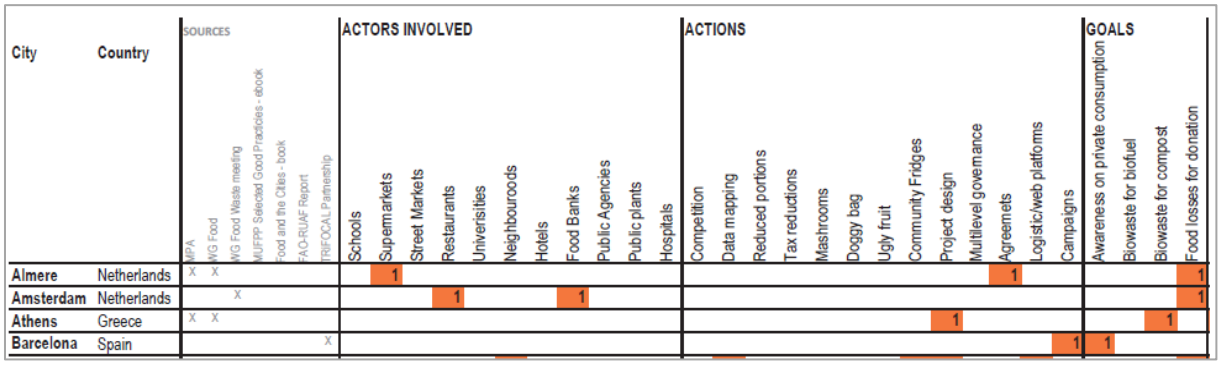


Figure 10: Excerpt of the EUROCITIES Working Group Food on relationships between urban actors and measures (Margarini et al. 2018).

PR#63: **At national level, finance well-elaborated food waste prevention campaigns** for food producers and processors and retailers and the general public ("How to reduce food waste in your daily life": planning for shopping, use leftovers, sharing and donating food etc.).[63] It is also important to promoting educational programmes to reduce food waste in school canteens, hospitals, nursing homes, etc. A **good practice example** for measures **involving school canteens** is the **City of Paris**, which introduced an adjustment of food portion sizes and encourages pupils to choose between two sizes of plates including mini portions etc. in order to reduce left-overs.[64] Another example to be introduced at national level are **Catalan guidelines** to prevent food waste at schools, hospitals, restaurants (Departament d'Acció Climàtica, Alimentació i Agenda Rural)[65] and the Catalan catalogue of actions (tools, advice, recipes...) to avoid food waste (Som gent de profit).[66] The **LIFE-Food.Waste.StandUp** project

[62] https://www.milanurbanfoodpolicypact.org/

[63] https://food.ec.europa.eu/system/files/2020-06/fw_lib_poster_reduce-food-waste-daily_en.pdf

[64] https://www.paris.fr/pages/la-ville-de-paris-poursuit-son-engagement-dans-la-lutte-contre-le-gaspillage-alimentaire-7264

[65] https://agricultura.gencat.cat/ca/ambits/alimentacio/malbaratament-alimentari/documents-interes/

[66] https://somgentdeprofit.cat

raised awareness of surplus food management among agri-food companies, food retailers and consumers. This aim was successfully accomplished by means of promoting and disseminating information, enhancing awareness and knowledge, providing backing for the implementation of the Italian food waste legislation, and fostering the development of synergistic collaborations among stakeholders within the food supply chain.[67]

PR#64: **At regional and local level, promote the consumption agricultural products which are not meeting the product standards of supermarkets** ("too small, too big, or misshapen" fruit and vegetables). A good practice example is the **Portuguese initiative "Fruta Feia - Beautiful People Eat Ugly Food"**, founded in 2013, which works directly with 310 local farmers from all over Portugal to buy up the fruit and vegetables they cannot sell to supermarkets and, resell them to consumers at 16 delivery points (8 in Lisbon, 1 in Amadora, 2 in Cascais, 1 in Almada, 2 in Porto, 1 in Gaia and 1 in Matosinhos) for very low prices, reaching 8,000 costumers.[68] **In addition, the sale of "misshapen" fruit and vegetables in the supermarkets should be promoted,** as for **example** done by the Austrian retailer "BILLA AG", who sells fruit and vegetables with small and large blemishes under an own **brand called "Wunderlinge".**[69]

PR#65: **At regional level, promote and fund the introduction of "doggie bags"** to take away leftovers from restaurants for later consumption, e.g., Rest-O-Pack Brussels[70] or Restorestje Gent[71]. In addition, **give financial support to promotional campaigns for initiatives such as the multinational "Too good to go" app[72] or the French "Phenix Anti-Gaspi" app**[73], which allow unsold food from shops and restaurants to be collected locally in the form of baskets at small prices.

3.4.2. Separate Biowaste Collection

At EU level, the amending Directive 2018/851 on waste introduced new **preparation for reuse and recycling targets for MSW**, including biowaste: **55%, 60% and 65% (by weight) by 2025, 2030 and 2035**. Another important European piece of legislation for separate biowaste collection is Directive (EU) 2018/850 on the landfill of waste that prohibits the landfilling of separately collected biodegradable waste and includes a **maximum target of 10% of MSW (by weight) to be landfilled by 2035,** hence promoting separate biowaste collection and the construction of new biowaste treatment plants.

In addition, Member States are required to separate and recycle biowaste at source or **collect biowaste separately by 31 December 2023** (Directive (EU) 2018/851). **In Spain,** this target has been introduced into National Law 7/2022 on Waste and Contaminated Soils for a Circular Economy. However, in **Catalonia**, the promotion of separate

[67] https://webgate.ec.europa.eu/life/publicWebsite/index.cfm?fuseaction=search.dspPage&n_proj_id=5825

[68] https://frutafeia.pt/pt

[69] https://www.billa.at/sortiment-und-eigenmarken/eigenmarken/die-wunderlinge

[70] https://eu-refresh.org/rest-o-pack.html

[71] https://stad.gent/nl/groen-milieu/klimaat/duurzaam-eten/vermijd-voedselverspilling/restorestje-neem-je-overschotjes-van-op-restaurant-mee

[72] https://www.toogoodtogo.com

[73] https://www.wearephenix.com/

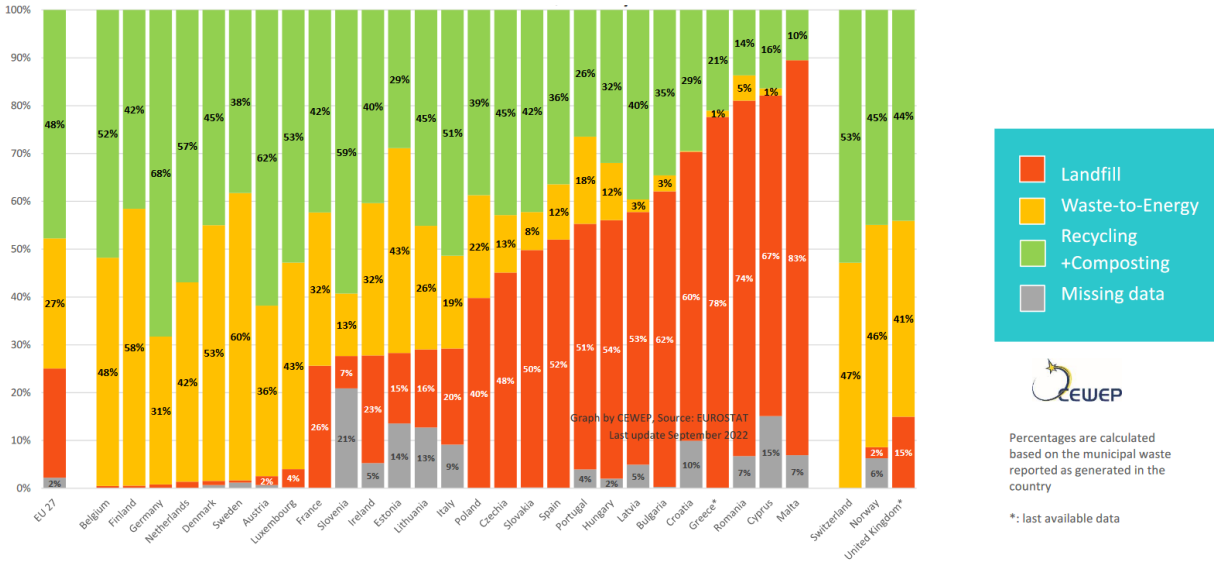
(bio)waste collection including municipalities with > 5,000 inhabitants was **already introduced in the legislation in 1993**[74] (with the implementation set for 1999) and for < 5,000 inhabitants through the regional Legislative Decree 1/2009.

The Implementing Decision (EU) 2019/1004 laying down rules for the calculation, verification, and reporting of data on waste introduces a standardised calculation method for the collection and recycling of biowaste at source and stricter calculation criteria for the recovery rate of biowaste, thus providing an additional incentive for the separate collection of biowaste.

Charges and restrictions for landfilling and incineration of (bio)waste

This measure incentivises waste prevention and recycling, while keeping landfilling the least preferred waste management option (according to Annex IV a to Directive 2008/98/EC). The landfill rate in Catalonia decreased from 43% in 2014 to 34% in 2020, fulfilling the national 35% target for 2020 (Spanish National Waste Management Framework Plan, PEMAR). The total separate collection rate in 2020 was about 46% in Catalonia,[75] almost reaching the national target of 50% (PEMAR) by 2020 but failing the regional target of 60% (PRECAT) and the local target of 55% (PREMET) by 2020. The incineration rate in Catalonia was 18% in 2020.[75] However, much remains to be done to reach the EU target of 10% by 2035.

Figure 11: Municipal waste treatment in the EU 27 + Switzerland, Norway, and the UK in 2020 (CEWEP).[76]



According to a policy paper from Zero Waste Europe (2015), analysing the introduction of landfill bans in Austria, Denmark, Germany, the Netherlands, Sweden, Norway and Switzerland, the use of landfill bans has mostly led to high incineration rates (see Figure 11) and an overcapacity of waste to energy plants, discouraging them to take

[74] Ley 6/1993, de 15 de julio, reguladora de los Residuos (repealed regulation). https://www.boe.es/eli/es-ct/l/1993/07/15/6

[75] https://residus.gencat.cat/web/.content/home/lagencia/publicacions/estadistiques/estadistiques_2020_en.pdf

[76] https://www.cewep.eu/municipal-waste-treatment-2020/

further efforts on waste prevention, reuse or recycling.[77] However, it has to be considered that the situation has changed in the meanwhile with the preparation for reuse and recycling targets for MSW of 65% (by weight) and the 10% maximum landfill target by 2035. Nevertheless, in this report we focus on incentives for the separate collection of (bio)waste and not on a landfill ban.

PR#66: **At national level - for countries that currently lack incineration and landfill taxes** (e.g., Cyprus, Croatia) - **their introduction at national level is highly recommended**.

PR#67: **At national level, increase the incineration and landfill taxes to the Catalan level:** For 2023, in **Catalonia the tax rates are 65.3 EUR/t for landfill and 32,7 EUR/t for incineration.** For 2024, an increase up to 71,6 EUR/t (landfill) and 35,8 EUR/t (incineration) is planned[78], which is significantly higher than the taxes national level. At national level, taxes were introduced in Spain in 2022 (Law 7/2022), reducing differences between regions[79]and the convenience of disposing of waste in landfills or incinerators in regions where no fees are charged. So, for entire Spain 40 EUR/t are charged for the landfilling of MSW and 20 EUR/t for MSW incineration (D10). In 2023, tax rates in Europe varied from 5 EUR/t in an Italian region to more than 110 EUR/t in parts of Belgium (Figure 12).[80] It must also be specified that the revenue from this tax may only be used for measures and investments related to the improvement of waste management (see Catalan Decree 17/2022)

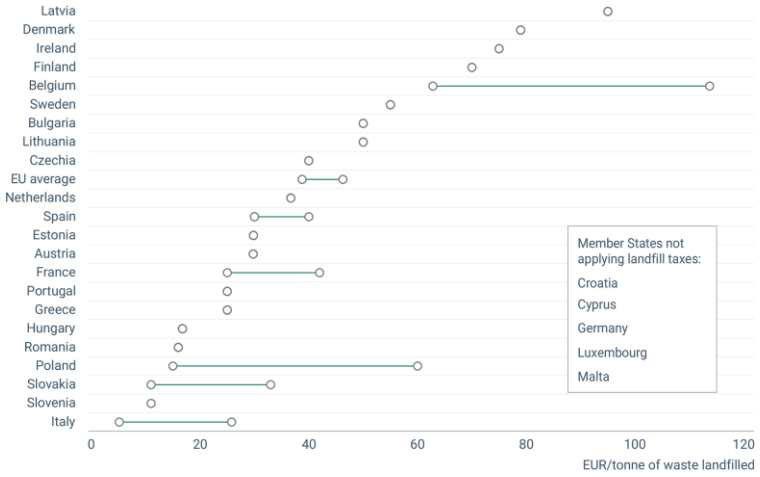


Figure 12: Overview of municipal waste landfill taxes levied in EU Member States in 2023 (EEA).[80]

PR# 68: **At EU level, Introduce binding targets for biowaste in the mixed residual waste stream** according to Zero Waste Europe "to incentivise the proper collection and recycling of bio-waste, we recommend adopting a binding reduction target on the amount of biowaste included in mixed residual waste (i.e., before landfill, incineration or

[77] https://zerowasteeurope.eu/wp-content/uploads/2015/12/zero_waste_europe_policy_paper_zero_waste_to_landfill_or_ban_en-3.pdf

[78] https://residus.gencat.cat/es/ambits_dactuacio/tipus_de_residu/residus_municipals/canons_sobre_la_disposicio_del_reb uig_dels_residus_municipals/

[79] https://www.cewep.eu/wp-content/uploads/2021/10/Landfill-taxes-and-restrictions-overview.pdf

[80] https://www.eea.europa.eu/data-and-maps/figures/overview-of-landfill-taxes-on

mechanical and biological treatment). Such a cap should be set at **25kg per capita by 2030 and 15kg per capita by 2035 of the maximum amount of biowaste in mixed residual waste per year**".[81]

Change of the biowaste collection system

PR#69: **At national level, introduce the mandatory application of the pay-as-you-throw (PAYT) principle in local waste charges.** Charging based on the actual amount of waste generated creates incentives for separating biowaste (and other recyclables) at source and reducing the amount of mixed residual waste. In Spain, according to Law 7/2022 local authorities shall introduce a charge or, where appropriate, a fee, which shall be specific, differentiated, and cover all waste management costs, and allow the introduction of PAYT schemes by 2025. **The recommendation is to have mandatory PAYT schemes at national level.** In the municipality of **Albano Laziale** (Italy),[82,83] the proportion of putrescible materials in separately collected biowaste (DtD collection with barcode containers) increased from 86%(2019) to 90%(2022) after the introduction of the PAYT system, showing an improvement in sorting behaviour. However, the introduction of PAYT has been combined with continuous information campaigns about separate collection and the benefits of well-separated collected biowaste as well as punishment (fines) of citizens who do not comply with it (ROOTS 2022).

PR#70: **At regional level, introduce sensibilisation campaigns to improve the quality of source-separated biowaste through KAYT (Know-As-You-Throw).** The **Bergamo municipality (IT)** wanted to improve the awareness of its residents to nudge behaviour by introducing a **KAYT system** in 2020 – an innovative way to provide individuals with continuous, tailored feedback so they can correct their behaviour when necessary (examples see Figure 13). The fact that people feel monitored is, in itself, an incentive to change their behaviour. The use of private messages means that not only those who are already sensitised to the topic are reached, but also those less engaged in waste reduction. In Bergamo the concept of a **'neighbourhood premium'** will also be introduced as a collective economic incentive based on the analysis of bag collection data (LIFE REthinkWASTE 2021).

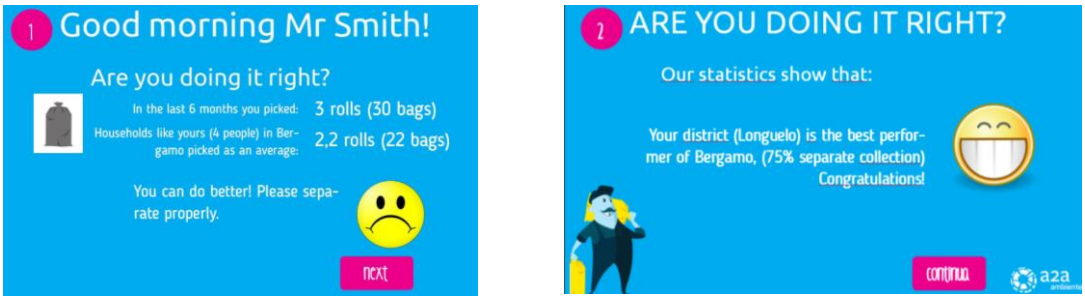


Figure 13: Draft of a sample advertisement of 'punctual information' (KAYT) in Bergamo, Italy.[84]

[81] https://zerowasteeurope.eu/wp-content/uploads/2023/06/joint_letter_-_biowaste_wfd__2__1_.pdf

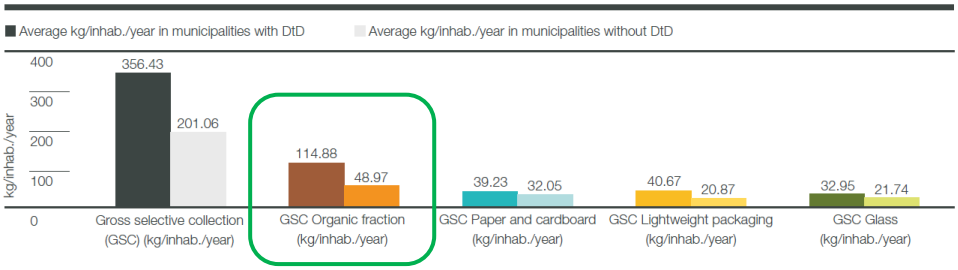
[82] https://scalibur.eu/

[83] https://hoopproject.eu/

[84] https://www.arsambiente.it/a-bergamo-kayt-2/

PR#71: At national level, introduce mandatory door-to-door (DtD) or smart bin collection in areas where there has been no bio-waste collection so far. The introduction of new "open bins" should be prohibited. Provide funding to balance the additional cost from DtD/ smart bin collection systems. Usually, the working hours (more collection points, data management in case of smart bins) and the equipment costs (more containers and - in case of smart bins - chips and sensors to weight the biowaste) are higher. In order to increase not only the quantity but also the quality of biowaste, the national Spanish Law 7/2022 provides that "Among the collection models for the above fractions to be established by local authorities, priority should be given to the most efficient collection models, such as door-to-door collection or the use of closed or smart containers that guarantee similar collection rates." **For regions with existing open container biowaste collection, introduce economic incentives for regional and local authorities for changing from open container biowaste collection to a system, where bins are associated with their users in order to achieve higher biowaste collection rates.** The cities of **Münster (Germany)** with a population of 317,713 and **Albano Laziale (Italy)** with a population of 41,598, both of which introduced DtD collection with biowaste barcode bins more than 20 years ago, collected 87% and 94% respectively of the total biowaste generated in 2019 (ROOTS 2022). There is also a trend in Catalan municipalities to switch from open street containers to the more efficient DtD collection (see Figure 14). As an example from the MAB, in **Corbera de Llobregat** with 15,210 inhabitants, the effect of the change in the collection system is very clear, with a collection rate of 23 kg/cap/year (impurities; 11.3%) before and 84 kg/cap/year (impurities: 2.9%) after the introduction of DtD collection in February 2022.[85]

GRAPH 11: COMPARISON OF THE RESULTS OF THE GROSS SELECTIVE COLLECTION PER CAPITA OF DIFFERENT WASTE FRACTIONS, IN MUNICIPALITIES WITH AND WITHOUT DtD IN 2020



An increasing number of municipalities in Catalonia have opted for the door-to-door collection model to increase selective collection. Graph 12 shows the evolution over the past 10 years

GRAPH 12: EVOLUTION OF THE NUMBER OF MUNICIPALITIES WITH DTD WASTE COLLECTION

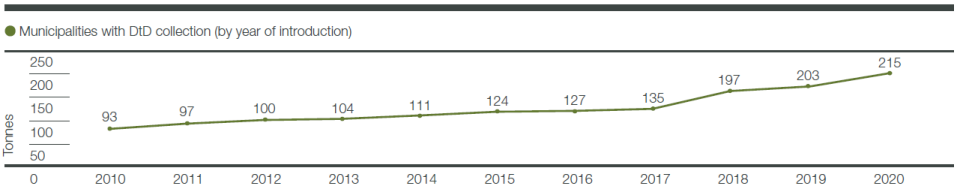


Figure 14: Evolution of separate collection in Catalan municipalities with door-to-door collection (data from 2020).[86]

[85] Information provided by AMB during the final local event in Barcelona.

[86] https://residus.gencat.cat/web/.content/home/lagencia/publicacions/estadistiques/estadistiques_2020_en.pdf

PR#72: At regional level, set up specific strategies and incentives for improving separate collection results, with priority given to large cities. Larger, high-density cities with many high-rise buildings face greater challenges when it comes to converting the open-container collection system to DtD collection and the overall collection rate is usually worse compared to smaller municipalities. A **good practice example for a larger city is Milan** (Italy) with 1.3 million inhabitants, a density above 7,000 inhabitants/km^2 and over 80% of the population living in high rise buildings. In February 2012, the first step of introducing biowaste separate collection was to replace the traditional black bag with a transparent bag for the collection of the mixed residual waste, to facilitate the monitoring of the collection. Then the municipality introduced the DtD collection with a collection frequency of 2x/week. The yearly quantity of collected biowaste per capita rose from 28 kg/cap/y in 2011 to 110 kg/cap/y in 2019, almost 6 times higher than the EU average. The quality of separately collected biowaste is very high, with a share of only 4.3% of non-compostable materials in 2019, fully compatible with the subsequent treatment by the Italian Association for Composting and Biogas (CIC). Separate collection of municipal waste in general increased from 35% in 2011 to 63% in 2020, as other waste fractions are also targeted for DtD collection.[87]

PR#73: At national level, introduce a legal requirement and financial support for municipalities to carry out waste composition analyses of biowaste and mixed residual waste at least once a year and to publish the data. Knowing the composition of the separately collected biowaste provides information about the proportion and composition of impurities, and the composition of the mixed residual waste fraction provides information about the remaining recyclables, including organic waste. Both types of sorting analysis are crucial for improving separate (bio)waste collection and communication campaigns for the public. In the **good practice example of Milan**, sorting analyses are carried out every 6 months. Knowing the exact composition of the mixed residual waste also helps to estimate the actual success of separate biowaste collection. In Milan's case, only 14% of food waste remains in the mixed residual waste.

PR#74: At local level, introduce clearly communicated sorting obligations for citizens and – in case of DtD collection - enforce the obligation by introducing controls on the separate collection of biowaste and the proportion of organic content in mixed residual waste. Enforcement of the corresponding fines for non-compliance (according to PREMET25). DtD collection alone does not necessarily lead to a higher biowaste quality, inspections are needed. In the **MAB**, controls are carried out by the operator at the time of collecting the bin or container (in the case of commercial collection). In the event of non-compliance with the sorting obligations, the bin or container is left standing, and the non-compliance is reported with a sticker as a notice/warning. If the stickers do not lead to an improvement, an official letter can be sent, which may result in a fine. But so far, few municipalities have dared to issue a fine. In the case of smart bin collection, the use of approved and coded bags could be enforced, but this is more complicated and less effective. So far, however, only a few municipalities have dared to impose a fine.[88] In the city of **Münster**, [89] a four-phase "Biowaste bin campaign" ("Aktion Biotonne") was launched in 2017, an information campaign combined with a **quality check of the biowaste bins** of each household biowaste (DtD collection with barcode identification). If the quality found in the bins does

[87] https://zerowastecities.eu/wp-content/uploads/2021/11/Milan-Case-Study-1.pdf

[88] Information from AMB at the last local event in Barcelona.

[89] https://hoopproject.eu/

not meet the standards, citizens receive a yellow card with instructions for better sorting. If the problem persists, the biowaste bin is removed and households must put the biowaste exclusively in the mixed residual waste bin, paying the highest annual fee. As a result, impurities decreased from 3.5% in mid-2017 to 1.9% in early-2018, indicating that the information campaign had an effect on separation behaviour (ROOTS 2022).

PR#75: At regional and local level, introduce strategies for the use of data generated by smart bins to improve citizens' habits and ensure data privacy for citizens. Smart biowaste bins with identification systems generate large amounts of data that can be used to improve citizens' habits by communicating the results obtained (Know-As-You-Throw), but at the same time pose a challenge in dealing with Big Data.

PR#76: At regional level, support awareness raising campaigns on separate biowaste collection and new collection systems. Communication of data security is also important for the introduction of smart bins. The target group should not only include permanent residents of different age groups, but also the tourism sector. At local level, **introduce regular training for workers involved in municipal biowaste management** to ensure sufficient knowledge of aspects related to regulations and targets, practical aspects of management, data collection and reporting, costs and financing of the service.

3.4.3. Construction of new Anaerobic Digestion plants

In 2021, Europe had around 20,000 units of anaerobic digestion (AD) plants in operation producing biogas, with the option of upgrading biogas into biomethane.[90] Currently, the number of Spanish plants (146 biogas and 5 biomethane installations in 2020[91] and 81 planned plants[92]) is lower compared to other countries such as Germany (>20,000 biogas production plants in 2020)[93], France (1,700 plants in 2022)[94] and Italy (approx. 2,000 biogas plants in 2020)[95], even though Spain is a country with such an important agri-food sector and hence potentially usable biowaste resources for anaerobic digestion. A lack of AD plants also means that there are few biomethane upgrading plants.

PR#77: At EU and national level, ensure planning security with regard to legal framework conditions and subsidies for a period of at least 15-20 years for the construction of new AD plants and the upscaling and technical improvement of existing AD plants – with anticipatory communication in the event of a change of policy direction. As an example, in 2002, the Renewable Electricity Act (Ökostromgesetz) was introduced in Austria, which guaranteed the operators of biogas plants a feed-in tariff for renewable power injected into the Austrian power grid for 13 years. As a result, many new biogas plants with renewable power grid injection started operation between 2003 and 2005. However, when the subsidies were discontinued after these 13 years and there was a

[90] https://www.europeanbiogas.eu/record-breaking-year-for-biomethane-production-shows-eba-gie-biomethane-map-2021/

[91] https://energia.gob.es/es-es/Novedades/Documents/OOHR_Biogas_V6.pdf

[92] https://www.residuosprofesional.com/miteco-otorga-ayudas-biogas/

[93] https://www.ieabioenergy.com/wp-content/uploads/2022/03/IEA_T37_CountryReportSummary_2021.pdf

[94] https://www.methafrance.fr/en-chiffres

[95] https://energiaoltre.it/tutti-i-numeri-del-biometano-in-italia-e-in-europa/

general overproduction of electricity, leading to lower prices, many biogas plants faced bankruptcy.[96] Now the Austrian biogas/biomethane sector successfully negotiated the 'Renewables Expansion Act' which will change the subsidy scheme for renewable electricity from a fixed feed-in tariff system towards a market premium system.[97] **Also, the supply of bio-based feedstock must be ensured for at least 15-20 years, e.g., by extending tender intervals** (e.g., biowaste for AD).

PR#78: **At national level, introduce financial incentives for the construction of new AD plants, biogas to biomethane conversion technologies, the upscaling of existing AD plants and the conversion of MBT plants into AD plants** (and composting plants for digestate composting), **treating only source-separated biowaste.** The biostabilised outputs produced in MBT plants will no longer contribute to the Spanish national recycling quota according to the national Law 7/2022. In 2020, 69% of the MSW in Catalonia was treated in MBT plants.[98] In addition, **set minimum construction targets for new plants until 2030.**

PR#79: **At national level, provide support to SMEs and local municipalities with the application for EU grants related to the National Recovery and Resilience Plans to facilitate investments in new AD and biomethane upgrading plants.** In **Italy**, the national Recovery and Resilience Plan (PNRR) is linked to the Biomethane Decree (Decree No. 240 of 15 September 2022). This new decree aims to support the retrofitting of existing agricultural biogas plants that can produce biomethane and to provide financial incentives for the construction of new biomethane production plants. **A capital subsidy of up to 40% of the investment costs for the new plants is envisaged. The total incentives available for this decree amount to 1.7 billion from the PNRR.** The European Commission also offers the Common Agricultural Policy Rural Development Funds, Structural and Cohesion Funds, Horizon Europe, Innovation and Modernisation Funds, LIFE funds, national funds, as well as access to innovation funds for innovative production and use of biomethane and biogas projects.

3.4.4. Biogas/Biomethane

Biogas and biomethane are a form of bioenergy. Biogas consists of 50-70% methane and 30-50% carbon dioxide (CO_2). It can be upgraded to biomethane by removing the CO_2 contained in the biogas through physical or chemical processes. Biomethane can be fed into the natural gas grid or used directly as BioCNG (compressed biomethane). An enhanced uptake of renewable hydrogen, biogas and biomethane by industry is seen as a key contributor to the **RePowerEU plan**'s[99] objectives of diversifying gas supply and reducing the EU's dependence on Russian fossil fuels, while at the same time decreasing dependence on fluctuating natural gas prices and tackling the climate crisis.[100] In 2022, the European Commission published the Staff working document **"Implementing the RePowerEU Action Plan: Investment Needs, Hydrogen Accelerator and Achieving the Biomethane Targets"** (SWD/2022/230 final), which aims at increasing biomethane production within the EU to 35 billion cubic metres (bcm) per year by 2030 and set the stage for

[96] https://www.botres.com/entwicklung-von-biogas-in-osterreich/

[97] https://www.europeanbiogas.eu/intranet-policy/support-schemes-for-biogas-and-biomethane-in-austria/

[98] https://residus.gencat.cat/web/.content/home/lagencia/publicacions/estadistiques/estadistiques_2020_en.pdf

[99] https://ec.europa.eu/commission/presscorner/detail/en/IP_22_3131

[100] https://energy.ec.europa.eu/topics/renewable-energy/bioenergy/biomethane_en

further increasing the potential by 2050. This document is containing several possible actions to unlock the potential of biogas from separately collected organic waste and biomethane across all EU countries.

The majority of EU regulations, from the **Alternative Fuels Infrastructure Directive** (2014/94/EU) to the Renewable Energy Directive (EU) 2018/2001, recognise the positive role of biomethane in both compressed and liquid form, especially in the heavy-duty transport and machinery sectors where de-fossilisation is difficult. The **Renewable Energy Directive** (EU) 2018/2001 includes a legally-binding EU-wide **target of 32% for renewable energy** by 2030, as well as sector-specific objectives, including an annual increase of 1.3% for renewable energy in the heating sector and an end target of **14% renewables in the transport sector** by 2030. The latter aims at promoting the further deployment of electric mobility and includes a sub-target of 3.5% for advanced biofuels and biogas.[101]

In October 2021, there were 1,023 biomethane production plants in Europe, with Germany showing the highest energy production (Figure 15).[102] Spain currently has only five operational biomethane production plants, reaching 95 GWh in 2020 (0.01 bcm; Guevara 2022). The optimal plant size highly depends on the feedstock availability, country regulation and selling price. Countries have different selling prices for different plant capacities or have size limitations depending on their needs. As an example, in Luxembourg, the biomethane plants with a capacity below 150Nm³/h have a tariff of 120 EUR/MWh (HCV) while the units above receive only 80 EUR/MWh (HCV). The energy demand of a plant depends to a large extent on the type of technologies used in the process.[103]

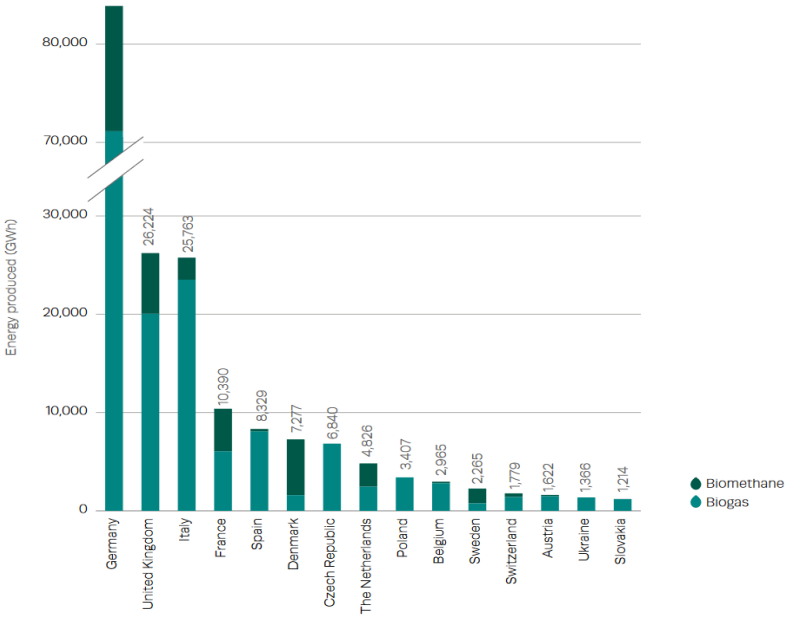


Figure 15: Combined biomethane and biogas production per country, top 15 countries (EBA 2022).[104]

[101] https://www.europeanbiogas.eu/overview-on-key-eu-policies-for-the-biogas-sector/

[102] https://www.europeanbiogas.eu/biomethane-map-2021/

[103] According to Jimmy Roussel, LIST, 3rd PRS

[104] https://www.europeanbiogas.eu/wp-content/uploads/2022/12/EBA-Statistical-Report-2022_Full-version-1.pdf

PR#80: At EU level, introduce more ambitious renewable energy targets for EU Member States, for EU Member States such as Spain, which have already reached the target of 32% energy from renewable sources by 2030. (Directive (EU) 2018/2001). Red Eléctrica estimates that Spain will reach 50%renewable energy (through mainly wind and solar power) of the annual electricity generation in 2023, having the 2nd place in the EU after Germany.[105]

PR#81: At national and regional level, harmonise national and regional renewable energy legislations between EU Member States, specifically concerning **biomethane production**. Currently, at EU level, Member States set different targets.

PR#82: At national level, introduce a higher minimum biogas target – at least 5 bcm by 2030 – into the Spanish Biogas Roadmap.[106] According to Guevara (2022), the Spanish production potential is estimated to be up to 20 bcm/y in 2050, which would place Spain only behind France and Germany with 22 bcm/y respectively.[107] According to a report by Sedigas (Spanish Gas Association), the production potential of biogas in Spain is 163 TWh (16.7 bcm) per year, which is equivalent to covering 45% of the national demand for natural gas. This would mean starting up 2,326 plants with an associated investment of 40,500 million euros (3.6% of GDP) and generating 62,000 direct and indirect jobs associated with their construction and maintenance.[108] The current Spanish target of 10.41 TWh biogas production per year (1.07 bcm) by 2030 is therefore too unambitious.

PR#83: At national level, also set a higher biomethane target (at least 5% of the total gas consumed) - linked to the target for new plants to be built - in the Spanish Biogas Roadmap. The current objective only foresees that in 2030 at least 1% (0.39 bcm) of the total gas consumed (2021: 377,157 GWh = 38.61 bcm)[109] through the natural gas grid should be biomethane). This is not in line with the RePowerEU target of 35 bcm for the EU by 2030. In 2022, only 2% of total gas consumption in Spain was biogas (Figure 16).

[105] https://www.ree.es/en/press-office/news/press-release/2023/03/renewable-energy-could-account-for-50percent-of-spains-electricity-generation-mix-in-2023

[106] https://energia.gob.es/es-es/Novedades/Documents/00HR_Biogas_V6.pdf

[107] https://www.europeanbiogas.eu/wp-content/uploads/2022/12/EBA-Statistical-Report-2022_Full-version-1.pdf

[108] https://www.elconfidencial.com/economia/2023-05-19/espana-potencial-producir-biogas-biometano_3632639/

[109] https://es.statista.com/estadisticas/797237/consumo-de-gas-natural-en-espana/

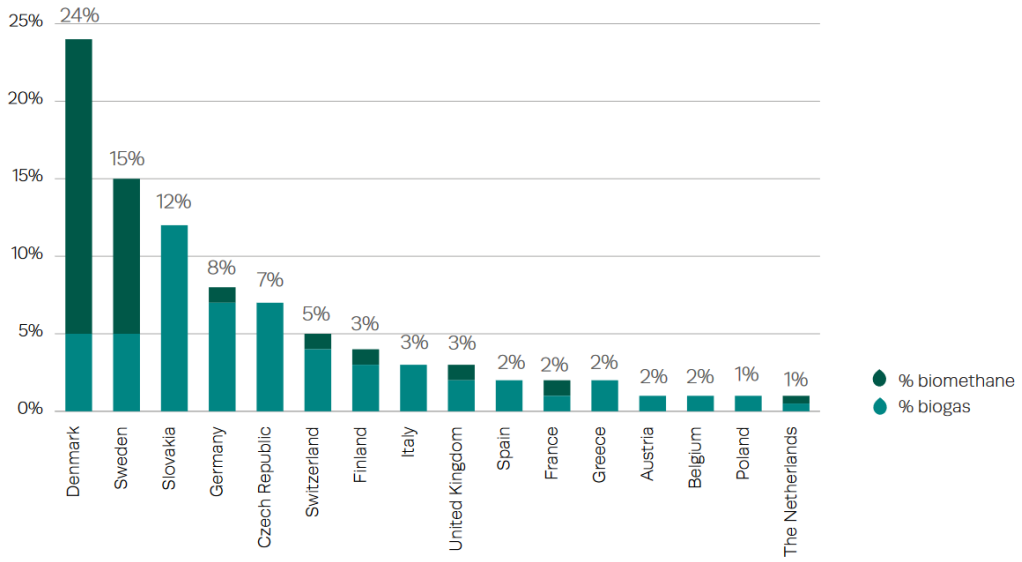


Figure 16: Biomethane and biogas production relative to total gas consumption in 2021 (EBA 2022).[110]

PR#84: At EU level, harmonise biomethane quality requirements for gas grid injection between Member States. Countries have different regulations regarding control and quality (95, 97, 99% methane content). **At national level, provide technical support for the safe injection of biomethane into the gas grid, the expansion of the existing gas network as well as the connection of decentralised generation plants with consumption centres** over large distances (for example, dispersed settlements; acc. to SWD/2022/230 final). Not all plants are located near a connection point and so currently their only option would be to produce Compressed Natural Gas (CNG).

PR#85: At EU and national level, introduce a well-to-wheel approach,[111] analysing GHG emissions, energy efficiency and industrial costs in order to take into account the benefits of gas from renewable energy sources. The third clean mobility package[112], published in May, includes the first ever CO_2 emission standards for heavy-duty vehicles. The focus on tailpipe emissions does not allow fair competition between the different clean mobility solutions. However, applying the "well-to-wheel" approach, i.e., taking into account the whole fuel chain including extraction, production, transport and use of the fuel or electricity, would allow for a more realistic comparison of the different options, as proposed by the European Biogas Association (EBA) and Natural & bioGas Vehicle Association (NGVA) Europe[113]. Currently, Italy has the most methane refuelling stations, 25% of all refuelling stations in the EU (Tratzi et al. 2022). A "well-to-wheel" study conducted in Denmark demonstrates that the use of compressed and liquefied natural gas results in a reduction of GHG emissions by 15-27% per kilometre driven compared to conventional fuels in both transport applications and for all vehicle classes. The effect is particularly large, 81-211%, when compressed and liquefied renewable natural gas is used alternatively. The outcomes depend on the type and source of feedstock used, the vehicle engine, the assumed methane leakage and slip, and

[110] https://www.europeanbiogas.eu/wp-content/uploads/2022/12/EBA-Statistical-Report-2022_Full-version-1.pdf

[111] https://joint-research-centre.ec.europa.eu/welcome-jec-website/jec-activities/well-wheels-analyses_en

[112] https://transport.ec.europa.eu/news-events/news/europe-move-commission-completes-its-agenda-safe-clean-and-connected-mobility-2018-07-10_en

[113] https://www.europeanbiogas.eu/overview-on-key-eu-policies-for-the-biogas-sector/

the allocated energy and environmental credits for digestate in each pathway (Hagos & Ahlgren, 2018). The Renewable Energy Directive (EU) 2018/2001) includes a target of 14% renewables in the transport sector by 2030. In 2020, the share of renewable energy in the Spanish transport sector was only 9,5% compared to Sweden with 31.8%[114]

PR#86: **At national level, support the implementation of innovative technologies for the sustainable production of biogas and biomethane** based on the gasification of biogenic waste (according to SWD/2022/230 final). For example, a process called **"biomethanation" – the biological conversion of H_2 and CO_2 to CH_4** – as a more efficient way to upgrade biogas rather than traditional biogas upgrading technologies. When biogas is upgraded to biomethane, about half of the volume is lost, as biogas contains 40-50% CO_2, which is removed during this process. A new solution would be the biological conversion of H_2 and CO_2 to CH_4. In the "methanation" process, the CO_2 from the biogas is converted into biomethane together with added hydrogen using excess electricity, producing the same amount of biomethane as the amount of biogas used (no losses). However, this technology is dependent on the price of hydrogen. For Spain, a further recommendation is **to convert the surplus electricity from solar or wind energy into hydrogen and convert this hydrogen (together with CO_2) into biomethane as a power-to-gas technology** (Zábranská and Pokorna 2018). In general, facilitate the dissemination/ utilisation of research results, e.g., from the SEMPREBIO project,[115] in which three different technologies for the production of biomethane with three different raw materials are being tested, or from the LIFE INFUSION project,[116] in which biogas, nutrients and treated water are obtained from landfill leachate and liquid digestate from organic municipal waste.

PR#87: **At national level, promote the biomethane demand through awareness raising campaigns about the Renewable Gas Guarantee of Origin system**, which is being introduced in Spain in the first half of 2023 to facilitate the market introduction of biomethane (Order TED/1026/2022). A "Renewable Energy Guarantee of Origin" (GO) is an electronic document that certifies the renewable nature of 1 MWh of gas while listing the specifics of its production: when and where it was produced, the type of production facility and energy source, etc. GOs have the unique function of proving to an end customer that a certain percentage or amount of energy was generated from renewable sources.[117]

PR#88: **At national level, introduce incentives for bioenergy compared to fossil energy** through measures such as a minimum purchase price or incentive tariffs for biomethane with a duration of 15 years (as enshrined in the Italian Biomethane Decree No. 240 of 15 September 2022). Another option is negative incentives for the use of fossil energy (e.g., tax increases). An incentive mechanism based on the assessment of the carbon footprint would also be conceivable (see PR#13, chapter 3.1.3).

PR#89: **At national level, encourage the Spanish participation in the Biomethane Industrial Partnership,**[118] a participatory multi-stakeholder platform between the EC, EU countries, industry representatives, ETIP (European

[114] https://cincodias.elpais.com/cincodias/2022/02/04/economia/1643974455_933172.html
[115] https://sempre-bio.com/project/
[116] https://lifeinfusion.eu/
[117] https://www.enagas.es/en/technical-management-system/general-information/guarantees-origin/
[118] https://bip-europe.eu/

Technology and Innovation Platform) Bioenergy[119], feedstock producers, academia and NGOs through conferences, workshops, and training with technical support, promoting public acceptance (see PR#24, chapter 3.1.5).

3.4.5. Compost/digestate

Policy recommendations for the production of industrial compost and digestate are related to the improvement of separately collected biowaste (chapter 3.4.2) in order to reduce impurities and to obtain higher quality compost and digestate, but also in order to increase the quantities. The recommendations for the treatment of biodegradable plastics in composting facilities at EU and pilot level are discussed in chapter 3.1.6.

At EU level, **Directive 2008/98/EC on waste** (as amended by Directive (EU) 2018/851) aims to promote recycling, including composting and anaerobic digestion, of biowaste in a way that meets a high level of environmental protection and results in production that meets relevant quality standards. In **Regulation (EU) 2019/1009 laying down on rules on the making available on the market of EU fertilising products**, criteria for reaching the end-of-waste status are set. In Spain, the EU law has been integrated into the **national Royal Decree 506/2013 of 28 June 2013 on fertiliser products** (last amendment: 18 February 2022) that defines the quality criteria for the use of compost from biowaste in agriculture and horticulture. The **Spanish national Law 7/2022, of April 8, on waste and contaminated soil for a circular economy** establishes that the competent authorities shall encourage the use of compost and digested compost that meet the end of waste status for compost and digestate laid down in Regulation (EU) No 2019/1009 in the agricultural sector, gardening, or the regeneration of degraded areas, prioritizing as far as possible the use of compost over digested compost.

The increasing number of anaerobic digestion plants in Europe (see chapter 3.4.3) leads to an increase in the amount of digestate produced. For 2021, the annual digestate production in Europe was estimated at 258 to 222 million t fresh mass, depending on the calculation method. For 2050, the digestate potential is calculated at 1,145 to 1,334 million t of digestate with a significant potential for replacing synthetic fertilisers (depending on the properties of the feedstock to be digested).[120]

PR#90: At national and regional level, introduce stricter limits for biowaste impurities in national (10% by 2027) and regional (5% by 2027) legislation. Currently, a more ambitious regional target for improving the quality of separate collection of biowaste is set in Catalonia with PREMET25, with an impurity target of < 8% by 2020, compared to 20% from 2022 and 15% from 2027 at national level under National Law 7/2022. However, these current limits are not sufficient to meet the minimum quality standards for compost production set by MITERD in 2013[121] and to ensure a quality compost with sufficient market demand.

[119] https://www.etipbioenergy.eu/

[120] https://www.europeanbiogas.eu/wp-content/uploads/2022/12/EBA-Statistical-Report-2022_Full-version-1.pdf

[121] https://www.miteco.gob.es/es/calidad-y-evaluacion-ambiental/publicaciones/GUIA_MO_DEF_tcm30-185554.pdf

PR#91: At national level, give financial support for laboratory analyses for SMEs to support third party conformity assessment tasks to certify the end-of-waste status of compost and digestate in accordance with Regulation (EU) No 2019/1009.

PR#92: At national level, introduce subsidies for compost and/or increase the cost of biowaste disposal in landfills and incineration facilities, through specific landfill and incineration taxes (see PR#67, chapter 3.4.2) **to balance the cost of biowaste treatment** in composting plants and anaerobic digestion plants with post-composting of the digestate **compared to the cost of less preferable options.**

PR#93: At regional and local level, introduce fee reductions for citizens for home and community composting, both at individual and community level as for example integrated into the **Italian national Law no. 221** of December 28, 2015. According to the Spanish national Law 7/2022 of April 8, local authorities shall adopt required measures for separate biowaste collection and the recycling of biowaste at source through domestic and municipal composting, especially in municipalities with less than 1,000 inhabitants.

PR#94: At local level, mobilise citizens for home and community composting. As a good practice example, in the **Helsinki Metropolitan Area**, composting of garden, food and toilet waste is encouraged for single-family homes. However, for composting food waste and/or toilet waste, a composting notification must be submitted to the municipal waste management authority HSY. HSY also offers a **composting guide and free composting courses** in cooperation with the Helsinki Metropolitan Area Reuse Centre and cities in the region.[122] Another incentive for citizens is **distributing free composters**, as for example foreseen in the **Bulgarian National Waste Management Plan 2021-2028 (NWMP)**, which includes that free composters shall be distributed to 100,000 households. Another example is the large and densely populated **City of Paris** (2,145,906 inhabitants; density: 20,359.6 habitants/km^2 in 2020[123]), where **collective composting** at the foot of buildings (minimum area 5m^2) is promoted, accompanied by training and a supervisor responsible for monitoring composting. Nearly 900 community composters have already been installed in Paris, making it the best-equipped city in France. In addition, 4,340 **worm composters**[124] were distributed free of charge between 2017 and 2020[125], as part of the Paris Compost Plan.[126]

[122] https://www.hsy.fi/en/waste-and-recycling/composting-on-properties/

[123] https://www.insee.fr/fr/statistiques/1405599?geo=DEP-75

[124] https://www.paris.fr/dossiers/composter-a-paris-20

[125] https://cdn.paris.fr/paris/2021/12/10/682a383f2dc741d7735b8bced8dcd81e.pdf

[126] https://cdn.paris.fr/paris/2019/07/24/bcfe293f7ccd090daaba249150202ba4.pdf

CONCLUSIONS

The BCC project describes biorefineries that process selected secondary biomass streams, i.e., municipal biowaste, organic waste from agriculture and industry, and forestry residues, into a range of marketable bio-based products, including biochemicals, bioplastics, novel food, and bioenergy. Bio-based products can make the economy more sustainable and reduce its dependence on fossil fuels. However, the "sustainability" of bio-based products must first be verified on a case-by-case basis (e.g., through LCAs). One example is bioplastics, which are also described in this report as potential products for all three pilot areas. Bioplastics must be designed to be reusable or recyclable, safe, and made from sustainably sourced raw materials, prioritising the efficient use of secondary biomass, and comply with relevant standards.

The policy recommendations (PRs) in this report are mainly based on the analysed legal framework of the three pilot areas at national, regional, local and at EU level. Examples of good practice are also an important part of the PRs. Of the 94 PRs defined, 30 are "**general policy recommendations for all three pilot areas**", covering broader principles and strategies. The main general policy recommendations focus on the following issues:

High quality data is the basis for decision-making processes, from the choice of the collection system to the choice of treatment method. Promoting the standardisation and harmonisation of data collection methods for all types of organic waste (forestry residues, agro-industrial organic waste, separately collected biowaste, etc.) through the development of guidelines is crucial. These guidelines should be applied to the assessment of annually updated, comprehensive, transparent, and freely accessible organic waste data streams fed into national digital waste management platforms to enable data sharing, comparison of results and meaningful EU-wide benchmarking.

Financial support (especially for SMEs) is necessary for the establishment and expansion of **organic waste treatment plants and sustainable biorefineries**, and planning security must be created with regard to legal framework conditions and subsidies, while at the same time subsidies that are not in line with the EU waste hierarchy and EU bioeconomy goals should be phased out. Permitting procedures for new biorefineries should be accelerated through capacity building in the respective municipal departments. Public and private investment in research and development of new innovative value chains and in the use of BAT is also essential.

An important priority of outreach is to promote market uptake of bio-based products. **Market incentives for bio-based products** should give preference to sustainable biorefineries (LCA-verified) that produce bio-based products according to the principle of "cascading biomass use", i.e., biochemicals are preferred over bioenergy. An effective instrument to stimulate market demand for new bio-based products is Green Public Procurement. The introduction of financial incentives based on carbon footprint assessment or VAT reductions for bio-based products (and other environmentally friendly products and services) compared to fossil-based products is recommended.

When it comes to food waste prevention, separate collection of municipal biowaste and consumption of bio-based products, raising **public awareness and support** is of utmost importance. Well-designed – and monitored – environmental education programmes can help change citizens' attitudes and perceptions. In addition, effective

communication between waste management organisations and citizens is crucial for the successful operation of waste management services.

Through platforms (e.g., technology and innovation clusters) and events along the CBE value chains, exchange of best practices and cooperation between different actors – i.e., policy makers, researchers, BBIs, NGOs and the general public – with different fields of knowledge and interests should be improved. In addition, **stakeholder involvement** in decision-making (e.g., in the construction of new (bio)waste treatment facilities or in changes to the collection system) should be enshrined in law.

Of the **policy recommendations that specifically target the pilot areas**, the number of PRs for the Metropolitan Area of Barcelona (MAB) pilot area is significantly higher (39) than for the Metropolitan City of Naples (MCN; 12) and Pazardzhik Province (PP; 13). This is mainly due to the fact that the legal framework for the feedstock "municipal biowaste" at EU level and at national, regional, and local level for MAB is very extensive and includes biowaste prevention, waste taxation, separate collection, and treatment of biowaste in anaerobic digestion and composting plants. Furthermore, the regulatory framework for biogas/biomethane is also very comprehensive compared to the processing of organic waste from agro-industry into novel food (MCN chain) or the production of bioenergy/biochemicals from forestry residues (PP chain).

For the **PP pilot area**, evaluation of soil characteristics, forest species composition, topography, and forest management type were identified as the most important issues for the environmental impact assessments to determine the range (at least 10-15%) between forestry residues to be left on the ground. This needs to be clarified before any decision is made on the collection and use of forestry residues. Financial support for this assessment is needed as well as for the collection of forestry residues in steep terrain (as is the case in PP), also with a view to reducing the costs of firefighting and reforestation after fires. Financial support is also needed for investments in local infrastructure and sustainable biorefineries (especially in rural areas) - favouring bio-based materials (such as biochemicals) over bioenergy.

There is a wide variety of recovery and bio-based product options for agro-industrial organic wastes and by-products. As the use of waste is much more limited than the use of by-products, it is crucial to allow classification as an "agro-industrial by-product" wherever possible. For agro-industrial organic waste in general, financial incentives and administrative and technical support should be provided to companies that use their by-products internally for the production of new products in order to avoid classification as waste. Moreover, incentives should be provided for local industrial symbioses. Novel foods such as functional ingredients from coffee silverskin (**MCN pilot area**) need to go through a lengthy authorisation process by EFSA under Regulation (EU) No 2015/2283 on novel foods to avoid harm to (human) health and the environment. For this purpose, SMEs in particular need financial support for laboratory analyses as part of independent scientific advice on existing and emerging risks in the food chain.

The policy recommendations for the **MAB pilot area** also take into account food waste prevention measures that need to be considered when planning the long-term supply of biowaste feedstock for valorisation technologies. Improving the quality and quantity of source-separated biowaste is the most important prerequisite for the development of new biowaste value chains such as biomethane production. The mandatory application of the pay-

as-you-throw (PAYT) principle in local waste charges not only would incentivise the separation of biowaste (and other recyclables) at source, but also would reduce the total amount of mixed residual waste. In areas where there has been no biowaste collection, door-to-door (DtD) collection systems or smart bins should be introduced instead of open containers. In order to produce high quality compost, stricter biowaste contamination limits in national and regional legislation are important. The obligation for citizens to sort biowaste must not only be clearly communicated, but controls on the separate collection of biowaste (quality control) and the proportion of organic components in mixed residual waste – in combination with enforcement of the corresponding fines for non-compliance – must also be ensured. In addition to increasing the feedstock (separately collected biowaste), the number and size of anaerobic digestion plants must also be increased in order to boost the production of biogas and thus biomethane. More ambitious national targets must be ensured for upgrading biogas to biomethane for use as fuel (promoting the "well-to-wheel" approach) or for injection into the local gas grid. In addition, the introduction of innovative technologies for the sustainable production of biogas and biomethane must be ensured.

The policy recommendations of D3.3 are in line with the results of D2.3 (LCA and LCC analyses of business-as-usual compared to the alternative scenarios of the respective biocircular value chains).

REFERENCES

ACORD GOV/141/2021, de 14 de setembre, pel qual s'aprova l'Estratègia de la bioeconomia de Catalunya 2021-2030. *Bioeconomy Strategy of Catalonia 2021-2030 (GOV/141/2021).* https://portaljuridic.gencat.cat/ca/document-del-pjur/?documentId=910227

Bulgarian National Waste Management Plan 2021-2028 (NWMP). НАЦИОНАЛЕН ПЛАН ЗА УПРАВЛЕНИЕ НА ОТПАДЪЦИТЕ 2021-2028 https://www.moew.government.bg/static/media/ups/tiny/%D0%A3%D0%9E%D0%9E%D0%9F/%D0%9D%D0%9F%D0%A3%D0%9E-2021-2028/NPUO_2021-2028.pdf

COM/2003/302 final: Communication from the Commission to the Council and the European Parliament: Integrated Product Policy - Building on Environmental Life-Cycle Thinking.

COM/2008/400 final: Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: Public procurement for a better environment.

COM/2018/673 final: Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions - A sustainable Bioeconomy for Europe: Strengthening the connection between economy, society, and the environment.

COM/2019/640 final: Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: The European Green Deal.

COM/2020/98 final: Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: A new Circular Economy Action Plan For a cleaner and more competitive Europe.

COM/2020/380 final: Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: EU Biodiversity Strategy for 2030 -Bringing nature back into our lives.

COM/2021/390 final: Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: Strategy for Financing the Transition to a Sustainable Economy.

COM/2021/572 final: Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: New EU Forest Strategy for 2030.

COM/2022/230 final: Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee and the Committee of the Regions - REPowerEU Plan.

COM/2022/682 final: Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: EU policy framework on bio-based, biodegradable, and compostable plastics.

COM/2023/420 final: Proposal for a Directive of the European Parliament and of the Council amending Directive 2008/98/EC on waste.

Commission Recommendation 2003/361/EC of 6 May 2003 concerning the definition of micro, small and medium-sized enterprises.

Commission Regulation (EU) No 1179/2012 of 10 December 2012 establishing criteria determining when glass cullet ceases to be waste under Directive 2008/98/EC of the European Parliament and of the Council.

Consultation on the Determination of the Status of a Novel Food under Article 4 (2) of Regulation (EU) 2015/2283. https://food.ec.europa.eu/system/files/2022-06/novel-food_consult-status_2022-4778355.pdf

Council Regulation (EU) No 333/2011 of 31 March 2011 establishing criteria determining when certain types of scrap metal cease to be waste under Directive 2008/98/EC of the European Parliament and of the Council.

Decreto-ley 17/2022, de 20 de diciembre, por el que se establecen medidas de adaptación al impuesto sobre el depósito de residuos en depósitos controlados, la incineración y la coincineración, y para la subrogación del Ente de Abastecimiento de Agua Ter-Llobregat en el convenio regulador de la financiación y la explotación de la red de abastecimiento de La Llosa del Cavall. *Decree-Law 17/2022, of 20 December, establishing measures to adapt to the tax on the deposit of waste in controlled deposits, incineration and co-incineration, and for the subrogation of the Ter-Llobregat Water Supply Agency in the agreement regulating the financing and operation of the supply network of La Llosa del Cavall. https://www.boe.es/eli/es-ct/dl/2022/12/20/17*

Directive (EU) 2014/94 of the European Parliament and of the Council of 22 October 2014 on the deployment of alternative fuels infrastructure.

Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources.

Directive (EU) 2018/850 of the European Parliament and of the Council of 30 May 2018 amending Directive 1999/31/EC on the landfill of waste.

Directive (EU) 2018/851 of the European Parliament and of the Council of 30 May 2018 amending Directive 2008/98/EC on waste.

EBA, European Biogas Association (2022): Statistical Report 2022 - Tracking biogas and biomethane deployment across Europe. https://www.europeanbiogas.eu/wp-content/uploads/2022/12/EBA-Statistical-Report-2022_Full-version-1.pdf

EC (2019): European Commission, Directorate-General for Research and Innovation, De Smet, M., Linder, M., Koopmans, R., et al., A circular economy for plastics : insights from research and innovation to inform policy and funding decisions, De Smet, M. (editor), Linder, M. (editor), Publications Office, 2019, https://data.europa.eu/doi/10.2777/269031

EC (2021): European Commission, Joint Research Centre, Camia A., Giuntoli, J., Jonsson, R., Robert, N., Cazzaniga, N.E., Jasinevičius, G., Avitabile, V., Grassi, G., Barredo, J.I., & S. Mubareka (2021): The use of woody biomass for energy purposes in the EU, EUR 30548 EN, Publications Office of the European Union, Luxembourg. https://data.europa.eu/doi/10.2760/831621

EC (2022): European Commission, Directorate-General for Environment, Watson, D., Kaarsberg, S. & B. Bauer: Synopsis report on the consultation on the policy framework on bio-based, biodegradable and compostable plastic, Publications Office of the European Union. https://data.europa.eu/doi/10.2779/126536

EC Eurostat (2022): Guidance on reporting of data on food waste and food waste prevention according to Commission Implementing Decision (EU) 2019/2000. https://ec.europa.eu/eurostat/documents/342366/351811/Guidance+on+food+waste+reporting/5581b0a2-b09e-adc0-4e0a-b20062dfe564

EFSA NDA Panel, Panel on Dietetic Products, Nutrition and Allergies (2021): Turck, D., Bresson, J.-L., Burlingame, B., Dean, T., Fairweather-Tait, S., Heinonen, M., Hirsch-Ernst, K.I., Mangelsdorf, I., McArdle, H. J., Naska, A., Neuhäuser-Berthold, M., Nowicka, G., Pentieva, K., Sanz, Y., Siani, A., Sjödin, A., Stern, M., Tomé, D., Vinceti, M., Willatts, P., Engel, K.-H., Marchelli, R., Pöting, A., Poulsen, M., Salminen, S., Schlatter, J., Arcella, D., Gelbmann, W., de Sesmaisons-Lecarré, A., Verhagen, H. & H. van Loveren (2021): Guidance on the preparation and submission of an application for authorisation of a novel food in the context of Regulation (EU) 2015/2283 (Revision1). EFSA Journal 2021;19(3):6555.https://doi.org/10.2903/j.efsa.2021.6555

EN 13432 Packaging. Requirements for packaging recoverable through composting and biodegradation. Test scheme and evaluation criteria for the final acceptance of packaging. BS EN 13432:2000. Released: 31/05/2007

Garcia, C. V. & K. Young-Teck (2021): Spent Coffee Grounds and Coffee Silverskin as Potential Materials for Packaging: A Review. Journal of Polymers and the Environment volume 29, pages 2372–2384

Guevara, P., R. (2022). Spanish biomethane here we go! Análisis de las potencias europeas en biometano para entender por qué y cómo replicar el modelo en España. RETEMA Revista Técnica de Medio Ambiente. Revista digital Especial Bioenergía 2022. nº241:60-72 Energia. https://www.retema.es/revista-digital/especial-bioenergia-8

Hagos, D. A. & Ahlgren, E. I. (2018): Well-to-wheel assessment of natural gas vehicles and their fuel supply infrastructures–Perspectives on gas in transport in Denmark. Transportation Research Part D 65 (2018) 14–35. https://doi.org/10.1016/j.trd.2018.07.018

Hejna, A., Barczewski, M., Kosmela, P., Mysiukiewicz, O. & A. Kuzmin (2021): Coffee Silverskin as a Multifunctional Waste Filler for High-Density Polyethylene Green Composites. Journal of Composites Science *5*(2), 44; https://doi.org/10.3390/jcs5020044

DECRETO 15 settembre 2022 Attuazione degli articoli 11, comma 1 e 14, comma 1, lettera b), del decreto legislativo 8 novembre 2021, n. 199, al fine di sostenere la produzione di biometano immesso nella rete del gas naturale, in coerenza con la Missione 2, Componente 2, Investimento 1.4, del PNRR. (22A06066). *Italian National Decree n. 240 of 15 September 2022. Development of biomethane, according to criteria to promote the circular economy - Biomethane production.* https://www.gazzettaufficiale.it/eli/id/2022/10/26/22A06066/sg

Klingel, T., Kremer, J.I., Gottstein, V., Rajcic de Rezende, T., Schwarz, S. & D.W. Lachenmeier, (2020): A review of coffee by-products including leaf, flower, cherry, husk, silverskin, and spent grounds as novel foods within the European Union. Foods 2020 9 (5). https://doi.org/10.3390/foods9050665

LIFE REthinkWASTE (2021): PAYT and KAYT Catalogue: Collection of experiences about pay as you throw (PAYT) and know as you throw (KAYT). https://rethinkwaste.eu/wp-content/uploads/2021/05/03_LIFE-REthinkWaste_Catalogue-final-updated.pdf

Legge 28 dicembre 2015, n. 221. Disposizioni in materia ambientale per promuovere misure di green economy e per il contenimento dell'uso eccessivo di risorse naturali. *Italian Environmental Law for the Promotion of Environmentally Friendly Economic Measures and the Curbing of the Excessive Consumption of Natural Resources (Law No. 221 of 28 December 2015).* https://www.gazzettaufficiale.it/eli/id/2016/1/18/16G00006/sg

Legge 19 agosto 2016, n. 166. Disposizioni concernenti la donazione e la distribuzione di prodotti alimentari e farmaceutici a fini di solidarieta' sociale e per la limitazione degli sprechi. *Italian Law on Provisions concerning the donation and distribution of food and pharmaceutical products for social solidarity purposes and for limiting waste (Law No. 166 of 19 August 2016).* https://www.gazzettaufficiale.it/eli/id/2016/08/30/16G00179/sg

Ley 6/2009, de 28 de abril, de evaluación ambiental de planes y programas. *Law 6/2009 of 28 April on the environmental assessment of plans and programmes.* Comunidad Autónoma de Cataluña/ *Catalonia*. https://www.boe.es/eli/es-ct/l/2009/04/28/6/con

LEY 3/2020, de 11 de marzo, de prevención de las pérdidas y el despilfarro alimentarios. *Law 3/2020 of 11 March on the Prevention of Food Losses and Waste in Catalonia.* *https://residus.gencat.cat/web/.content/home/consultes_i_tramits/normativa/normativa_catalana_en_materia_de_residus/llei_3_2020_es.pdf*

Ley 7/2022, de 8 de abril, de residuos y suelos contaminados para una economía circular. *National Law 7/2022 on Waste and Contaminated Soils for a Circular Economy. https://www.boe.es/buscar/act.php?id=BOE-A-2022-5809*

Magarini, A., De Cunto, A. & E. Porreca (2018): Milano Food Policy: Food Losses and Waste in European Cities. Working Document. https://refreshcoe.org/wp-content/uploads/2018/05/REPORT-Food-Losses-and-Waste-in-European-Cities-WG-Food-City-of-Milan.pdf

NF T 51-800: Plastiques - Spécifications pour les plastiques aptes au compostage domestique. *Plastics - Specifications for plastics suitable for home composting*. Publication date: Oct. 2015. https://www.boutique.afnor.org/fr-fr/norme/nf-t51800/plastiques-specifications-pour-les-plastiques-aptes-au-compostage-domestiqu/fa060127/1525

Nolasco, A., Squillante, J., Esposito, F., Velotto, S., Romano, R., Aponte, M., Giarra, A., Toscanesi, M., Montella, E. & T. Cirillo (2022a): Coffee Silverskin: Chemical and Biological Risk Assessment and Health Profile for Its Potential Use in Functional Foods. Foods 2022, 11, 2834. https://doi.org/10.3390/foods11182834

Nolasco, A., Squillante, J., Velotto, S., D'Auria, G., Ferranti, P., Mamone, G., Errico, M.E., Avolio, R., Castaldo, R., Cirillo, T. & F. Esposito (2022b): Valorization of coffee industry wastes: Comprehensive physicochemical characterization of coffee silverskin and multipurpose recycling applications. Journal of Cleaner Production 370 (2022a): 133520. https://doi.org/10.3390/foods11182834

Orden TED/1026/2022, de 28 de octubre, por la que se aprueba el procedimiento de gestión del sistema de garantías de origen del gas procedente de fuentes renovables. *Order TED/1026/2022, of 28 October, approving the procedure for the management of the system of guarantees of origin of gas from renewable sources.* https://boe.es/diario_boe/txt.php?id=BOE-A-2022-17721

PRECAT20. Programa general de prevenció i gestió de residus i recursos de Catalunya 2013-2020. *Programme for the Prevention and Management of Waste and Resources in Catalonia 2013-2020.* http://www20.gencat.cat/docs/arc/Home/Ambits%20dactuacio/Planificacio/PROCAT20/PRECAT20.pdf

PEMAR. Plan Estatal Marco de Gestión de Residuos 2016-2022. *Spanish National Waste Management Framework Plan 2016-2022.* https://www.miteco.gob.es/content/dam/miteco/es/calidad-y-evaluacion-ambiental/planes-y-estrategias/pemaraprobado6noviembrecondae_tcm30-170428.pdf

PREMET25. Programa metropolità de prevenció i gestió de recursos i residus municipals 2019-2025. Metropolitan Program on Prevention and Use of Resources and Municipal Waste 2019-2025, including the Metropolitan Zero Waste Agreement. 2019. https://www.premet25.cat/wp-content/uploads/2019/02/04_EAE-1.pdf

Riconfigure (2021): D6.4: Quadruple Helix Collaborations in Practice: Stakeholder Interaction, Responsibility and Governance. http://riconfigure.eu/wp-content/uploads/2021/06/D6.4-Quadruple-Helix-Collaborations-in-Practice-1.pdf

Regulation (EU) 2015/2283 of the European Parliament and of the Council of 25 November 2015 on novel foods, amending Regulation (EU) No 1169/2011 of the European Parliament and of the Council and repealing Regulation (EC) No 258/97 of the European Parliament and of the Council and Commission Regulation (EC) No 1852/2001. Off. J. Eur. Union. 2015, 327, 1-22-

Regulation (EU) 2019/1009 of the European Parliament and of the Council of 5 June 2019 laying down rules on the making available on the market of EU fertilising products and amending Regulations (EC) No 1069/2009 and (EC) No 1107/2009 and repealing Regulation (EC) No 2003/2003.

ROOTS (2022) - CirculaR pOlicies for changing the biOwasTe System. A position paper from the projects HOOP, VALUEWASTE, SCALIBUR, WaysTUP! and CITYLOOPS. https://circulareconomy.europa.eu/platform/en/knowledge/circular-policies-changing-biowaste-system-roots-position-paper

Schütz, F., Heidingsfelder, M.L. & M. Schraudner (2019): Co-shaping the Future in Quadruple Helix Innovation Systems: Uncovering Public Preferences toward Participatory Research and Innovation. She Ji: The Journal of Design, Economics, and Innovation. Volume 5, Issue 2, Pages 128-146. https://doi.org/10.1016/j.sheji.2019.04.002

Stegman, P., Londo, M., & M. Junginger (2019):The circular bioeconomy: Its elements and role in European bioeconomy clusters. Resources, Conservation & Recycling: X. 6: 100029. https://doi.org/10.1016/j.rcrx.2019.100029

SWD/2022/230 final: Commission staff working document: Implementing the repower EU action plan: investment needs, hydrogen accelerator and achieving the biomethane targets, accompanying COM/2022/230 final.

Titus, B.D., Brown, K., Helmisaari, H.-S., Vanguelova, E., Stupak, I., Evans, A., Clarke, N., Guidi, C., Bruckman, V.J., Varnagiryte-Kabasinskiene, I., Armolaitis, K., de Vries, W., Hirai, K., Kaarakka, L., Hogg, K. & P. Reece (2021): Sustainable Forest biomass: A review of current residue harvesting guidelines. Energy, Sustainability and Society 11:10. https://doi.org/10.1186/s13705-021-00281-w

Tratzi, P., Torre, M., Paolini, V., Tomassetti, L., Montiroli, C., Manzo, E. & F. Petracchini (2022): Liquefied biomethane for heavy-duty transport in Italy: A well-to-wheels approach. Transportation Research Part D: Transport and Environment. Volume 107: 103288. https://doi.org/10.1016/j.trd.2022.103288

Ververis, E., Ackerl, R., Azzollini, D., Colombo, P.A., de Sesmaisons, A., Dumas, C., Fernandez-Dumont, A., Ferreira da Costa, L., Germini, A., Goumperis, T., Kouloura, E., Matijevic, L., Precup, G., Roldan-Torres, R., Rossi, A., Svejstil, R., Turla, E. & W. Gelbmann (2020): Novel foods in the European Union: Scientific requirements and challenges of the risk assessment process by the European Food Safety Authority. Food Research International 137: 109515. https://doi.org/10.1016/j.foodres.2020.109515

Zábranská, J. & D. Pokorna (2018): Research review paper: Bioconversion of carbon dioxide to methane using hydrogen and hydrogenotrophic methanogens. Biotechnology Advances. Volume 36, Issue 3, May–June 2018, Pages 707-720. https://doi.org/10.1016/j.biotechadv.2017.12.003

www.biocircularcities.eu